Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan

Prepared for

Northwest Power and Conservation Council

CONTRIBUTORS

Subbasin Leads

Lower Columbia Estuary Partnerships

Lower Columbia Fish Recovery Board

Contributors

Blaine Ebberts, U.S. Army Corps of Engineers

Cathy Tortorici, National Oceanic & Atmospheric Administration

Cedric Cooney, ODF&W (Oregon Technical Support)

Dave Ward, Oregon Department of Fish &Wildlife

Debrah Marriott, Lower Columbia River Estuary Partnership

Gustavo Bisbal, U.S. Fish & Wildlife Service

Jeff Breckel, Lower Columbia Fish Recovery Board

Jessica Wilcox, Bonneville Power Administration

Jim Middaugh, City of Portland

Jim Owens, Oregon Coordinating Group (Tier II)

Lee Van Tussenbrook, Washington Department of Fish & Wildlife

Matt Van Ess, Columbia River Estuarine Task Force

Patty Dornbusch, National Oceanic & Atmospheric Administration

Paul Lumley, Columbia Intertribal Fish Commission

Phil Miller, Washington Governor's Office

Phil Trask, Lower Columbia Fish Recovery Board

Rhon Rhew, U.S. Fish & Wildlife Service

Rick Bastasch,Willamette Restoration Initiative

Taunja Berquam, U.S. Army Corps of Engineers

Todd Jones, CEDC Fisheries

Tom Byler, Oregon Governor's Office

Tony Grover, Northwest Planning and Conservation Council (Tier II)

Project Staff

Zenn Associates: Doug Zenn, Finlay Anderson, Mike Dahlstrom, Marlys Mock

Lower Columbia Fish Recovery Board: Phil Trask

Parametrix Inc: John Marsh

S.P. Cramer & Associates, Inc.: Mike Daigneault

EXECUTIVE SUMMARY

In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act, which authorized creation of the Northwest Power and Conservation Council (Council) by the states of Washington, Oregon, Idaho and Montana. The Act directed the Council to develop a program "to protect, mitigate and enhance fish and wildlife…in the Columbia River and its tributaries…affected by the development, operation and management of [hydroelectric projects] while assuring the Pacific Northwest an adequate, efficient, economical and reliable power supply." The Council has established four primary objectives for the Columbia River Fish and Wildlife Program.

- A Columbia River ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife
- Mitigation across the Columbia River Basin for the adverse effects to fish and wildlife caused by the development and operation of the hydrosystem
- Sufficient populations of fish and wildlife for abundant opportunities for tribal trust and treaty rights harvest and for non-tribal harvest
- Recovery of the fish and wildlife that are affected by the development and operation of the hydrosystem and are listed under the Endangered Species Act (ESA)

The Columbia River Basin was divided into 62 subbasins based on Columbia River tributaries. Each subbasin is developing its own plan that will establish locally defined biological objectives to meet the four primary objectives defined by the Council. Plans developed at the subbasin level will be combined into the fourteen province-level plans and will form the framework within which the Bonneville Power Administration will fund proposed fish and wildlife projects. The subbasin planning process is viewed as an ongoing effort and will occur on a three-year cycle. The plans are considered "living documents" that will incorporate new information as part of periodic updates.

The subbasin plans also will play a significant role in addressing the requirements of the ESA. National Oceanic and Atmospheric Administration (NOAA) Fisheries and United States Fish and Wildlife Service (USFWS) intend to use the plans to help in recovery of ESA-listed species. In addition, the Council, Bonneville Power Administration (BPA), NOAA Fisheries, and USFWS will use the adopted subbasin plans to help meet subbasin and province requirements under the 2000 Federal Columbia River System Biological Opinion. Other regulatory standards and planning efforts, including the Clean Water Act (CWA) and various state requirements, affect, and are affected by, the subbasin plans. In particular, an interactive relationship is expected to be developed between subbasin planning, watershed plans and state salmon recovery plans.

Mainstem Lower Columbia River and Columbia River Estuary Subbasins

This plan concerns the Mainstem Lower Columbia River and Columbia River Estuary in western Oregon and Washington. The subbasin begins at the Columbia River plume and extends 146 river miles to Bonneville Dam. The Mainstem Lower Columbia River and Columbia River Estuary subbasin plan does not extend past the confluence of the tributaries that drain into it. The exception to this rule concerns the western-most Oregon tributaries (WOTs), which includes Youngs Bay, Nicolai-Wikiup, Lower Columbia-Clatskanie River, and Scapoose Bay watersheds.

These watersheds have been included in this plan since they are not already covered under other subbasin planning efforts.

Organization and Coordination: Two States, Two Subbasins, One Plan.

The planning process in the Mainstem Lower Columbia River and Columbia River Estuary subbasin involves a number of federal and state agencies, and regional organizations, and managed primarily by the lead entities: the Lower Columbia River Estuary Partnership (LCREP) in partnership with the Lower Columbia fish Recovery Board (LCFRB).

The Mainstem Lower Columbia and Columbia River Estuary subbasins fall within the jurisdictions of both Oregon and Washington and encompass nearly the same geographic area covered by the LCREP. The Estuary Partnership is a two-state, public/private partnership that has developed a management plan for the lower 146 miles of the Columbia River and which has a board of directors comprised of individuals and interests from both states. The Estuary Partnership works to restore habitat, provide education and information and eliminate pollution from the lower river. It was asked by the Governors of Washington and Oregon to coordinate a policy-level committee of federal and state partners to address efforts to recover threatened and endangered species. In developing its own management plan, the Estuary Partnership used an extensive process to involved stakeholders, constituents and members of the public from both states and all other jurisdictions within its study area. This effort also capitalizes on the LCREP organizational framework. It also utilizes information and involvement opportunities presented by LCFRB's ongoing recovery planning efforts.

The Oregon and Washington Coordinating (Level II) Groups have agreed to combine the two subbasins and to develop one plan that covers both subbasins. In addition, as noted, the geography of the two subbasins aligns closely with the area within the Estuary Partnership study area. The Estuary Partnership aimed to use the same two-state integrated approach to developing the plan that it employs in all its work and organizational structure.

About the Subbasins

In the Columbia River, tidal impacts in water level have been observed as far upstream as Bonneville Dam (RM 146) during low flow. Reversal of river flow has been measured as far upstream as Oak Point (RM 53), and intrusion of salt water is typically to Harrington Point (RM 23) at the minimum regulated monthly flow, although at lower daily flows saltwater intrusion can extend past Pillar Rock (RM 28) (Neal 1972). The lowest river flows generally occur during September and October, when rainfall and snowmelt runoff are low. The highest flows occur from April to June, resulting from snowmelt runoff. High flows also occur between November and March, caused by heavy winter precipitation. The discharge at the mouth of the river ranges from 100,000 to 500,000 cfs, with an average of about 260,000 cfs. Historically, unregulated flows at the mouth ranged from 79,000 cfs to over 1 million cfs, with average flows about 273,000 cfs (Neal 1972, Marriott et al. 2002).

The Willamette River is the largest tributary to the lower Columbia River. Major tributaries originating in the Cascades include the Sandy River in Oregon and the Washougal, Lewis, Kalama and Cowlitz Rivers in Washington. Major Coast Range tributaries include the Elochoman and Grays Rivers in Washington and the Lewis and Clark, Youngs and Clatskanie Rivers in Oregon. Numerous other minor tributaries drain small watersheds but do not have substantial influence on the Columbia River because of their small size.

The size of the subbasin lends itself to an abundance of possible land uses. The area contains multiple population centers and political jurisdictions, including the largest Oregon population center (Portland) and the fourth largest in Washington (Vancouver). Approximately 2.5 million people live in the basin; many others visit for recreation or business. Major land uses in the subbasin are related to urban and industrial uses, cropland, forest and pasturage. For example, five deep-water ports support a shipping industry that transports 30 million tons of goods annually; timber harvest occurs throughout the basin; six major pulp and paper mills contribute to the regions economy; aluminum plants along the river produce 43 percent of U.S. aluminum; agriculture is widespread throughout the floodplain, including many fruit and vegetable crops as well as beef and dairy cattle; and although commercial fishing activity has declined in recent years, the industry continues to play a significant role in the region.

Focal Species

The Mainstem Lower Columbia River and Columbia River Estuary subbasin plan concerns itself primarily with fish and wildlife focal species and their relationships and habitat needs. Focal species were selected based on:

- ESA status
- Cultural importance of the species
- Level of information available about species' life histories allowing an effective assessment
- Life histories representative of the *use* of Mainstem Lower Columbia River and Columbia River Estuary subbasin

This last consideration stemmed from the recognition by the Planning Group that the subbasin is unique from the remaining 61 subbasins because it is a melting pot for all upriver subbasins and tributaries. The health of all upriver migratory stocks depends, to some extent, on a functioning estuary and lower Columbia ecosystem. The significance of the subbasin to the entire basin led the Planning Group to conclude that it must address the range of life history types of salmonids that use the estuary – not just those that produce in the estuary. Based on the above criteria, the project team selected focal species. It also recognized a number of other species as important to for consideration in the planning effort. These included species of ecological significance, economic interest and recreational significance. The information from the examination of the focal species forms the core of the plan, supplemented with applicable information from the other species of interest.

Table ES-1-1. Species Selection and Planning Context.

Species	ESA	Ecological[1]	Cultural	Economic[2]	Recreation[3]
Species of Primary Interest (Focal Species)					
Fall Chinook	X	X	X	X	X
Chum	X	X	X	X	X
Spring Chinook	X	X	X	X	X
Winter Steelhead	X	X	X	X	X
Summer Steelhead	X	X	X	X	X
Coho	X	X	X	X	X
Pacific Lamprey	X	X	X		
Bald Eagle	X	X	X		
CWT Deer	X	X[4]	X		
Green Sturgeon		X	X		
White Sturgeon		X	X	X	X
Species of Ecological Significance					
N. Pikeminnow		X		X[8]	X
Shad		X[7]		X	X
River Otter		X[9]			
Eulachon		X	X	X	X
Caspian Tern		X[6]		X	
Osprey		X			
Yellow Warbler		X[10]			
Red-eyed Vireo		X[10]			
Species of Management Interest					
Dusky Canada Goose				X[5]	
Sandhill Crane	X			X[5]	
Species of Recreational Significance					
Walleye		X[7]			X
Smallmouth Bass		X[7]			X
Channel Catfish		X[7]			X

1 May be positive or negative ecological impact; this column only indicates relative significance.
2 May be positive or negative economic impact; this column only indicates relative significance.
3Active recreation potential (e.g., harvest).
4 Likely ecologically important historically.
5 Seasonal crop damage.
6 Historically not present in estuary.
7 Non-native species.
8 Some economic importance for control program.
9 Indicator of ecosystem health.
10 Indicator of habitat type.

Assessments

The terrestrial and aquatic asssement for the Mainstem Lower Columbia River and Columbia River Estuary subbasin takes a qualitative approach in recognition of the limits of ecosystem modeling available for these highly complex mainstem environments. For the Lower Columbia River and Columbia River Estuary, the project team completed an Estuary and Mainstem Assessment (EMA) using the most current available literature on the critical functions of the estuary and mainstem. The project team also used an expert panel of estuarine scientists

to review the "state of the science." It is worth noting that significant efforts that may further enhance this understanding are currently underway in fulfilling the Reasonable and Prudent Alternatives (RPAs) in the 2000 Biological Opinion (BiOp) and supporting the BiOp remand effort. The project team expects that information from these effort will be integrated with this plan as soon as the new information becomes available.

In upriver tributaries, models such as Ecosystem Diagnostics and Treatment (EDT) were available to compare historic conditions in the watershed to current conditions and to identify restoration and protection values in a given production area. These valuations are possible because the modeling allows for an outcome-based assessment of possible management actions. In a system such as the mainstem and estuary, this mechanism for prioritizing restoration and protection measues was not available. The science of the estuary and mainstem does not currently support such a model. Also, the inclusion of species that produce outside the subbasin would make the application of such a model, if it existed, even more difficult. Indeed, the development of an adaptive management model for systematically ranking geographic areas of the subbasin emerged from this process as a priority strategy for the region.

Although not quantitative, EMA provides a logical derivation of limiting factors and opportunities for management actions.

The subbasin assessment concludes with the development of a collection of component hypotheses – a set of key assumptions that are based on assessment data and analysis. These establish the basis for the future management plan. These are detailed in the table below.

Table ES-1-2: Mainstem and Estuary Working Hypotheses

Working Hypotheses – Estuary & Lower Columbia Mainstem	
E.H1.	Complex and dynamic interactions between physical river and oceanographic processes, as modulated by climate and human activities, affect the general features of fish and wildlife habitat in the Columbia River estuary and lower mainstem.
E.H2.	Human activities have altered how the natural processes interact, changing habitat conditions in the Columbia River estuary and lower mainstem.
E.H3.	Rates of obvious physical habitat change in the Columbia River estuary and lower mainstem have slowed in recent years; current physical and biological processes are likely still changing such that habitat conditions represent a degraded state.
E.H4.	Our current understanding of the interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem is not robust and introduces substantial uncertainty in decisions intended to benefit recovery and sustainability of natural resources.
E.H5.	Exotic species are capitalizing on the Columbia River estuary and lower mainstem habitats and they have impacted ecosystem processes and relationships.
E.H6.	Of all fish and wildlife species utilizing the Columbia River estuary and lower mainstem habitat, salmonids appear the most distressed.
E.H7.	The Columbia River estuary and lower mainstem ecosystem is critical to the expression of salmonid life history diversity and spatial structure which support population resilience and production.
E.H8.	Changes in the Columbia River estuary and lower mainstem habitat have decreased the productivity of the ecosystem and contributed to the imperiled status of salmon and steelhead.
E.H9.	Construction and operation of the Columbia River hydropower system has contributed to changes in Columbia River estuary and lower mainstem habitat conditions that have reduced salmonid population resilience and inhibited recovery.
E.H10.	Predation has always been a significant source of juvenile salmonid mortality in the lower Columbia River mainstem and estuary but habitat changes resulting from human activities

Working Hypotheses – Estuary & Lower Columbia Mainstem	
	have substantially altered predator concentration and distribution, particularly Caspian terns and northern pikeminnow.
E.H11.	Density dependent factors affect salmonid productivity in the Columbia River estuary and lower mainstem. However, the relationships of the quantity and quality of habitat in relation to the expression of life history strategies of salmonids requires further clarification.
E.H12	Habitat restoration efforts are capable of significantly improving conditions for fish and wildlife species in the Columbia River estuary and lower mainstem.

In the Western Oregon tributaries, a Qualitative Habitat Assessment (QHA) approach was applied to a subset of the aquatic focal species, with participation from local fisheries experts and representatives of the local watershed councils. QHA utilizes a Delphi approach to reach consensus among a group of experts who rate reaches in the watershed on current conditions and reference conditions, as they relate to species hypotheses developed for the focal species. In the WOTs subarea, limiting factors for coho, fall Chinook, winter steelhead, and chum salmon are universally lack of habitat diversity and lack of channel stability. Passage barriers and habitat connectivity, particularly in the lower reaches of the tributaries, also are significant threats.

The working hypotheses for the Western Oregon tributaries are included in the table below.

Table ES-1-3: Western Oregon tributaries working hypotheses

Working Hypotheses – Western Oregon Tributaries	
W.H1	If habitat diversity and channel stability in high-priority reaches of the Western Oregon tributaries subarea are protected and restored, salmonids production and abundance will increase.
W.H2	If n-type coho are promoted and restored to the Western Oregon tributaries subarea, then population diversity in the coastal range emographically independent populations (DIPs) will improve.
W.H3.	If habitat diversity is restored in the lower reaches of the Lewis and Clark River, spawning and rearing of all salmonid populations will improve.
W.H4.	If geomorphic behavior of channels in the lower reaches of the Youngs River is restored, and connectivity to the floodplains and estuary is enhanced, spawning and rearing of salmonids will improve.
W.H5.	If access to productive habitat above the Big Creek hatchery is improved and if concerns about disease transmittal at the hatchery can be addressed., the spatial structure of salmonid populations in the coastal DIPs will improve and productivity of coho, steelhead, and Chinook populations will increase.
W.H6.	If habitat diversity and channel stability are restored in the lower reaches of the Klaskanine River, chum spawning and summer rearing opportunities for Steelhead will improve.
W.H7.	If protection measures are applied to key reaches of the Clatskanie River and if channelization, habitat diversity, and water quality attributes are mitigated in its lower reaches, the population and abundance of salmonids, including chum, coho and winter steelhead, will improve.
W.H8.	Habitat conditions in Scappoose Bay are impaired throughout the watershed, and significant impacts in the lower reaches have been observed due to channelization and diking. Protection of the south end of Scappoose Bay should be a priority, as it is one of the few remaining relatively intact portions of the lowland floodplain portion of the watershed; restoration opportunities in Jackson Creek and Joy Creek are possible means of improving habitat conditions; Artficial and natural barriers to fish passage limit access to potentially

Working Hypotheses – Western Oregon Tributaries
productive habitat.

Management Plan

This management plan builds on information in the assessment and inventory, articulates the subbasin vision and values and examines four major areas of emphasis: working hypotheses, limiting factors, objectives (biological and physical) and strategies.

The vision statement and supporting statements for the management plan were formulated by the Planning Group through a collaborative effort. The vision statement is as follows:

Vision: Fish and wildlife resources and their habitats are maintained at healthy levels; clean, safe water is available for people, fish and wildlife. The lower Columbia River and estuary nourish all communities.

Together with the supporting statements, the vision statement establishes an approach to management based on protection, enhancement, and restoration of habitats; stewardship of natural resources; coordination with other planning efforts; development of a scientific foundation; and providing information to the interested public.

Working hypotheses, limiting factors, objectives (biological and physical) and strategies areas are examined at a species level for each of our focal species and also other species of interest (ecological interest, management interest and recreational interest). From the species level, this information was compiled and synthesized for use in decision making. The information from focal species provides a foundation for the management plan, supplemented with information from other identified species of interest and from information acquired through the assessment process for the Western Oregon tributaries subarea.

This compilation and synthesis is included in the management plan; the species-level information is included with the management plan supplement.

Limiting Factors

The limiting factors section includes all the limiting factors from all of the subbasin focal and non-focal species. The section also includes the applicable species and (for aquatic species) life stage or stages affected. The synthesis eliminates duplication and identifies common limiting factors among the species. The result is 39 limiting factors for focal aquatic species, 11 limiting factors for non-focal aquatic species and 12 limiting factors for focal terrestrial species.

The most common themes among limiting factors include impaired habitat connectivity, lack of refugia and resting areas, predation, interaction between species and contaminants. For salmon producing in the estuary and mainstem (chum salmon and fall Chinook) access to spawning habitat and dewatering of redds due to flows and operations at Bonneville Dam pose significant threats.

Biological and physical objectives

The biological objectives (or desired future conditions) were formulated, when possible, to support value statements for each species. The physical objectives were formulated to address limiting factors and then used in evaluating strategies.

The summary of physical objectives is compiled from each of the species-specific sections included in the Management Plan Supplement (Chapter 5). These have been synthesized to eliminate duplication and identify common objectives among the species. From this effort, we have a total of 33 physical objectives.

In the management plan, the physical objectives summary includes species-specific working hypotheses and applicable species life stages. Each of these has been evaluated by: 1) the level of difficulty of addressing objectives, 2) potential benefit and 3) degree of certainty with which these qualitative judgements are applied.

The project's technical staff conducted the initial evaluation, which was then amended or verified based on reviews by species experts and Planning Group members. The evaluation uses the qualitative terms of "High," "Medium" and "Low" to provide a relative benefit of each identified physical objective.

The physical objectives and the species to which they apply are included in the Table ES -4.

Table ES-4: Physical Objectives for Mainstem Lower Columbia River and Columbia River Estuary Focal Aquatic Species (W=generated out of Western Oregon tributaries assessment)

	Fall Chinook	Spring Chinook	Chum	Coho	Summer Steelhead	Winter Steelhead	White Sturgeon	Pacific Lamprey	Bald Eagle	Columbian White-tailed Deer	Ecological Interest	Management Interest	Recreational Interest
PO1. Protect existing rearing and spawning habitat to ensure no further net degradation.	X	X	X	X	X	X	X				X		
PO2. Increase shallow water peripheral and side-channel habitats toward historic levels.	X		X										
PO3. Restore connectivity between tributary deltas and the estuary, the river and the floodplain, as well as in-river habitats.	X	X	X	X	X	X				X			
PO4. Reduce predation mortality on emigrating salmonid juveniles and migrating adults, developing sturgeon embryos and migrating Pacific lamprey adults.	X	X	X	X	X	X	X	X			X		
PO5. Reduce contaminant exposure of emigrating salmonid and Pacific lamprey juveniles and sturgeon eggs and juveniles.	X	X	X	X	X	X	X	X	X		X		
PO6. Document the interactions between emigrating salmonid juveniles, white sturgeon and Pacific lamprey adults and juveniles and introduced species; minimize negative interactions.	X	X	X	X	X	X	X	X			X		X
PO7. Develop an understanding of emigrating salmonid juvenile life history diversity and habitat use, white sturgeon spawning habitat characteristics and Pacific lamprey use in the lower mainstem, the Western Oregon tributaries, the estuary and the plume.	X	X	X	X	X	X	X	X			X		X
PO8. Evaluate/improve survival of upriver juvenile salmonids emigrating via barge or dam passage.	X	X		X	X	X							

	Fall Chinook	Spring Chinook	Chum	Coho	Summer Steelhead	Winter Steelhead	White Sturgeon	Pacific Lamprey	Bald Eagle	Columbian White-tailed Deer	Ecological Interest	Management Interest	Recreational Interest
PO9. Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (All 12 months depending on species/life stage.)	X	X	X	X	X	X							
PO10. Avoid dredging mortality.							X	X			X		
PO11. Develop an understanding of white sturgeon and Pacific lamprey juvenile and adult habitat use in the lower mainstem, the Western Oregon tributaries, the estuary and the plume.							X	X			X		
PO12. Protect population from overexploitation.							X	X					
PO13. Avoid incidental operations and maintenance mortality at Bonneville Dam.							X						
PO14. Restore spring peak flows in the lower Columbia River.								X			X		
PO15. Improve dam passage.								X			X		
PO16. Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery-derived stocks.													
PO17. Eliminate or mitigate access barriers for migrating adults, creating additional spawning and rearing habitat.	W			W		W							
PO18. Seek methods for restoring historic run timing to coastal stratum, including the Western Oregon tributaries.	W			W									
PO19. Restore spawning and rearing habitat in the Western Oregon tributaries.				W									
PO20. Protect existing over-wintering habitat to ensure no future net degradation.												X	

	Fall Chinook	Spring Chinook	Chum	Coho	Summer Steelhead	Winter Steelhead	White Sturgeon	Pacific Lamprey	Bald Eagle	Columbian White-tailed Deer	Ecological Interest	Management Interest	Recreational Interest
PO21. Encourage use of public lands over private lands.												X	
PO22. Increase the availability of habitat on public lands.												X	
PO23. Limit crop depredation.												X	
PO24. Manage populations to maintain or decrease current level of abundance.													X
PO25. Encourage breeding colony distribution among multiple breeding sites, preferably in locations where non-salmonid food sources are plentiful.										X		X	
PO26. Protect existing foraging habitat to ensure no further net degradation.									X	X			
PO27. Increase forested areas in lowlands and floodplain with hardwood and some coniferous riparian species.										X	X		
PO28. Increase availability of habitat including pasture and woodlots.										X			
PO29. Artificially reintroduce deer.										X			
PO30. Minimize disturbance during breeding and rearing season.										X			
PO31. Identify and protect existing nesting and foraging areas to ensure no population declines.													
PO32. Continue to reduce, monitor and understand contaminant sources in the Lower Columbia River									X		X		
PO33. Reduce threats from physical hazards and persecution									X		X		

Strategies

As with the limiting factors and objectives, the subbasin project team compiled all of the species-specific strategies, then combined them where commonalities existed to form a single set of master strategies for the subbasins. Each of these was further examined to identify and articulate the relationships to the biological objectives outlined in the previous chapter.

At the direction of the Planning Group, the subbasin-wide strategies were reviewed based on their:

- ability to address key objectives
- relationship to ESA
- relationship to focal species of the subbasin
- socio-economic considerations as stated in the vision

Through this synthesis, the project team has identified 23 strategies covering aquatic focal species, species of interest, terrestrial species and the Western Oregon tributary subbasin.

The Planning Group established an upper tier of strategies based on the criteria above. Eight strategies rise to an upper tier through their extensive coverage of physical objectives and emphasis on socio-economic priorities. These strategies include:

Strategy 1: Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Strategy 2: Strive to understand, protect, and restore habitat-forming processes in the Columbia River Columbia River lower mainstem, Western Oregon tributaries, estuary and plume.

Strategy 3: Avoid large-scale habitat changes where risks to salmonids, white sturgeon and Pacific lamprey are uncertain.

Strategy 4: Mitigate small-scale local habitat impacts such that no net loss occurs.

Strategy 10: Our understanding the relationships between salmonids, white sturgeon, Pacific lamprey and the lower mainstem, Western Oregon tributaries, estuary and the plume ecosystems needs to be improved.

Strategy 11: Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Strategy 23: Assess the mainstem lower Columbia River and the Columbia River estuary by discreet geographic reaches for restoration and protection priorities, and develop approach for determining expected outcomes of research, monitoring and evaluation activities.

Strategy 15: Manage Columbia River fisheries at sustainable levels, maintaining a viable population through adequate spawner abundance and directing harvest away from depressed stocks.

The other strategies include:

Strategy 5: Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Strategy 6: Utilize a combination of active and passive habitat restoration measures to provide near-term and long-term benefits.

Strategy 7: Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Strategy 8: Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introduced species.

Strategy 9: As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Strategy 12: Limit the effects of toxic contaminants in the Columbia River estuary, lower mainstem and nearshore ocean.

Strategy 13: Evaluate the level of predation mortality during the embryo and juvenile life states to determine the extent of predation related recruitment failure for white sturgeon and during juvenile and adult migration of Pacific lamprey.

Strategy 14: Avoid incidental mortality of embryos and juveniles during dredging operations.

Strategy 16: Avoid incidental operations and maintenance mortality at Bonneville Dam.

Strategy 17: Evaluate and improve downstream and upstream lamprey passage conditions at mainstem and tributary dams. In doing so, ensuring no negative effects on salmonid passage.

Strategy 18: Open access to productive habitat by removing or mitigating passage barriers.

Strategy 19: Promote management actions that support sufficient life-history diversity to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes.

Strategy 20: Protect and restore habitat diversity and channel stability attributes in Western Oregon tributaries to complement salmonid life-history requirements.

Strategy 21: Minimize physical crop losses and economic effects from lost agricultural production.

Strategy 22: Investigate and minimize competition among shad and ESA-listed salmonids.

Strategy 23: Assess the mainstem lower Columbia River and the Columbia River estuary by discrete geographic reaches for restoration and protection priorities, and develop approach for determining expected outcomes of RM&E activities.

Measures

The project team identified measures and activities that may be pursued to implement strategies identified in this chapter. Measures were detailed on a species-specific basis in the Management Plan Supplement (Chapter 5) then compiled and synthesized to support the broad biological and physical objectives. The measures are not prioritized.

Research Monitoring and Evaluation

The Planning Group recognizes that in this subbasin planning area, RM&E planning efforts from a variety of entities are responding to an array of court-mandated or Northwest-Power-Planning-Act- inspired management and recovery plans. The RM&E efforts discussed in this plan are intended to defer to and complement the progress of these evolving planning activities.

RM&E efforts developed specifically to implement this subbasin plan are included as part of the LCFRB Lower Columbia Salmon and Steelhead Recovery and Subbasin Plan Chapter 8, Monitoring and Research, May 2004. It is expected that this along with the substantial ongoing RM&E planning efforts can be used to assist in evaluating this plan's strategies and measures.

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ACRONYMS

303d list	State of Washington's list of impaired water bodies
AABM	abundance-based management agreements
ACOE	US Army Corps of Engineers
ADFG	Alaska Department of Fish and Game
AEQ	adult equivalent
ARP	aggregate recovery percentage
ATV	all terrain vehicle
BBS	Breeding Bird Survey
BC	British Columbia
BCWD	bacterial cold water disease
B-IBI	Benthic Index of Biotic Integrity
BKD	bacterial kidney disease
BMPs	Best Management Practices
BPA	Bonneville Power Administration
BPH	Bonneville Pool Hatchery
BRT	Biological Review Team
C&S fisheries	commercial and subsistence fisheries
CBFWA	Columbia Basin Fish and Wildlife Authority
CCC	ESA-listed (1998) central California coast coho
CCD	Cowlitz Conservation District
CCD/WCD	Cowlitz and Wahkiakum Conservation District
CDFG	California Department of Fish and Game
CFD	computational fluid dynamics
CFFCF	Cowlitz Falls Fish Collection Facility
CPUE	catch per unit of effort
CRFMP	Columbia River Fish Management Plan
CRITFC	Columbia River Inter-Tribal Fish Commission
CRRL	Columbia River Research Lab
CWT	coded-wire tag
DART	data access real time
DD	degree days
DDAC	didecyldimethylammonium chloride
DDE	dichloro-diphenyl-ethane

ACRONYMS (CONTINUED)

DDT	dichloro-diphenyl-trichlorethane
DFO	Department of Fisheries and Oceans of Canada
DIPs	demographically independent population
DNR	Washington Department of Natural Resources
DO	dissolved oxygen
DPS	distinct population segment
EA	environmental assessment
EDT	ecosystem diagnosis and treatment
ENSO	El Nino Southern Oscillation Index
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
ETM	Estuary Turbidity Maximum
FERC	Federal Energy Regulatory Commission
FGE	fish guidance efficiency
FHC	Fish Health Center
FL	fork length
FMMPA	Federal Marine Mammal Protection Act
FMP	Fish Management Plan
GDU	genetic diversity unit
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IFIM	Instream Flow Incremental Methodology
IFMP	Integrated Fisheries Management Plan
IHNV	Infectious Hematopoeitic Necrosis Virus
IMA	Interim Management Agreement
INPFC	International North Pacific Fisheries Commission
IPC	Idaho Power Company
ISBM	individual stock base management
LC50	Lethal Concentrate 50
LCN	lower Columbia natural
LFA	Limiting Factors Analysis
LOA	Letter of Agreement negotiated as part of the Pacific Salmon Treaty
LRH	lower river hatchery

ACRONYMS (CONTINUED)

LRW	lower river wild
LWD	large woody debris
MCB	mid-Columbia bright
MMOP	Marine Mammal Observer Program
MSY	maximum sustainable yield
mtDNA	mitochondrial deoxyribose nucleic acid
NBS	National Biological Service
NF	National Forest
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NOAA	Fisheries Division of National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council (formerly Northwest Power Planning Council)
NPMP	Northern Pikeminnow Management Plan
NPPC	Northwest Power Planning Council, now called Northwest Power and Conservation Council
NRC	Natural Resource Council
NRCS	Natural Resources Conservation Service
NTU	nephelometric turbidity unit
OC	Oregon coast
OCN	ESA-listed (1998) Oregon coast coho
OCNL	Oregon coastal natural lake
OCNR	Oregon coastal natural river
ODFW	Oregon Department of Fish and Wildlife
OFC	Oregon Fish Commission
OFWC	Oregon Fish and Wildlife Commission
OPI	Oregon Production Index
OPIA	Oregon Production Index Area
OPIH	Oregon Production Index Hatchery
OSY	optimum sustained yield
PCB	polychlorienated biphenyls
PDO	Pacific Decadal Oscillation
PFC	Properly Functioning Condition
PFMC	Pacific Fisheries Management Council

ACRONYMS (CONTINUED)

PIT	passive integrated transponder
PNFHPC	Pacific Northwest Fish Health Protection Committee
PNRBC	Pacific Northwest River Basins Commission
PRIH	private hatchery
PSC	Pacific Salmon Commission
PSMFC	Pacific States Marine Fishery Commission
PST	Pacific Salmon Treaty
PSTRT	Puget Sound Technical Recovery Team
PUD	Public Utility District
RCW	Revised Code of Washington
REAP	Regional Ecosystem Assessment Project
RKm	river kilometer
RM	river mile
SAFE	Select Area Fishery Enhancement
SAS	Salmon Advisory Subpanel
SaSi	Salmonid Stock Inventory
SASSI	Salmon and Steelhead Stock Inventory
SCH	Spring Creek Hatchery
SCTC	Salmon Culture Technology Center
SF	square foot
SFMP	Salmon Fishery Management Plan
SMTF	Sturgeon Management Task Force
SONC	Southern Oregon/Northern California
SRS	sediment retention structure
SSHIAP	Salmon and Steelhead Habitat Inventory and Assessment
STEP	Salmon Trout Enhancement Program
STT	Salmon Technical Team
T	temperature
TAG	Technical Advisory Group
TDG	total dissolved gases
TL	total length
TMDL	total maximum daily load
TRT	Technical Recovery Team
TSS	total suspended solid

ACRONYMS (CONTINUED)

TU	thermal units
UCD	Underwood Conservation District
UCM	unit characteristic method
UPGMA	unweighted pair group method with arithmatic mean
URB	upriver bright
US	United States
USDOC	U.S. Department of Commerce
USFS	US Forest Service
USFWS	US Fish and Wildife Service
USGS	United States Geologic Survey
USWFS	United States Fish and Wildife Service
VSP	viable salmonid population
WA/OR	Washington/Oregon
WAC	Washington Administrative Code
WAU	Watershed Administrative Unit
WCC	Washington Conservation Commission
WCD	Wahkiakum Conservation District
WDF	Washington Department of Fisheries
WDFG	Washington Department of Fish and Game
WDFW	Washington Department of Fish and Wildlife
WDG	Washington Department of Game
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WDW	Washington Department of Wildlife
WFC	Washington Fish Commission
WQRP	Water Quality Restoration Plan
WRCC	Western Regional Climate Center
WRIA	Water Resource Inventory Area
WSCC	Washington State Conservation Commission
YIN	Yakama Indian Nation
YOY	young of the year

1. INTRODUCTION AND OVERVIEW

This plan covers two subbasin: the Columbia River Estuary subbasin and the Mainstem Lower Columbia subbasin. The subbasin plan has five chapters and three appendies. These include:

- Chapter 1 Introduction
- Chapter 2 Assessment
- Chapter 3 Inventory
- Chapter 4 Management Plan
- Chapter 5 Management Plan Supplement
- Appendix A: Species Technical foundation (Assessment)
- Appendix B: Willamette/Lower Columbia Technical Review Team population identification information for the Western Oregon tributaries
- Appendix C: Lower Columbia Fish Recovery Board Programs Inventory

Planning entity

The Northwest Power Act of 1980 directs the Northwest Power Planning Council (Council) to develop a program to protect, mitigate, and enhance fish and wildlife of the Columbia River Basin and make annual funding recommendations to the Bonneville Power Administration (Bonneville) for projects to implement the program. Subbasin plans will contain the strategies that drive the implementation of the Council's Fish and Wildlife Program at the subbasin level.

Because the mainstem Lower Columbia River and Lower Columbia River Estuary subbasins share many of the same issues, and include many of the same agency representatives with the charge to address these issues, this plan combines both geographic areas for efficiency in coordination.

The lead agency identified by Oregon for the Mainstem Lower Columbia and Lower Columbia River Estuary is the Lower Columbia River Estuary Partnership (Estuary Partnership). To ensure coordination of the bi-state effort and integrated planning, the Estuary Partnership worked closely with the Washington Lower Columbia Fish Recovery Board (LCFRB), the lead entity for these subbasins in Washington.

Participants

At the project's outset, the project team organized a Planning Group to monitor all aspects of the plan and recommend technical and sub-group work as needed. This Planning Group assisted in the development of all plan elements including the vision, objectives and strategies. It also directed technical review and public involvement efforts. The Planning Group met nine times throughout the process. It includes many of the LCREP Board members directly involved with developing and implementing related planning efforts, including federal, state and local government representatives as well as other interests.

The project's Planning Group includes representatives of:

- Lower Columbia Fish Recovery Board
- NOAA Fisheries
- Lower Columbia Estuary Partnership
- Fish & Wildlife (U.S., Oregon, Washington)
- Bonneville Power Administration
- Army Corps of Engineers
- City of Portland
- Clatsop County
- Economic Development Commission
- States (Oregon, Washington)
- Columbia River Inter-Tribal Fish Commission

Planning group participants have included:

- The Blaine Ebberts, U.S. Army Corps of Engineers
- Cathy Tortorici, National Oceanic & Atmospheric Administration
- Cedric Cooney, ODF&W (Oregon Technical Support)
- Dave Ward, Oregon Department of Fish &Wildlife
- Debrah Marriott, Lower Columbia River Estuary Partnership
- Gustavo Bisbal, U.S. Fish & Wildlife Service
- Jeff Breckel, Lower Columbia Fish Recovery Board
- Jessica Wilcox, Bonneville Power Administration
- Jim Middaugh, City of Portland
- Jim Owens, Oregon Coordinating Group (Tier II)
- John Marsh, Parametrix
- Lee Van Tussenbrook, Washington Department of Fish & Wildlife
- Matt Van Ess, Columbia River Estuarine Task Force
- Patty Dornbusch, National Oceanic & Atmospheric Administration
- Paul Lumley, Columbia Intertribal Fish Commission
- Phil Miller, Washington Governor's Office
- Phil Trask, Lower Columbia Fish Recovery Board
- Rhon Rhew, U.S. Fish & Wildlife Service
- Rick Bastasch,Willamette Restoration Initiative
- Taunja Berquam, U.S. Army Corps of Engineers
- Todd Jones, CEDC Fisheries
- Tom Byler, Oregon Governor's Office
- Phil Rogers, Columbia River Intertribal Fish Comission

- Tony Grover, Northwest Planning and Conservation Council (Tier II)

Stakeholder and Public involvement

The project team conducted this planning effort in an open, public process including the participation of a wide range of state, federal, and tribal governments, local managers, fish and wildlife managers, land and water resources managers, landowners, local governments, interest groups and other stakeholders.

The participation structure ensured that known interests have had opportunities for involvement and that other interests could become involved as well. The project team expects that this transparency will continue through the ISRP, Tier II and NPCC reviews and the adoption process.

Stakeholder interviews early in the process helped identified interests for involvement on the Planning Group. Further outreach included open houses, presentations, workshops, and electronic notifications sent to a broad list acquired from CBFWA and an interested parties list developed throughout this project.

In Oregon, open houses were held in Astoria, St. Helens and Portland in September, 2003. In Washington the open houses were held in Longview, Cathlamet, Stevenson and Vancouver (2). Washington hosted a spring, 2004, series of workshops as well. Additionally, the project team gave presentations in late 2004 to the Lower Columbia-Clatskanie Watershed Association and the Nicolia-Wickiup watershed Council. (An early June, 2004, presentation to the Clatsop County Board of Commissioners is also scheduled.) Also as part of the Western Oregon tributaries analysis, the project team hosted workshops in Clackamas, Astoria and with watershed council representatives and ODFW staff.

Overall Approach

The purpose of the subbasin planning process is to conduct a thorough scientific assessment, define a vision and goals for fish, wildlife, and habitat in the Lower Mainstem Columbia and Estuary Subbasins, define objectives that measure progress toward those goals, and establish strategies to meet objectives.

The plan will be used by National Marine Fisheries Service (NOAA Fisheries) and US Fish and Wildlife Services (USFWS) to aid recovery planning for species listed under the Endangered Species Act and will be evaluated for consistency with the Clean Water Act, federal treaty and trust responsibilities with the basin Native American Tribes, and the Council's 2000 Fish and Wildlife Program. The plan also will incorporate the goals and actions of the FCRPS Biological Opinion issued by the NOAA Fisheries.

Because they are at the river's end, these subbasins are unique from all of the other subbasins and present unique challenges. As such, NPCC guidance did not apply or could not be used in many cases. In upriver tributaries, models--such as Ecosystem Diagnostics and Treatment (EDT)--were available to compare historic conditions in the watershed to current conditions and to identify restoration and protection values in a given production area. These valuations are possible because the modeling allows for an outcome-based assessment of possible management actions. In a system such as the mainstem and estuary, this mechanism for prioritizing restoration and protection measues was not available. The science of the estuary and mainstem does not currently support such a model. Also, the inclusion of species that produce outside the subbasin would make the application of such a model, if it existed, even more

difficult. Indeed, the development of an adaptive management model for systematically ranking geographic areas of the subbasin emerged from this process as a priority strategy for the region.

The Mainstem Lower Columbia River and Columbia River Estuary subbasin plan utilizes a qualitative approach in recognition of the limits of ecosystem modeling available for these highly complex mainstem environments. We structured the qualitative assessment and subsequent management planning effort to meet the intent of Council guidance, with major elements that parallel other subbasin plans. In doing so, the project team attempted to formally articulate the links between the elements of this plan whenever possible and provide transparency to the logic supporting such links.

Organization and Coordination: Two States, Two Subbasins, One Plan.

The planning process in the Mainstem Lower Columbia River and Columbia River Estuary subbasin involves a number of federal and state agencies, and regional organizations, and managed primarily by the lead entities: the Lower Columbia River Estuary Partnership (LCREP) in partnership with the Lower Columbia fish Recovery Board (LCFRB).

The Mainstem Lower Columbia and Columbia River Estuary subbasins fall within the jurisdictions of both Oregon and Washington and encompass nearly the same geographic area covered by the LCREP. The Estuary Partnership is a two-state, public/private partnership that has developed a management plan for the lower 146 miles of the Columbia River and which has a board of directors comprised of individuals and interests from both states. The Estuary Partnership works to restore habitat, provide education and information and eliminate pollution from the lower river. It was asked by the Governors of Washington and Oregon to coordinate a policy-level committee of federal and state partners to address efforts to recover threatened and endangered species. In developing its own management plan, the Estuary Partnership used an extensive process to involved stakeholders, constituents and members of the public from both states and all other jurisdictions within its study area. This effort also capitalizes on the LCREP organizational framework. It also utilizes information and involvement opportunities presented by LCFRB's ongoing recovery planning efforts.

The Oregon and Washington Coordinating (Level II) Groups have agreed to combine the two subbasins and to develop one plan that covers both subbasins. In addition, as noted, the geography of the two subbasins aligns closely with the area within the Estuary Partnership study area. The Estuary Partnership aimed to use the same two-state integrated approach to developing the plan that it employs in all its work and organizational structure.

For purposes of subbasin planning, the study area ends at the confluence of tributaries, The Columbia River for tributaries that are part of other subbasins and subbasin processes. The exception to this rule covers tributaries, or sub-areas, that are not otherwise being addressed in separate subbasin planning processes. These included the Western-most Oregon tributaries. In addressing these tributaries, the plan will be specific to particular salmon populations. In these sub-areas, the planning processes included subcommittees formed to work specific tributaries.

Coordination with the Lower Columbia River Fish Recovery Board.

Because of the relationship with Washington planning efforts and the overlap in jurisdictions and ecosystems, the Estuary Partnership worked closely and directly with the LCFRB. The Lower Columbia Fish Recovery Board has served as the lead entity for nine additional subbasin planning processes in Washington along with the Lower Columbia River and Columbia Estuary subbasins. The LCFRB led the assessment-development effort, provided

inventory-related information and expertise along with funding to the Estuary Partnership for development of this two-subbasin plan.

Additionally, the Estuary Partnership and the LCFRB coordinated efforts and hosted stakeholder and public meetings and other events as appropriate. Staff and consultants from both organizations worked closely throughout the planning processes.

Decision structure

At the project's outset, an infrastructure for product development and decision-making was designed including a planning group, technical advisory groups and subcommittees.

Planning Group--The Planning Group monitored all aspects of the plan and recommended technical and sub-group work as needed. This Planning Group assisted in the development of all plan elements including the vision, objectives and strategies. It also directed technical review and public involvement efforts. The planning group met nine times throughout the process.

Technical Advisory groups (TAC): The Estuary Partnership Science Work Group provided a pool of resources from which to draw upon for assistance with the plan's technical issues. In taking the lead on the assessment, the LCFRB enlisted it's technical resources in gathering detailed information about the estuary and mainstem ecosystems and species of interest. The project team used these technical resources extensively for the development and review of the management plan sections.

Subcommittees—The subbasin project team also used subcommittees to address specific issues, such as the Western Oregon tributaries analysis, assessment structure development and the vision development.

Process and schedule for revising and updating the Plan

The project team expects to present this plan before the ISRP in early July and participate in the public review process during the latter half of 2004. The project team and Planning Group have recognized that the state of the science relative to ecosystem processes and salmon in the Columbia River estuary is dissimilar to that of the tributaries. In particular, the ability to model productive capacity and predict responses to management action is limited. Focused efforts currently are underway that will further define the limiting factors, research, monitoring and evaluation. Significant progress will be made in these areas during the last half of 2004 and in early 2005.

As such, this plan moves forward with assumptions about which the degree of certainty is not always high. While the assumptions in this subbasin plan are derived from currently available information, the project team expects that these will likely need adjustments as new information becomes available.

The project team has attempted, whenever possible, to develop and articulate the links between limiting factors, objectives and strategies and explain the logic behind making such links. The project team also attempted to articulate the level of certainty on which assumptions and decisions are based. This transparency should help keep this plan dynamic and allow for adjustments and plan adaptations based on more refined data and information.

2. ASSESSMENT

This chapter includes assessments for the Columbia River and Lower Mainstem (1.1) and the Western Oregon tributaries subarea (1.2). The former serves as the primary source of assessment material that informs management plan while the latter provides supplemental coverage of a "subarea" outside mainstem and estuary.

2.1 Columbia River Estuary and Lower Mainstem

This chapter describes physical processes, habitat, fish and wildlife species, and ecological relationships within the lower Columbia River mainstem (i.e. below Bonneville Dam) and estuary. A balanced and complete ecosystem-based approach was desired for this assessment, however, was not possible based on currently available data. Certain topics are discussed in far greater detail than others because of this difference in data availability. For example, the estuary is discussed in detail throughout the chapter, while specific discussions regarding the lower mainstem are not presented, simply because the data do not exist. In the same regard, considerable research has focused on salmonid species in the Columbia River while much less is known about the other species presented here.

Another necessary point of clarification is the use of the word *estuary*, which was not standardized across all previous research efforts. For the purposes of this subbasin plan, the Columbia River estuary was defined as the tidally influence portion of the Columbia River from the mouth to Bonneville Dam (rm 146) including the Columbia River plume. However, many other studies have defined the estuary differently. For example, some define the estuary upper boundary as the extent of salt water intrusion (typically Harrington Point at rm 23) while others define the upper boundary as the extent of river flow reversal (up to Oak Point at rm 53). Also, recent research suggests that the Columbia River plume environment also should be considered as part of the estuary. Thus, when presenting the work of others, *estuary* refers to the estuary boundaries described by the respective research. The reader is encouraged to review the original publication to alleviate any confusion as to which part of the estuary is being discussed. Where possible, clarification was provided to indicate if the information being presented applied to the tidal freshwater portion of the lower mainstem (i.e. rm 46-146), the lower portion of the river (rm 0-46), or the Columbia River plume.

The geographic area covered in this subbasin assessment and qualitative analysis includes the Columbia River estuary and the lower Columbia River up to Bonneville Dam (Figure 2-1, Figure 2-2, and Figure 2-3); the major tributaries are not included in this analysis as they have been designated as subbasins by the Northwest Power and Conservation Council (NPCC) and are addressed separately in this Technical Foundation. The description and analysis, however, focuses on the Columbia River estuary by default; far more research to date has focused on the estuary and not the tidal freshwater portion of the lower mainstem. Where possible, data specific to the lower Columbia River mainstem were included; elsewhere, assumptions were made as to whether the habitat conditions, habitat-forming processes, and species-habitat interactions in the estuary also were applicable to the lower Columbia River mainstem.

Figure 2-1. Large-scale map of the lower Columbia River mainstem and estuary, depicting major tributaries and population centers (R2 2003).

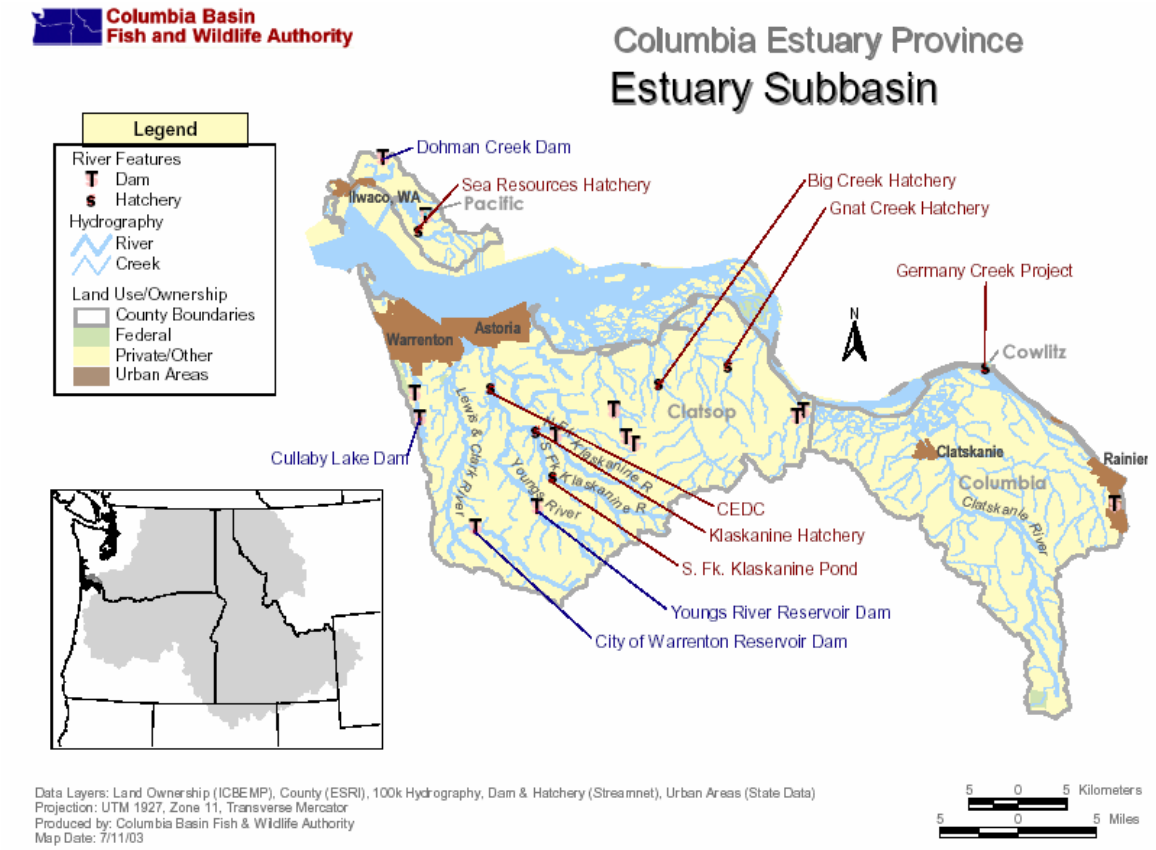


Figure 2-2. Boundaries of the Columbia Estuary Subbasin as defined by the Northwest Power and Conservation Council.

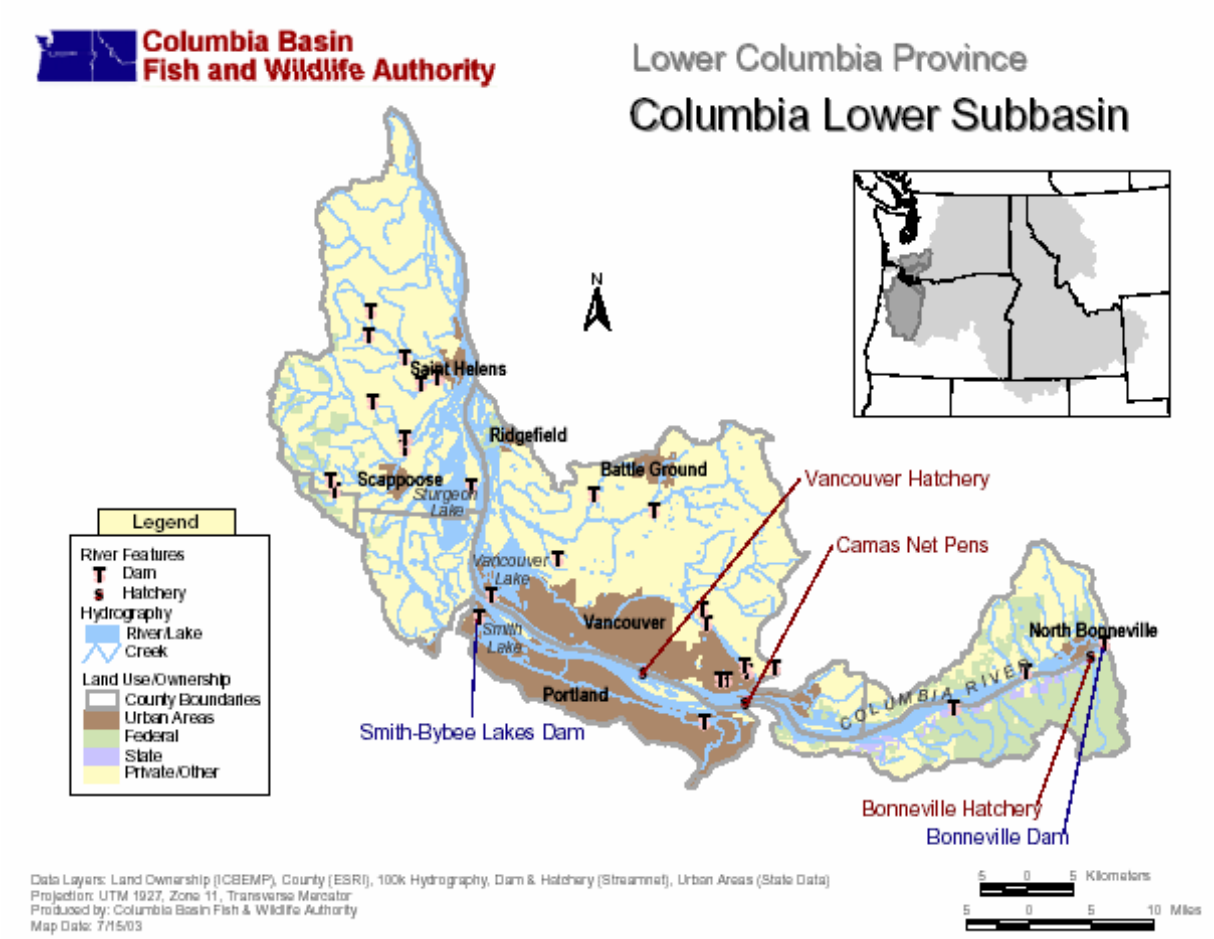


Figure 2-3. Boundaries of the Lower Columbia Subbasin as defined by the Northwest Power and Conservation Council.

This section is organized into the following subsections:

2.1.1Subbasin Description; 2.1.2 Focal Species; 2.1.3

Habitat; 2.1.4 Species/Habitat Interactions; 2.1.5 Ecological Relationships; 2.1.6 Knowledge Gaps; 2.1.7. Hypothesis Statements.

Subbasin Description, provides the context for the subbasin assessment as well as an overview of the physical setting, fish and wildlife resources, and habitats in the lower Columbia River mainstem and estuary subbasin.

Section 2.1.2, Focal Species, describes the selection process for identifying focal species and provides a brief description of each species status and abundance trends as well as life history as it relates to the potential use of lower mainstem and estuary habitats. Section 2.1.3,

Habitat, discusses the physical processes that create habitats in the lower mainstem and estuary, identifies the natural and anthropogenic factors that have affected habitat change in the lower mainstem and estuary, and compares the historical and modern day acreage of specific habitat types. Section 2.1.4, Species/Habitat Interactions, presents the association of focal species with lower mainstem and estuary habitats. Further, this section discusses potential relationships between lower mainstem and estuary habitat change and focal species, particularly salmonids. Section 2.1.5, Ecological Relationships briefly discusses potential ecological interactions among native and exotic species in the Columbia River estuary and lower mainstem. Section 2.1.6, Knowledge Gaps, identifies and prioritizes critical areas where we lack adequate understanding of linkages between lower mainstem and estuary habitats and focal species. The section also acknowledges the on-going development of tools designed to describe physical and biological processes in the estuary. Finally, Section 2.1.7, Hypothesis Statements presents a series of hypotheses that are intended to summarize our current knowledge of estuary processes, habitat condition, and focal species. Collectively, the hypotheses constitute the working hypothesis of the subbasin assessment as defined by the Northwest Power Planning Council (2001).

2.1.1 *Subbasin Description*

Section 2.1.1.1, "Purpose" describes the purpose of this subbasin assessment in the context of the Northwest Power and Conservation Council (NPCC; formerly Northwest Power Planning Council) subbasin planning process and how the chapter integrates with the Washington Lower Columbia River Fish Recovery Plan Technical Foundation.

Section 2.1.1.2, "History" provides a brief description of the rich history of the subbasins.

Section 2.1.1.3, "Physical Setting describes the general physical of the subbasins.

Section 2.1.1.4, "Fish and Wildlife Resources" provides a species list of the fish and wildlife species known to occur in the subbasins.

Section 2.1.1.5, "Habitat Classification". describes estuary and mainstem habitat types, the abundance of habitat classification systems available to describe habitat, the habitat classification systems utilized in this analysis, and the potential relationship among each habitat classification system.

Section 2.1.1.6, "Estuary and Lower Mainstem Zones" describes geographic estuary and mainstem areas utilized to facilitate subsequent discussions of habitat change.

Section 2.1.1.7, "Major Land Uses" identifies the variety of human activities that occur within the subbasins.

Section 2.1.1.8, "Areas of Biological Significance" identifies areas that provide critical natural habitats and help maintain the delicate balance of the ecosystem

2.1.1.1 Purpose

This chapter serves as the principal Subbasin Assessment portion of the Lower Columbia River Estuary and Lower Mainstem Subbasins Plan. For purposes of supplementing this assessment with subarea specific information for the westernmost Oregon tributaries, an additional assessment section (2.2) completes this chapter. The Subbasin Assessment will provide an overview of the subbasins (2.1.1), describe focal species (Section 2.1.2), environmental conditions (Section 2.1.3), and ecological relationships (Sections 2.1.4 and 2.1.5), identify limiting factors (Sections 2.1.3, 2.1.4, and 2.1.6), and provide a synthesis of the

information (Section 2.1.7). The subbasin assessment will not include a complete inventory of existing activities in the lower Columbia River mainstem and estuary nor will it present a Management Plan for the subbasins; these are both additional chapters of the subbasin plan. From the perspective of subbasin planning, the most important outcome of the subbasin assessment is the development of the working hypothesis (Section 2.1.7). All of the other information presented in the assessment provides a means to that end. The working hypothesis provides a metric of our current understanding of the subbasins and serves as the link between the subbasin assessment and the management plan.

2.1.1.2 History

By the early 1800s, approximately 50,000 Native Americans (primarily the Chinooks) inhabited villages scattered along the banks of the Columbia River (Cone and Ridlington 1996, Thompson 2001). Paleological records indicate that people in the region harvested Pacific salmon as early as 9,000 years ago (Lichatowich 1999). The Chinook peoples were skilled traders and the Columbia River served as a major trade route; tribes came from inland valleys and as far away as the Great Plains to trade for salmon and other valuable resources (Thompson 2001). Estimates indicate that the Chinookan peoples harvested almost 41 million pounds of salmon annually, much of which was traded to interior tribes (Cone and Ridlington 1996).

As early as 1543, European explorers ventured along the Oregon coast, but failed to find the mouth of the Columbia River. Finally, in 1792, Captain Robert Gray of the United States sailed across the bar at the mouth of the river and explored the vicinity of Astoria. Later, William Robert Broughton, a Spanish lieutenant, mapped and named many features of the lower Columbia River as far upriver as the Portland area (Miller 1958).

In 1803, Meriwether Lewis and William Clark began an expedition in St. Louis with the intent of finding a trade route across the continent to the Orient. By 1805, the expedition reached the lower Columbia River, making contact with the native people. After this expedition, European settlement in the region advanced rapidly; the Hudson Bay Company played a substantial role in establishing trade with the native people. In 1840, ‘Oregon Fever’ brought many settlers from the midwest; timber and fisheries became the driving forces behind European settlement of the region.

Earliest accounts of European exploitation of salmon date around 1830, when salmon were dried and salted for storage and distribution. The salmon industry began to realize its full potential when the first cannery began operating in Eagle Cliff, WA, in 1867. Many other canneries began operating over the next decade and by 1883, there were 55 canneries on or near the Columbia River. Initially, chinook salmon were the primary catch, but fisheries began harvesting other salmon by the late 1800s; catch of all species peaked at 47 million pounds in 1911 (Cone and Ridlington 1996).

Introductions of exotic fish species had substantial impacts on early fisheries. For example, American shad were introduced to San Francisco in 1871; by 1903, Columbia River fisherman reported that shad had become so numerous they were a nuisance. Other species (i.e. warm-water fish such as bluegill, crappie, and bass) were becoming increasingly abundant in the lower reaches of many Columbia River tributaries and slough habitats of the lower mainstem Columbia River; these sloughs are ideal habitats for these warm water species (Fies 1971).

Concomitant to the growth of the fishing industry, the timber industry was experiencing a boom. Timber industry practices included the removal of stream debris, temporary construction

of splash dams to store timber, and log drives that flushed timber through the system as freshet flows blasted the splash dams (Farnell 1980). Although efficient and inexpensive, such practices destroyed instream and riparian habitat. Log drive practices were eliminated by 1914, but other logging practices (such as the lack of riparian buffers) continued to negatively affect fish and wildlife habitat, including that of salmonids.

Early settlers maintained farms for subsistence; initially, commercial farming was not a major industry. By the late 1800s, a substantial amount of acreage in the subbasin had been cleared of trees, burned, and converted to agricultural land; much of this land conversion was occurring in the lower Columbia River floodplain and the interior valleys. Many of these floodplain areas remain in agricultural use today.

Since the late 1800s, the US Army Corps of Engineers has been responsible for maintaining navigation safety on the Columbia River. In 1878, Congress directed the Corps to maintain a 20-foot minimum channel depth, authorizing the Columbia River navigation channel project. To maintain this channel depth, periodic dredging was required in a few shallow reaches where controlling depths ranged from 12-15 feet (USACE 1999). At the mouth of the Columbia River, construction of the south jetty began in 1885; an extension to the original south jetty began in 1903 and was completed in 1914 (Sherwood et al. 1990). Meanwhile, construction of the north jetty began in 1913 and was completed in 1917 (Sherwood et al. 1990). Additionally, use of pile dikes to assist in channel depth maintenance began in the lower Columbia River in 1885 at St. Helens Bar; other early dikes included Martin Island Bar and Walker Island Bar in 1892-93. Over time, Congress continually authorized increases to the minimum navigation channel depth and width: 1899 – depth authorized to 25 ft; 1912 – depth authorized to 30 ft, width established at 300 ft; 1930 – depth authorized to 35 ft, width authorized to 500 ft, channel course was realigned in some reaches; 1936-1957 – periodic channel alignment adjustments; 1962 – depth authorized to 40 ft; 1999 – depth authorized to 43 ft. Most of the current pile dike system was during the periods 1917-1923 and 1933-1939; the existing system consists of 256 dikes totaling 240,000 linear feet (USACE 2001).

In the early 1930s, the Columbia River was slated for development of the next major federal hydropower project; Bonneville Dam began operation in the late 1930s, affecting salmonid access to spawning habitat above Bonneville Dam. With extensive hydroelectric development, the lower Columbia River was quickly viewed as a production zone for salmon. Mitigation for the loss of habitat caused by dams came in the Mitchell Act of 1948, which created a system of hatcheries on the Columbia River. Although the some of the first hatcheries where generally unsuccessful, hatcheries were viewed as the solution to overfishing, habitat loss, and hydroelectric development.

2.1.1.3 Physical Setting

The Columbia River estuary has formed over geologic time by the forces of glaciation, volcanism, hydrology, and erosion and accretion of sediments. Circulation of sediments and nutrients throughout the estuary are driven by river hydrology and coastal oceanography. Sea levels have risen since the late Pleistocene period, which has submerged river channels and caused deposition of coarse and fine sands (Marriott et al. 2001).

The Columbia River estuary and lower mainstem span two ecological provinces as defined by the NPCC: Columbia River Estuary (river mouth, including nearshore waters and Columbia River plume, to rm 34) and the Lower Columbia River mainstem (rm 34 to Bonneville

Dam). The historical (circa 1880) total surface area of the Columbia River estuary has been estimated from 160 to 186 square miles (Thomas 1983, Simenstad et al. 1984), with extensive sand beds and variable river flow. The current estuary surface area has been estimated as 101,750 acres, which is equivalent to 159 square miles (Marriott et al. 2002). The Willamette River is the largest tributary to the lower Columbia River. Major tributaries originating in the Cascades include the Sandy River in Oregon and the Washougal, Lewis, Kalama and Cowlitz Rivers in Washington. Major Coast Range tributaries include the Elochoman and Grays Rivers in Washington and the Lewis and Clark, Youngs and Clatskanie Rivers in Oregon. Numerous other minor tributaries drain small watersheds but do not have substantial influence on the Columbia River because of their small size (Marriott et al. 2002).

In the Columbia River, tidal impacts in water level have been observed as far upstream as Bonneville Dam (RM 146) during low flow, reversal of river flow has been measured as far upstream as Oak Point (RM 53), and intrusion of salt water is typically to Harrington Point (RM 23) at the minimum regulated monthly flow, although at lower daily flows saltwater intrusion can extend past Pillar Rock (RM 28) (Neal 1972). The lowest river flows generally occur during September and October, when rainfall and snowmelt runoff are low. The highest flows occur from April to June, resulting from snowmelt runoff. High flows also occur between November and March, caused by heavy winter precipitation. The discharge at the mouth of the river ranges from 100,000 to 500,000 cfs, with an average of about 260,000 cfs. Historically, unregulated flows at the mouth ranged from 79,000 cfs to over 1 million cfs, with average flows about 273,000 cfs (Neal 1972, Marriott et al. 2002).

The estuarine shoreline in both Washington and Oregon consist primarily of rocky, forested cliffs or low elevation, gently sloping floodplain areas. The topography of the riverine portion of the two ecological provinces does not vary considerably (Marriott et al. 2001).

The climate conditions vary across the subbasins; in general, coastal areas receive more precipitation and experience cooler summer temperatures and warmer winter temperatures than inland areas. In the lower part of the subbasin, climate data has been collected in Astoria, Oregon, since 1953 (WRCC 2003). Total average annual precipitation is 68 inches, ranging from 1.04 inches in July to 10.79 inches in December. January is the coldest month in Astoria with an average maximum temperature of 48.2°F and an average minimum temperature of 36.5°F; August is the warmest month with an average maximum temperature of 68.7°F and an average minimum temperature of 52.8°F. In the middle part of the subbasin, climate conditions have been recorded at St. Helens, Oregon, since 1976 (WRCC 2003). Total average annual precipitation is 44 inches, ranging from 0.79 inches in July to 6.77 inches in December. January is the coldest month in St. Helens with an average maximum temperature of 46.9°F and an average minimum temperature of 33.5°F; August is the warmest month with an average maximum temperature of 82.7°F and an average minimum temperature of 55.6°F. In the upper part of the subbasin, climate conditions have been recorded at Bonneville Dam since 1948 (WRCC 2003). Total average annual precipitation is 77 inches, ranging from 0.90 inches in July to 12.91 inches in December. January is the coldest month at Bonneville with an average maximum temperature of 42.4°F and an average minimum temperature of 32.7°F; August is the warmest month with an average maximum temperature of 78.7°F and an average minimum temperature of 56.4°F.

2.1.1.4 Fish and Wildlife Resources

An abundance of fish and wildlife species are known to occur in the Columbia Estuary and Lower Columbia Subbasins, either as year-round residents, seasonal residents, or migratory visitors. Early species survey work in the estuary was performed for aquatic species (Gaumer et al. 1973, Bottom et al. 1984, Dawley et al. 1985), birds (Hazel 1984), mammals (Howerton et al. 1984), and marine mammals (Jeffries et al. 1984). More recently, Marriott et al. (2002) provided an excellent summary of the aquatic species, birds, mammals, reptiles, and amphibians found in the Columbia River estuary and lower mainstem. A species list adapted from Marriott et al. (2002) and IBIS (2003) has been included on the subsequent pages to demonstrate the variety of species present in the subbasins (Table 2-1).

Table 2-1. List of fish and wildlife species known to occur in the Columbia Estuary and Columbia Lower Subbasins.

Species Group	Common Name	Scientific Name
FISH	Pacific lamprey	*Lampetra tridentata*
	River lamprey	*Lampetra ayresi*
	Spiny dogfish	*Squalus acanthias*
	Big skate	*Raja binoculata*
	Green sturgeon	*Acipenser medirostris*
	White sturgeon	*Acipenser transmontanus*
	American shad	*Alosa sapidissima*
	Pacific herring	*Clupea harengus pallasi*
	Northern anchovy	*Engraulis mordax*
	Chum salmon	*Oncorhynchus keta*
	Coho salmon	*Oncorhynchus kisutch*
	Sockeye salmon	*Oncorhynchus nerka*
	Chinook salmon	*Oncorhynchus tshawytscha*
	Steelhead	*Oncorhynchus mykiss*
	Cutthroat trout	*Oncorhynchus clarki clarki*
	Mountain whitefish	*Prosopium williamsoni*
	Whitebait smelt	*Allosmerus elongates*
	Surf smelt	*Hypomesus pretiosus*
	Night smelt	*Spirinchus starksi*
	Longfin smelt	*Spirinchus thaleichthys*
	Eulachon	*Thaleichthys pacificus*
	Common carp	*Cyprinus carpio*
	Peamouth	*Mylocheilus caurinus*
	Northern pikeminnow	*Ptychocheilus oregonensis*
	Largescale sucker	*Catostomus macrocheilus*
	Yellow bullhead	*Ictalurus natalis*
	Brown bullhead	*Ictalurus nebulosus*
	Channel catfish	*Ictalurus punctatus*
	Pacific hake	*Merluccius productus*
	Pacific tomcod	*Microgadus proximus*
	Walleye Pollock	*Theragra chalcogramma*
	Threespine stickleback	*Gasterosteus aculeatus*
	Bay pipefish	*Syngnathus leptorhynchus*
	Pumpkinseed	*Lepomis gibbosus*
	Warmouth	*Lepomis gulosus*
	Bluegill	*Lepomis macrochirus*
	Walleye	*Stizostedium vitreum*
	Smallmouth bass	*Micropterus dolomeiui*
	Largemouth bass	*Micropterus salmoides*
	White crappie	*Pomoxis annularis*
	Black crappie	*Pomoxis migromaculatus*
	Yellow perch	*Perca flavenscens*

Species Group	Common Name	Scientific Name
	Redtail surfperch	*Amphistichus rhodoterus*
	Shiner perch	*Cymatogaster aggregata*
	Striped seaperch	*Embiotoca lateralis*
	Spotfin surfperch	*Hyperprosopon anale*
	Walleye surfperch	*Hyperprosopon argenteum*
	Silver surfperch	*Hyperprosopon ellipticum*
	White seaperch	*Phanerodon furcatus*
	Pile perch	*Rhacochilus vacca*
	Pacific sandfish	*Trichodon trichodon*
	Snake prickleback	*Lumpenus sagitta*
	Saddleback gunnel	*Pholis ornata*
	Pacific sand lance	*Ammodytes hexapterus*
	Bay goby	*Lepidogobius lepidus*
	Black rockfish	*Sebastes melanops*
	Kelp greenling	*Hexogrammus decagrammus*
	Lingcod	*Ophiodon elongatus*
	Padded sculpin	*Artedius fenestralis*
	Coastrange sculpin	*Cottus aleuticus*
	Prickly sculpin	*Cottus asper*
	Buffalo sculpin	*Enophyrs bison*
	Red Irish lord	*Hemilepidotus hemilepidotus*
	Pacific staghorn sculpin	*Leptocottus armatus*
	Cabezon	*Scorpaenichthys marmoratus*
	Warty poacher	*Ocella verrucosa*
	Tubenose poacher	*Pallasina barbata*
	Pricklebreast poacher	*Stellerina xyosterna*
	Slipskin snailfish	*Liparis fucencis*
	Showy snailfish	*Liparis pulchellus*
	Ringtail snailfish	*Liparis rutteri*
	Pacific sanddab	*Citharichthys sordidus*
	Speckled sanddab	*Citharichthys stigmaeus*
	Butter sole	*Isopsetta isolepis*
	English sole	*Parophrys vetulus*
	Starry flounder	*Platichthys stellatus*
	C-O sole	*Pleuronichthys coenosus*
	Sand sole	*Psettichthys melanostictus*
	Larval smelt	
	Larval flatfish	
	Other larval fish	
AMPHIBIANS	Northwestern Salamander	*Ambystoma gracile*
	Long-toed Salamander	*Ambystoma macrodactylum*
	Cope's Giant Salamander	*Dicamptodon copei*
	Pacific Giant Salamander	*Dicamptodon tenebrosus*

Species Group	Common Name	Scientific Name
	Columbia Torrent Salamander	*Rhyacotriton kezeri*
	Cascade Torrent Salamander	*Rhyacotriton cascadae*
	Rough-skinned Newt	*Taricha granulosa*
	Dunn's Salamander	*Plethodon dunni*
	Larch Mountain Salamander	*Plethodon larselli*
	Van Dyke's Salamander	*Plethodon vandykei*
	Western Red-backed Salamander	*Plethodon vehiculum*
	Ensatina	*Ensatina eschscholtzii*
	Clouded Salamander	*Aneides ferreus*
	Oregon Slender Salamander	*Batrachoseps wrighti*
	Tailed Frog	*Ascaphus truei*
	Western Toad	*Bufo boreas*
	Pacific Chorus (Tree) Frog	*Pseudacris regilla*
	Red-legged Frog	*Rana aurora*
AMPHIBIANS	Cascades Frog	*Rana cascadae*
	Oregon Spotted Frog	*Rana pretiosa*
	Columbia Spotted Frog	*Rana luteiventris*
	Bullfrog	*Rana catesbeiana*
BIRDS	Red-throated Loon	*Gavia stellata*
	Pacific Loon	*Gavia pacifica*
	Common Loon	*Gavia immer*
	Yellow-billed Loon	*Gavia adamsii*
	Pied-billed Grebe	*Podilymbus podiceps*
	Horned Grebe	*Podiceps auritus*
	Red-necked Grebe	*Podiceps grisegena*
	Eared Grebe	*Podiceps nigricollis*
	Western Grebe	*Aechmophorus occidentalis*
	Clark's Grebe	*Aechmophorus clarkii*
	Sooty Shearwater	*Puffinus griseus*
	Short-tailed Shearwater	*Puffinus tenuirostris*
	Fork-tailed Storm-petrel	*Oceanodroma furcata*
	Leach's Storm-petrel	*Oceanodroma leucorhoa*
	Brown Pelican	*Pelecanus occidentalis*
	Brandt's Cormorant	*Phalacrocorax penicillatus*
	Double-crested Cormorant	*Phalacrocorax auritus*
	Pelagic Cormorant	*Phalacrocorax pelagicus*
	American Bittern	*Botaurus lentiginosus*
	Great Blue Heron	*Ardea herodias*
	Great Egret	*Ardea alba*
	Cattle Egret	*Bubulcus ibis*
	Green Heron	*Butorides virescens*
	Black-crowned Night-heron	*Nycticorax nycticorax*
	Turkey Vulture	*Cathartes aura*

Species Group	Common Name	Scientific Name
	Greater White-fronted Goose	*Anser albifrons*
	Snow Goose	*Chen Ccaerulescens*
	Ross's Goose	*Chen rossii*
	Canada Goose	*Branta canadensis*
	Dusky Canada Goose	*Branta canadensis occidentalis, Baird*
	Brant	*Branta bernicla*
	Trumpeter Swan	*Cygnus buccinator*
	Tundra Swan	*Cygnus columbianus*
	Wood Duck	*Aix sponsa*
	Gadwall	*Anas strepera*
	Eurasian Wigeon	*Anas penelope*
	American Wigeon	*Anas americana*
	Mallard	*Anas platyrhynchos*
	Blue-winged Teal	*Anas discors*
	Cinnamon Teal	*Anas cyanoptera*
	Northern Shoveler	*Anas clypeata*
	Northern Pintail	*Anas acuta*
	Green-winged Teal	*Anas crecca*
	Canvasback	*Aythya valisineria*
	Redhead	*Aythya americana*
	Ring-necked Duck	*Aythya collaris*
	Greater Scaup	*Aythya marila*
	Lesser Scaup	*Aythya affinis*
	Harlequin Duck	*Histrionicus histrionicus*
	Surf Scoter	*Melanitta perspicillata*
	White-winged Scoter	*Melanitta fusca*
	Black Scoter	*Melanitta nigra*
	Long-tailed Duck	*Clangula hyemalis*
	Bufflehead	*Bucephala albeola*
	Common Goldeneye	*Bucephala clangula*
	Barrow's Goldeneye	*Bucephala islandica*
	Hooded Merganser	*Lophodytes cucullatus*
	Common Merganser	*Mergus merganser*
	Red-breasted Merganser	*Mergus serrator*
	Ruddy Duck	*Oxyura jamaicensis*
	Osprey	*Pandion haliaetus*
	White-tailed Kite	*Elanus leucurus*
	Bald Eagle	*Haliaeetus leucocephalus*
	Northern Harrier	*Circus cyaneus*
	Sharp-shinned Hawk	*Accipiter striatus*
	Cooper's Hawk	*Accipiter cooperii*
	Northern Goshawk	*Accipiter gentilis*
	Red-tailed Hawk	*Buteo jamaicensis*

Species Group	Common Name	Scientific Name
	Rough-legged Hawk	*Buteo lagopus*
	Golden Eagle	*Aquila chrysaetos*
	American Kestrel	*Falco sparverius*
	Merlin	*Falco columbarius*
	Gyrfalcon	*Falco rusticolus*
	Peregrine Falcon	*Falco peregrinus*
	Prairie Falcon	*Falco mexicanus*
	Gray Partridge	*Perdix perdix*
	Ring-necked Pheasant	*Phasianus colchicus*
	Ruffed Grouse	*Bonasa umbellus*
	White-tailed Ptarmigan	*Lagopus leucurus*
	Blue Grouse	*Dendragapus obscurus*
	Wild Turkey	*Meleagris gallopavo*
	Mountain Quail	*Oreortyx pictus*
	California Quail	*Callipepla californica*
	Northern Bobwhite	*Colinus virginianus*
	Virginia Rail	*Rallus limicola*
	Sora	*Porzana carolina*
	American Coot	*Fulica americana*
	Sandhill Crane	*Grus canadensis*
	Black-bellied Plover	*Pluvialis squatarola*
	American Golden-Plover	*Pluvialis dominica*
	Pacific Golden-Plover	*Pluvialis fulva*
	Snowy Plover	*Charadrius alexandrinus*
	Semipalmated Plover	*Charadrius semipalmatus*
	Killdeer	*Charadrius vociferus*
	Black Oystercatcher	*Haematopus bachmani*
	Greater Yellowlegs	*Tringa melanoleuca*
	Lesser Yellowlegs	*Tringa flavipes*
	Solitary Sandpiper	*Tringa solitaria*
	Spotted Sandpiper	*Actitis macularia*
	Willet	*Catoptrophorus semipalmatus*
	Wandering Tattler	*Heteroscelus incanus*
	Whimbrel	*Numenius phaeopus*
	Long-billed Curlew	*Numenius americanus*
	Marbled Godwit	*Limosa fedoa*
	Ruddy Turnstone	*Arenaria interpres*
	Black Turnstone	*Arenaria melanocephala*
	Surfbird	*Aphriza virgata*
	Red Knot	*Calidris canutus*
	Sanderling	*Calidris alba*
	Semipalmated Sandpiper	*Calidris pusilla*
	Western Sandpiper	*Calidris mauri*
	Least Sandpiper	*Calidris minutilla*

Species Group	Common Name	Scientific Name
	Baird's Sandpiper	*Calidris bairdii*
	Pectoral Sandpiper	*Calidris melanotos*
	Sharp-tailed Sandpiper	*Calidris acuminata*
	Rock Sandpiper	*Calidris ptilocnemis*
	Dunlin	*Calidris alpina*
	Stilt Sandpiper	*Calidris himantopus*
	Buff-breasted Sandpiper	*Tryngites subruficollis*
	Ruff	*Philomachus pugnax*
	Short-billed Dowitcher	*Limnodromus griseus*
	Long-billed Dowitcher	*Limnodromus scolopaceus*
	Common Snipe	*Gallinago gallinago*
	Wilson's Phalarope	*Phalaropus tricolor*
	Red-necked Phalarope	*Phalaropus lobatus*
	Red Phalarope	*Phalaropus fulicaria*
	South Polar Skua	*Catharacta maccormicki*
	Pomarine Jaeger	*Stercorarius pomarinus*
	Parasitic Jaeger	*Stercorarius parasiticus*
	Bonaparte's Gull	*Larus philadelphia*
	Heermann's Gull	*Larus heermanni*
	Mew Gull	*Larus canus*
	Ring-billed Gull	*Larus delawarensis*
	California Gull	*Larus californicus*
	Herring Gull	*Larus argentatus*
	Thayer's Gull	*Larus thayeri*
	Western Gull	*Larus occidentalis*
	Glaucous-winged Gull	*Larus glaucescens*
	Glaucous Gull	*Larus hyperboreus*
	Sabine's Gull	*Xema Sabini*
	Black-legged Kittiwake	*Rissa tridactyla*
	Caspian Tern	*Sterna caspia*
	Elegant Tern	*Sterna elegans*
	Common Tern	*Sterna hirundo*
	Arctic Tern	*Sterna paradisaea*
	Forster's Tern	*Sterna forsteri*
	Black Tern	*Chlidonias niger*
	Common Murre	*Uria aalge*
	Pigeon Guillemot	*Cepphus columba*
	Marbled Murrelet	*Brachyramphus marmoratus*
	Ancient Murrelet	*Synthliboramphus antiquus*
	Cassin's Auklet	*Ptychoramphus aleuticus*
	Rhinoceros Auklet	*Cerorhinca monocerata*
	Tufted Puffin	*Fratercula cirrhata*
	Rock Dove	*Columba livia*
	Band-tailed Pigeon	*Columba fasciata*

Species Group	Common Name	Scientific Name
	Mourning Dove	*Zenaida macroura*
	Barn Owl	*Tyto alba*
	Flammulated Owl	*Otus flammeolus*
	Western Screech-owl	*Otus kennicottii*
	Great Horned Owl	*Bubo virginianus*
	Snowy Owl	*Nyctea scandiaca*
	Northern Pygmy-owl	*Glaucidium gnoma*
	Burrowing Owl	*Athene cunicularia*
	Spotted Owl	*Strix occidentalis*
	Barred Owl	*Strix varia*
	Long-eared Owl	*Asio otus*
	Short-eared Owl	*Asio flammeus*
	Northern Saw-whet Owl	*Aegolius acadicus*
	Common Nighthawk	*Chordeiles minor*
	Black Swift	*Cypseloides niger*
	Vaux's Swift	*Chaetura vauxi*
	White-throated Swift	*Aeronautes saxatalis*
	Black-chinned Hummingbird	*Archilochus alexandri*
	Anna's Hummingbird	*Calypte anna*
	Calliope Hummingbird	*Stellula calliope*
	Rufous Hummingbird	*Selasphorus rufus*
	Belted Kingfisher	*Ceryle alcyon*
	Lewis's Woodpecker	*Melanerpes lewis*
	Acorn Woodpecker	*Melanerpes formicivorus*
	Williamson's Sapsucker	*Sphyrapicus thyroideus*
	Red-naped Sapsucker	*Sphyrapicus nuchalis*
	Red-breasted Sapsucker	*Sphyrapicus ruber*
	Downy Woodpecker	*Picoides pubescens*
	Hairy Woodpecker	*Picoides villosus*
	Three-toed Woodpecker	*Picoides tridactylus*
	Black-backed Woodpecker	*Picoides arcticus*
	Northern Flicker	*Colaptes auratus*
	Pileated Woodpecker	*Dryocopus pileatus*
	Olive-sided Flycatcher	*Contopus cooperi*
	Western Wood-pewee	*Contopus sordidulus*
	Willow Flycatcher	*Empidonax traillii*
	Hammond's Flycatcher	*Empidonax hammondii*
	Dusky Flycatcher	*Empidonax oberholseri*
	Pacific-slope Flycatcher	*Empidonax difficilis*
	Say's Phoebe	*Sayornis saya*
	Ash-throated Flycatcher	*Myiarchus cinerascens*
	Western Kingbird	*Tyrannus verticalis*
	Eastern Kingbird	*Tyrannus tyrannus*
	Loggerhead Shrike	*Lanius ludovicianus*

Species Group	Common Name	Scientific Name
	Northern Shrike	*Lanius excubitor*
	Cassin's Vireo	*Vireo cassinii*
	Hutton's Vireo	*Vireo huttoni*
	Warbling Vireo	*Vireo gilvus*
	Red-eyed Vireo	*Vireo olivaceus*
	Gray Jay	*Perisoreus canadensis*
	Steller's Jay	*Cyanocitta stelleri*
	Western Scrub-Jay	*Aphelocoma californica*
	Pinyon Jay	*Gymnorhinus cyanocephalus*
	Clark's Nutcracker	*Nucifraga columbiana*
	Black-billed Magpie	*Pica pica*
	American Crow	*Corvus brachyrhynchos*
	Northwestern Crow	*Corvus caurinus*
	Common Raven	*Corvus corax*
	Horned Lark	*Eremophila alpestris*
	Purple Martin	*Progne subis*
	Tree Swallow	*Tachycineta bicolor*
	Violet-green Swallow	*Tachycineta thalassina*
	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
	Cliff Swallow	*Petrochelidon pyrrhonota*
	Barn Swallow	*Hirundo rustica*
	Black-capped Chickadee	*Poecile atricapillus*
	Mountain Chickadee	*Poecile gambeli*
	Chestnut-backed Chickadee	*Poecile rufescens*
	Bushtit	*Psaltriparus minimus*
	Red-breasted Nuthatch	*Sitta canadensis*
	White-breasted Nuthatch	*Sitta carolinensis*
	Brown Creeper	*Certhia americana*
	Rock Wren	*Salpinctes obsoletus*
	Canyon Wren	*Catherpes mexicanus*
	Bewick's Wren	*Thryomanes bewickii*
	House Wren	*Troglodytes aedon*
	Winter Wren	*Troglodytes troglodytes*
	Marsh Wren	*Cistothorus palustris*
	American Dipper	*Cinclus mexicanus*
	Golden-crowned Kinglet	*Regulus satrapa*
	Ruby-crowned Kinglet	*Regulus calendula*
	Western Bluebird	*Sialia mexicana*
	Mountain Bluebird	*Sialia currucoides*
	Townsend's Solitaire	*Myadestes townsendi*
	Veery	*Catharus fuscescens*
	Swainson's Thrush	*Catharus ustulatus*
	Hermit Thrush	*Catharus guttatus*
	American Robin	*Turdus migratorius*

Species Group	Common Name	Scientific Name
	Varied Thrush	*Ixoreus naevius*
	Wrentit	*Chamaea fasciata*
	Northern Mockingbird	*Mimus polyglottos*
	European Starling	*Sturnus vulgaris*
	American Pipit	*Anthus rubescens*
	Cedar Waxwing	*Bombycilla cedrorum*
	Orange-crowned Warbler	*Vermivora celata*
	Nashville Warbler	*Vermivora ruficapilla*
	Yellow Warbler	*Dendroica petechia*
	Yellow-rumped Warbler	*Dendroica coronata*
	Black-throated Gray Warbler	*Dendroica nigrescens*
	Townsend's Warbler	*Dendroica townsendi*
	Hermit Warbler	*Dendroica occidentalis*
	Palm Warbler	*Dendroica palmarum*
	Macgillivray's Warbler	*Oporornis tolmiei*
	Common Yellowthroat	*Geothlypis trichas*
	Wilson's Warbler	*Wilsonia pusilla*
	Yellow-breasted Chat	*Icteria virens*
	Western Tanager	*Piranga ludoviciana*
	Green-tailed Towhee	*Pipilo chlorurus*
	Spotted Towhee	*Pipilo maculatus*
	California Towhee	*Pipilo crissalis*
	Chipping Sparrow	*Spizella passerina*
	Brewer's Sparrow	*Spizella breweri*
	Clay-colored Sparrow	*Spizella pallida*
	Vesper Sparrow	*Pooecetes gramineus*
	Savannah Sparrow	*Passerculus sandwichensis*
	Grasshopper Sparrow	*Ammodramus savannarum*
	Fox Sparrow	*Passerella iliaca*
	Song Sparrow	*Melospiza melodia*
	Lincoln's Sparrow	*Melospiza lincolnii*
	Swamp Sparrow	*Melospiza georgiana*
	White-throated Sparrow	*Zonotrichia albicollis*
	Harris's Sparrow	*Zonotrichia querula*
	White-crowned Sparrow	*Zonotrichia leucophrys*
	Golden-crowned Sparrow	*Zonotrichia atricapilla*
	Dark-eyed Junco	*Junco hyemalis*
	Lapland Longspur	*Calcarius lapponicus*
	Black-headed Grosbeak	*Pheucticus melanocephalus*
	Snow Bunting	*Plectrophenax nivalis*
	Lazuli Bunting	*Passerina amoena*
	Red-winged Blackbird	*Agelaius phoeniceus*
	Tricolored Blackbird	*Agelaius tricolor*
	Western Meadowlark	*Sturnella neglecta*

Species Group	Common Name	Scientific Name
	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
	Brewer's Blackbird	*Euphagus cyanocephalus*
	Brown-headed Cowbird	*Molothrus ater*
	Bullock's Oriole	*Icterus bullockii*
	Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*
	Pine Grosbeak	*Pinicola enucleator*
	Purple Finch	*Carpodacus purpureus*
	Cassin's Finch	*Carpodacus cassinii*
	House Finch	*Carpodacus mexicanus*
	Red Crossbill	*Loxia curvirostra*
	Common Redpoll	*Carduelis flammea*
	Pine Siskin	*Carduelis pinus*
	Lesser Goldfinch	*Carduelis psaltria*
	American Goldfinch	*Carduelis tristis*
	Evening Grosbeak	*Coccothraustes vespertinus*
	House Sparrow	*Passer domesticus*
MAMMALS	Virginia Opossum	*Didelphis virginiana*
	Masked Shrew	*Sorex cinereus*
	Vagrant Shrew	*Sorex vagrans*
	Montane Shrew	*Sorex monticolus*
	Baird's Shrew	*Sorex bairdi*
	Water Shrew	*Sorex palustris*
	Pacific Water Shrew	*Sorex bendirii*
	Trowbridge's Shrew	*Sorex trowbridgii*
	Shrew-mole	*Neurotrichus gibbsii*
	Townsend's Mole	*Scapanus townsendii*
	Coast Mole	*Scapanus orarius*
	California Myotis	*Myotis californicus*
	Western Small-footed Myotis	*Myotis ciliolabrum*
	Yuma Myotis	*Myotis yumanensis*
	Little Brown Myotis	*Myotis lucifugus*
	Long-legged Myotis	*Myotis volans*
	Fringed Myotis	*Myotis thysanodes*
	Long-eared Myotis	*Myotis evotis*
	Silver-haired Bat	*Lasionycteris noctivagans*
	Big Brown Bat	*Eptesicus fuscus*
	Hoary Bat	*Lasiurus cinereus*
	Townsend's Big-eared Bat	*Corynorhinus townsendii*
	American Pika	*Ochotona princeps*
	Brush Rabbit	*Sylvilagus bachmani*
	Eastern Cottontail	*Sylvilagus floridanus*
	Nuttall's (Mountain) Cottontail	*Sylvilagus nuttallii*
	Snowshoe Hare	*Lepus americanus*

Species Group	Common Name	Scientific Name
	Black-tailed Jackrabbit	*Lepus californicus*
	Mountain Beaver	*Aplodontia rufa*
	Yellow-pine Chipmunk	*Tamias amoenus*
	Townsend's Chipmunk	*Tamias townsendii*
	Yellow-bellied Marmot	*Marmota flaviventris*
	California Ground Squirrel	*Spermophilus beecheyi*
	Golden-mantled Ground Squirrel	*Spermophilus lateralis*
	Cascade Golden-mantled Ground Squirrel	*Spermophilus saturatus*
	Eastern Gray Squirrel	*Sciurus carolinensis*
	Eastern Fox Squirrel	*Sciurus niger*
	Western Gray Squirrel	*Sciurus griseus*
	Douglas' Squirrel	*Tamiasciurus douglasii*
	Northern Flying Squirrel	*Glaucomys sabrinus*
	Northern Pocket Gopher	*Thomomys talpoides*
	Western Pocket Gopher	*Thomomys mazama*
	Camas Pocket Gopher	*Thomomys bulbivorus*
	American Beaver	*Castor canadensis*
	Western Harvest Mouse	*Reithrodontomys megalotis*
	Deer Mouse	*Peromyscus maniculatus*
	Columbian Mouse	*Peromyscus keeni*
	Pinon Mouse	*Peromyscus truei*
	Dusky-footed Woodrat	*Neotoma fuscipes*
	Bushy-tailed Woodrat	*Neotoma cinerea*
	Southern Red-backed Vole	*Clethrionomys gapperi*
	Western Red-backed Vole	*Clethrionomys californicus*
	Heather Vole	*Phenacomys intermedius*
	White-footed Vole	*Phenacomys albipes*
	Red Tree Vole	*Phenacomys longicaudus*
	Montane Vole	*Microtus montanus*
	Gray-tailed Vole	*Microtus canicaudus*
	Townsend's Vole	*Microtus townsendii*
	Long-tailed Vole	*Microtus longicaudus*
	Creeping Vole	*Microtus oregoni*
	Water Vole	*Microtus richardsoni*
	Muskrat	*Ondatra zibethicus*
	Black Rat	*Rattus rattus*
	Norway Rat	*Rattus norvegicus*
	House Mouse	*Mus musculus*
	Western Jumping Mouse	*Zapus princeps*
	Pacific Jumping Mouse	*Zapus trinotatus*
	Common Porcupine	*Erethizon dorsatum*
	Nutria	*Myocastor coypus*
	Coyote	*Canis latrans*

Species Group	Common Name	Scientific Name
	Red Fox	*Vulpes vulpes*
	Gray Fox	*Urocyon cinereoargenteus*
	Black Bear	*Ursus americanus*
	Raccoon	*Procyon lotor*
	American Marten	*Martes americana*
	Fisher	*Martes pennanti*
	Ermine	*Mustela erminea*
	Long-tailed Weasel	*Mustela frenata*
	Mink	*Mustela vison*
	Wolverine	*Gulo gulo*
	American Badger	*Taxidea taxus*
	Western Spotted Skunk	*Spilogale gracilis*
	Striped Skunk	*Mephitis mephitis*
	Northern River Otter	*Lutra canadensis*
	Mountain Lion	*Puma concolor*
	Bobcat	*Lynx rufus*
	Elk	*Cervus elaphus*
	Mule Deer	*Odocoileus hemionus*
	White-tailed Deer	*Odocoileus virginianus*
	Columbian White-tailed Deer	*Odocoileus virginianus leucurus*
	Mountain Goat	*Oreamnos americanus*
MARINE MAMMALS	Northern (Steller) Sea Lion	*Eumetopias jubatus*
	California Sea Lion	*Zalophus californianus*
	Harbor Seal	*Phoca vitulina*
REPTILES	Snapping Turtle	*Chelydra serpentina*
	Painted Turtle	*Chrysemys picta*
	Western Pond Turtle	*Clemmys marmorata*
	Red-eared Slider Turtle	*Trachemys scripta*
	Northern Alligator Lizard	*Elgaria coerulea*
	Southern Alligator Lizard	*Elgaria multicarinata*
	Western Fence Lizard	*Sceloporus occidentalis*
	Western Skink	*Eumeces skiltonianus*
	Rubber Boa	*Charina bottae*
	Racer	*Coluber constrictor*
	Ringneck Snake	*Diadophis punctatus*
	California Mountain Kingsnake	*Lampropeltis zonata*
	Gopher Snake	*Pituophis catenifer*
	Western Terrestrial Garter Snake	*Thamnophis elegans*
	Northwestern Garter Snake	*Thamnophis ordinoides*
	Common Garter Snake	*Thamnophis sirtalis*

Species Group	Common Name	Scientific Name
	Western Rattlesnake	*Crotalus viridis*

2.1.1.5 Habitat Classification

The estuary includes a complex mosaic of interconnected and interacting habitat types. One of the difficulties in describing these habitat types is choosing a habitat classification system that adequately describes the habitats used by focal species and is acceptable to all stakeholders in the subbasin. For example, habitat type descriptions differ as a result of the resolution of the methods utilized to map and classify the habitat. Further, habitat mapping methods are designed to describe aquatic or terrestrial habitat types, but generally are not capable of adequately mapping both. Choosing the appropriate habitat classification system is further complicated by the diversity of habitats found throughout the lower Columbia River mainstem and estuary or by different area coverage of each habitat mapping effort. For the purposes of this subbasin assessment, a habitat classification was needed that could: describe aquatic habitats, describe terrestrial habitats, and provide a historical context for evaluating the change in estuary and mainstem (to Bonneville Dam) habitat types over time. There is not one habitat classification system that provides for all these needs; thus, we chose to utilize multiple habitat classification systems to describe estuary and mainstem habitat types as described below. The Inventory of Riparian Habitats and Associated Wildlife along the Columbia and Snake Rivers (Tabor, J.E., 1976) was not used directly under the assumption that this data is integrated with more recent information including IBIS data. However, this study's 1970s mapping data should be utilized for future comparisons of habitats and wildlife-habitat relationships.

The use of multiple habitat classification systems creates additional challenges because the habitat types among different classification systems are rarely directly comparable. However, we evaluated each habitat classification system to determine potential groupings of specific habitat types from each classification system, limiting the comparison to habitat types known to occur in the lower Columbia River and estuary.

2.1.1.5.1 Bathymetric Mapping

Bathymetry is a low resolution mapping method that provides coarse delineations of habitat types. Habitat classification using bathymetry provides a means to segregate aquatic habitat based on depth criteria; additionally, published bathymetric mapping efforts provide a historical context for evaluating Columbia River estuary habitat change. Using bathymetric survey maps of the U.S. Coast Survey (now U.S. Geodetic Survey), five major types of estuary (i.e. rm 0-46.5) habitat were defined by the Columbia River Estuary Data Development Program (Thomas 1983) according to elevation and the dominant vegetation: tidal swamps, tidal marshes, shallow water/flats, medium depth water, and deep water. A cross-sectional view of these habitat types is depicted in Figure 2-4. Tidal swamps are those areas where the dominant vegetation is mostly shrub and woody species with elevations varying between mean high high water (MHHW) and the line of non-aquatic vegetation. Tidal marshes vary considerably depending on dominant low shrubs or emergent herbaceous vegetation and have been recorded slightly above mean low low water (MLLW) to slightly above MHHW. Shallow water/flats are defined as being between an elevation slightly above the MLLW mark to -6 ft MLLW. Medium depth water is between 6 ft and 18 ft below MLLW, while deep water is defined as 18 ft and deeper. Further, at a given elevation, there is an overriding influence of time and salinity in development

of specific types of habitat. For example, tidal marsh habitat may be classified as a saltwater or freshwater marsh and each is characterized by distinctive vegetation as driven by salinity levels. Additionally, shallows/flats habitat may be present in an area formerly classified as medium depth water as a result of accretion; given time and further accretion, shallows/flats habitat may transition to tidal marsh.

Thomas (1983) also investigated five categories of non-estuarine habitat (i.e. developed floodplain, natural and filled uplands, non-tidal swamps, non-tidal marshes, and non-tidal water) to identify the fate of floodplain areas that were removed from the estuarine system. Developed floodplain habitat was defined as all diked floodplain converted to agriculture, residential, or other land use. Natural and filled uplands included those areas where measurable acreages have been filled, primarily through disposal of dredge material. Non-tidal swamps were areas of the diked floodplain that were never cleared or were cleared and converted back to swamp. Non-tidal marshes included areas of the diked floodplain that support emergent wetland vegetation; these were typically abandoned pastures dominated by rush and sedge. Non-tidal water were those areas of former tidal sloughs that were separated from the river by dikes and tidegates.

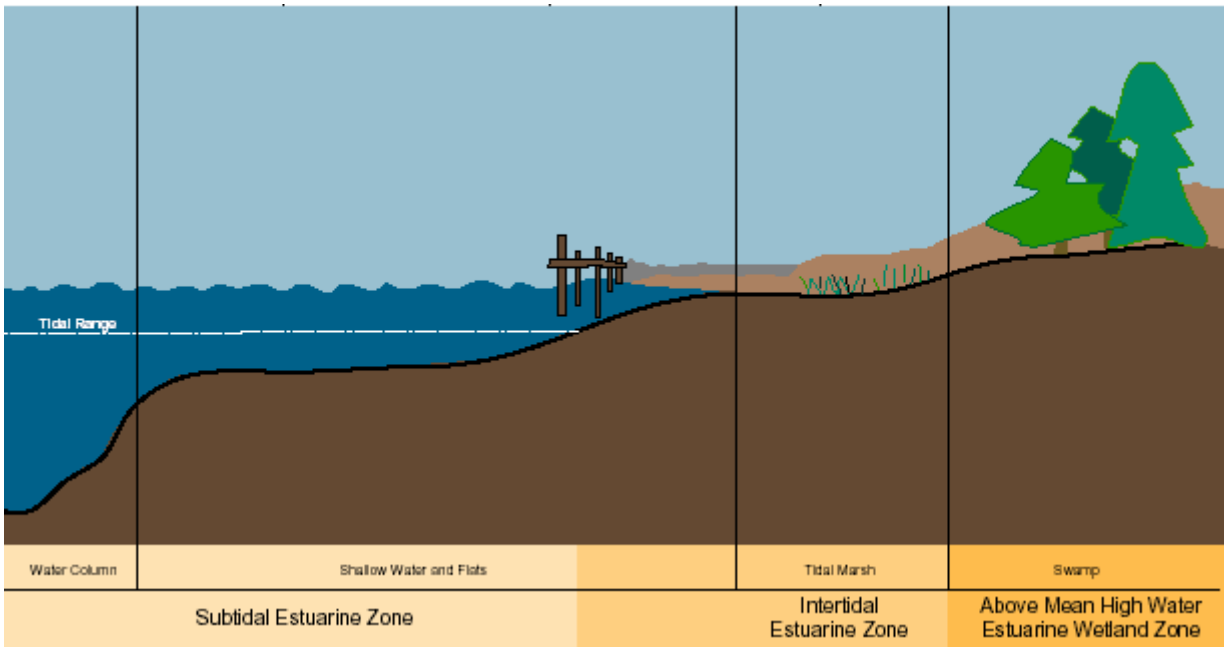


Figure 2-4. Cross-sectional depiction of general estuary habitat types (USACE 2001).

2.1.1.5.2 Satellite Imagery Habitat Mapping

Satellite imagery provides a high resolution habitat mapping method that principally uses vegetative communities to describe habitat types. Because of the use of vegetation, satellite imagery is generally not capable of distinguishing different types of aquatic habitats. Different satellite imagery technology are available that provide different levels of resolution; two of these technologies are compared in Garono et al. (2003b).

A widely accepted habitat classification system developed from satellite imagery is that of Johnson and O'Neil (2001); this habitat classification system describes wildlife habitats present in Washington and Oregon and provides a historical context for evaluating habitat change in lower Columbia River mainstem and estuary habitats. A total of 32 wildlife habitat types are delineated in this classification system (Table 2-2); each habitat type is further

described based on geographic distribution, physical setting, landscape setting, structure, and composition. Johnson and O'Neil (2001) also provide information on other classification systems and key references, natural disturbance regimes, succession and stand dynamics, management and anthropogenic impacts, and status and trends to provide further insight for each habitat type. This habitat classification system has been utilized by the Northwest Habitat Institute for producing maps comparing historical and current wildlife habitat types in the lower Columbia River mainstem and estuary as part the NPCC subbasin planning process (IBIS 2003).

Table 2-2: Wildlife habitat types in Washington and Oregon determined by Johnson and O'Neil (2001).

Wildlife Habitat Types Vegetative/Land Use/Marine Groupings	Wildlife Habitat Types Vegetative/Land Use/Marine Groupings
Westside Lowland Conifer-Hardwood Forest	**Upland Aspen Forests**
Alnus rubra-Acer macrophyllum Upland Forests	*Populus tremuloides* Upland Forests
Picea sitchensis-Tsuga heterphylla Forests	**Subalpine Parklands**
Pseudotsuga menziesii-Alnus rubra-Acer macrophyllus Forests	Subalpine and Alpine Wetlands
Maritime *Tsuga heterphylla-Thuja plicata* Forests	*Pinus albicaulis-Abies lasiocarpa* Woodlands and Parklands
Forested Dunes	*Tsuga mertensiana* Parklands
Westside Oak and Dry Douglas-fir Forest and Woodlands	**Alpine Grasslands and Shrublands**
Westside *Quercus garryana* Forests and Woodlands	Subalpine and Alpine Grasslands
Westside *Quercus garryana-Pseudotsuga menziesii* Forests	Alpine Dwarf Shrublands-Fellfields and Sedge Turf
Westside Dry *Pseudotsuga menziesii* Forests	**Westside Grasslands**
Pseudotsuga menziesii-Arbutus menziesii Forests	Westside *Festuca idahoensis var. romeri-Danthonia californica*
Southwest Oregon Mixed Conifer-Hardwood Forests	**Ceanothus-Manzanita Shrublands**
Abies concolor Mixed conifer Forests	Chaparral
Pinus jefferii Woodlands	**Western Juniper and Mountain Mahogany Woodlands**
Pseudotsuga menziesii-Lithocarpus densiflorus Forests	*Juniperus occidentalis* Scablands
	Juniperus occidentalis-Artemisia tridentata

Southwest Oregon Low Elevation Mixed Conifer Forests

Montane Mixed Conifer Forests

Abies amabilis-Tsuga heterophylla Forests

Abies lasiocarpa-Picea englemannii Forests

Abies magnifica var. shastensis Forests and Woodlands

Tsuga mertensiana Forests

Tsuga mertensiana-Abies amabilis Forests

Eastside (Interior) Mixed Conifer Forest

Eastside *Abies grandis- Pseudotsuga menziesii* Forest

Eastside *Pseudotsuga menziesii- Pinus ponderosa* Forest

Eastside *Tsuga heterphylla-Thuja plicata* Forests

Lodgepole Pine Forests and Woodlands

Pinus contorta Grass understory

Pinus contorta Shrub understory

Pinus contorta Subalpine Forests

Pinus contorta Woodlands and Forests on Pumice

Ponderosa Pine Forests and Woodlands

Pinus ponderosa Woodlands

Eastside *Pinus ponderosa -Quercus garryana* Forest and Woodlands

Tall Shrublands

Juniperus occidentalis/ Bunchgrass

Cercocarpus ledifolius

Eastside (Interior) Canyon Shrublands

Eastside Moist Deciduous Shrublands

Eastside (Interior) Grasslands

Pseudoroegneria spicata Grasslands

Eastside Low-to-Mid-elevation *Festuca idahoensis* Grasslands

Eastside Modified Grasslands

Sporobolus cryptandrus-Aristida puppurea var.longiseta Grasslands

Shrub-steppe

Artemisia tripartita Shrub-steppe

Artemisia cana Shrub-steppe

Artemisia tridentata ssp. tridentata and ssp. wyomingensis Shrub-steppe

Artemisia tridentata ssp. vaseyana Shrublands

Purshia tridentata Shrub-steppe

Sandy steppe and Shrub-steppe

Dwarf Shrub-steppe

Artemisia rigida/Eriogonum spp./Poa secunda Dwarf-Shrub Scabland

Artemisia arbuscula Dwarf-Shrub-steppe

Eastside *Quercus garryana* Woodlands	*Artemisia nova* Dwarf-Shrublands

Wildlife Habitat Types Vegetative/Land Use/Marine Groupings
Desert Playa and Salt Scrub
Alkali Grasslands and Wetlands
Atriplex confertifolia Shrublands
Mixed Saltdesert Shrub-Non-Playa
Mixed Saltdesert Shrub-Playa
Sarcobatus vermiculatus Shrublands
Agriculture, Pasture, and Mixed Environs*
Cultivated Croplands
Improved Pasture
Modified Grasslands
Orchard/Vineyard/Nursery
Unimproved Pasture
Urban and Mixed Environs*
High Density
Moderate Density
Low Density
Open Water-Lakes, Rivers, Streams
Riverine
Lacustrine-Open Water
Herbaceous Wetlands
Graminoid Wet Meadow

Wildlife Habitat Types Vegetative/Land Use/Marine Groupings
Montane Coniferous Wetlands
Westside Montane Coniferous Wetlands
Picea engelmannii Forested Wetlands
Eastside (Interior) Riparian - Wetlands
Eastside Midmontane *Alnus incana-Salix ssp.* Riparian Shrublands
Eastside Lowland Riparian Shrublands
Eastside *Populus balsamifera ssp. trichocarpa*
Alnus rhombifolia Riparian
Pinus ponderosa Riparian Woodlands
Populus tremuloides Riparian/Wetland Forests and Woodlands
Coastal Dunes and Beaches
Coastal Dune Grasslands
Coastal Dune Shrublands
Coastal Headlands and Islets
Coastal Headland Shrublands and Grasslands
Bays and Estuaries*
Bays and Estuaries (includes Intertidal Marshes)
Inland Marine Deeper Waters*
Puget Sound to Strait of Juan de Fuca

Freshwater Aquatic Beds

Herbaceous and Sedge Wetlands

Westside Riparian - Wetlands

Alnus viridis ssp. sinuata-Acer circinatum Shrublands

Westside Riparian and Wetland Deciduous Forests

Picea sitchensis Wetland Forests and Woodlands

Tsuga heterophylla-Thuja plicata coniferous wetlands

Westside Riparian/Wetland Shrublands

Shrub/herbaceous Sphagnum Bogs

Wooded Bogs

* Wildlife habitats were determined by an expert panel process.

Marine Nearshore*

Marine environment from shore line to 20m depth

Marine Shelf*

Marine environment from 20m to 200m depth

Oceanic*

Marine environment greater than 200m depth

The Lower Columbia River Estuary Partnership (LCREP) was interested in producing spatial data sets describing the location and distribution of estuarine and tidal freshwater habitat cover types along the Columbia River from the mouth to Bonneville Dam using a consistent method and data source (Garono et al 2003c). The habitat mapping focused on estuarine and tidal freshwater habitats; areas not located along the river and >175 ft elevation (for the eastern dataset) or >100 ft elevation (for the western dataset) were deleted from the habitat classification (Garono et al 2003c). The habitat types designated in this research differed from that of Thomas (1983) and Johnson and O'Neil (2001). In general, the vegetated habitat types are more specific than that of Thomas (1983) but less specific than that of Johnson and O'Neil (2001); the aquatic habitat types were less specific than Thomas (1983) and similar to that of Johnson and O'Neil (2001). However, in order to compare the habitats mapped in 2000 with a National Oceanic and Atmospheric Administration (NOAA) mapping dataset from1992, a more generalized list of habitat types were derived to achieve consistency between the two datasets (Garono et al. 2003a). This habitat change analysis provided a recent context for evaluating lower Columbia River mainstem and estuary habitat change.

The resulting habitat types from the merge of the 1992 and 2000 datasets include: herbaceous wetland, scrub-shrub wetland, forested wetland, herbaceous upland, scrub-shrub upland, deciduous forest upland, coniferous forest upland, mixed forest upland, unconsolidated shoreline, water, urban, and other (Garono et al 2003a). The following general guidelines defined the major habitat classes: herbaceous habitat types had >70% herbaceous cover, scrub-shrub habitat types had >70% woody vegetation <8 ft high, forest habitat types had >60% conifers of broad-leaved vegetation, mixed forest habitat types were defined based on the proportion of conifers/deciduous ranging from 40/60 to 50/50, and unconsolidated shoreline habitat had at least 70% of the area as exposed substrate (Garono et al. 2003c). It is not clear what criteria Garono et al. (2003a,c) utilized to distinguish between wetland and upland habitat.

2.1.1.5.3 WDFW Priority Habitats

WDFWs Priority Habitats and Species Program was initiated in 1989 and remains in use today. WDFW priority habitats are generally defined as habitat types with unique or significant value to many species. An area identified and mapped as priority habitat has one or more of the following attributes: comparatively high fish and wildlife density, comparatively high fish and wildlife species diversity, important fish and wildlife breeding habitat, important fish and wildlife seasonal ranges, important fish and wildlife movement corridors, limited availability, high vulnerability to habitat alteration, or unique or dependent species. A priority habitat may be described by a unique vegetation type or by a dominant plant species that is of primary importance to fish and wildlife (e.g., oak woodlands, eelgrass meadows). A priority habitat may also be described by a successional stage (e.g., old growth and mature forests). Alternatively, a priority habitat may consist of a specific habitat element (e.g., consolidated marine/estuarine shorelines, talus slopes, caves, snags) of key value to fish and wildlife.

Specific descriptions of the four WDFW Priority Habitats considered in this subbasin assessment follows. Old growth forest west of the Cascade crest are generally defined as stands of at least two tree species, forming a multi-layered canopy with occasional small openings, with at least eight trees/acre that are >81 cm diameter at breast height (dbh) or >200 years old. Mature forests are defined as stands with average tree diameter >53 cm dbh; decay, number of snags, and quantity of large downed material is generally less than old growth forests. Riparian habitats are a general grouping that includes all areas adjacent to aquatic systems with flowing water that

contain elements of both aquatic and terrestrial ecosystems. Freshwater wetlands are defined as transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water; no vegetation is specified other than the presence of hydrophytic plants. Numerous conditions may satisfy the designation as rural natural open space: an area where a priority species resides or uses for breeding or regular feeding, a corridor connecting other priority habitats, or an isolated remnant of natural habitat larger than 10 acres and surrounded by agricultural development. Rural natural open space is a general habitat type that may or may not possess wetland, riparian, aquatic, or forested habitat attributes; thus, specific descriptions of habitat attributes and relationship to focal species habitat requirements is fairly subjective.

Little data are available regarding the relationship between historical and current habitat conditions of WDFW priority habitats; thus, we have no context in which to evaluate habitat change of WDFW priority habitats in the lower Columbia River mainstem and estuary.

Because of the general nature of these habitat designations, there may be considerable overlap among the characteristics of each habitat; thus, analysis of the specific relationships between these habitats and the focal species is problematic. For example, riparian habitats is a general grouping that include elements of aquatic and terrestrial environments; freshwater wetland habitats associated with flowing water may be a subset of the riparian category. Within the freshwater wetland category, there is uncertainty as to whether the wetland is dominated by herbaceous vegetation, shrubs, or trees; each of these wetlands provides very different habitat opportunities for the focal species. Additionally, the rural natural open space is also a general habitat type; unless some knowledge of a specific rural natural open space habitat is available, it is difficult to distinguish whether the habitat includes forest, riparian, wetland, or any combination of these habitat characteristics.

2.1.1.5.4 Relationship Between Habitat Classification Systems

Each habitat classification system described above was developed with a specific purpose; each system only partially satisfies the needs for this subbasin assessment (i.e. describe aquatic habitats, describe terrestrial habitats, and provide a historical context for evaluating the change in estuary and mainstem habitat types over time). For example, each system differs in the specificity of habitat types and the area covered by those habitat types. In order to completely describe the aquatic and terrestrial habitats throughout the lower Columbia River mainstem and estuary, the habitat classification systems were compared to establish similarities among them. However, because each habitat classification system was developed with different methods, there is no direct relationship among the habitat types used in each system and we relied heavily on professional judgment to determine the relationship among each classification system. We evaluated each habitat classification system to determine possible groupings of specific habitat types from each classification system (Table 2-3), limiting the comparison to habitats known to occur in the lower Columbia River and estuary. For example, wildlife habitats from Johnson and O'Neil (2001) that only occur in eastern regions of Washington or Oregon were not included in the comparison.

Table 2-3. Potential relationship of specific habitat types among the different habitat classification systems.

Estuarine Habitat Types (Thomas 1983)	Wildlife Habitat Types (Johnson and O'Neil 2001)	LCREP Estuary and Tidal Freshwater Habitats (Garono et al. 2003a)	WDFW Priority Habitats
Deep Water	Open Water – Lakes, River, and Streams	Water	NA
Medium Depth Water	Open Water – Lakes, River, and Streams	Water	NA
Shallow Water/Flats	Open Water – Lakes, River, and Streams Bays and Estuaries	Water	NA
Tidal Marsh	Herbaceous Wetlands	Herbaceous Wetlands Scrub-Shrub Wetlands	Riparian
Tidal Swamp	Westside Riparian-Wetlands	Forested Wetland	Riparian
Non-estuarine Water	Open Water – Lakes, River, and Streams	Water	NA
Non-estuarine Marsh	Herbaceous Wetlands	Herbaceous Wetlands Scrub-Shrub Wetlands	Freshwater Wetland Riparian
Non- estuarine Swamp	Westside Riparian-Wetlands	Forested Wetland	Riparian Freshwater Wetland
Developed Floodplain	Agriculture, Pastures, and Mixed Environs Urban and Mixed Environs	Urban	Rural Natural Open Space
Natural and Filled Uplands	Coastal Dunes and Beaches	Unconsolidated Shore	NA
NA	Westside Lowland Conifer-Hardwood Forest	Coniferous Forest Upland	Old Growth/Mature Forest
NA	Westside Oak and Dry Douglas-fir Forest	Deciduous Forest Upland	Old Growth/Mature Forest
NA	Montane Mixed Conifer	Mixed Forest Upland	Old Growth/Mature

Estuarine Habitat Types (Thomas 1983)	Wildlife Habitat Types (Johnson and O'Neil 2001)	LCREP Estuary and Tidal Freshwater Habitats (Garono et al. 2003a)	WDFW Priority Habitats
	Forest		Forest
		Coniferous Forest Upland	
NA	Westside Grasslands	Herbaceous Upland	Rural Natural Open Space

2.1.1.6 Estuary and Lower Mainstem Zones

The Columbia River estuary and lower mainstem consists of two major physiographic subsystems: the estuarine subsystem and the tidal freshwater subsystem (Johnson et al. 2003b). The estuary and lower mainstem are dynamic subsystems, resulting partially from interactions between seasonal flow and salinity-tidal regimes. Subsystem designation was based on efforts of the Columbia River Estuary Data Development Program (Simenstad et al. 1984). The estuarine subsystem extends from the Columbia River mouth to Puget Island (rm 0-46) and includes seven distinct areas based on habitat structure, salinity concentration, and sediment composition: Entrance, Mixing Zone, Youngs Bay, Baker Bay, Grays Bay, Cathlamet Bay, and the Upper Estuary. A map of the estuarine subsystem boundaries is provided in Figure 2-5, however, a similar map was not available for the tidal freshwater subsystem. Boundary delineation of these areas is consistent with the estuary areas discussed by Thomas (1983). The freshwater subsystem extends from Puget Island to Bonneville Dam and is separated into two areas (i.e. rm 46-105 and rm 105-146). The distinct areas within the estuary and tidal freshwater subsystems are briefly described below based on Johnson et al. (2003b):

- **Entrance** – The area is dominated by subtidal habitat and has the highest salinity in the estuary. Historically, the Entrance was a high-energy area of natural fluvial land forms (e.g. Clatsop Spit, Trestle Bay), and a complex of channels, shallow water, and sand bars. The Entrance area supports the Columbia Plume, which creates a unique low-salinity, high productivity environment extending well into the ocean. The dynamic nature of the area has changed as a result of dredging and jetty construction, which have limited wave action and the ocean-fed supply of sediment.
- **Mixing Zone** – The area is characterized by a network of mid-channel shoals and flats, such as Desdemona and Taylor Sands. The Mixing Zone has the highest variation in salinity within the estuary based on interactions between tide cycles and river flow. The estuary turbidity maximum (ETM), which is created through these interactions, is often located within the Mixing Zone. Urban development, primarily around Astoria, has moderately impacted intertidal and subtidal habitats in the area.
- **Youngs Bay** – The area is characterized by a broad flood plain and was historically abundant in tidal marsh and swamp habitat. Diking and flood control structures were used to convert floodplain habitat in the area to pasture. The remaining fragmented tidal marsh and tidal swamp habitats in Youngs Bay are thought to be different in structure and vegetative community than the historical condition of these habitats.

- **Baker Bay** – The area was historically a high energy area from ocean currents and wave action, which have been altered as a result of dredging and jetty construction. Additionally, migration of mid-channel islands toward the interior of Baker Bay has sheltered the area from wave action. As a result, tidal marsh habitat has recently started to develop in some areas while much of the historical tidal marsh and tidal swamp habitat has been lost because of dike construction in the floodplain. Because of proximity to the river mouth, Baker Bay consists primarily of brackish water.
- **Grays Bay** – Historically, water circulation in the area was a result of interactions between river flow and tidal intrusion. Pile dikes constructed adjacent to the main Columbia River navigation channel have decreased circulation in Grays Bay; this circulation change has caused flooding problems in the Grays and Deep River valley bottoms and has promoted tidal marsh habitat development in the accreting bay. Dike construction, primarily for pasture conversion, has isolated the main channel from its historical floodplain and eliminated much of the historical tidal swamp habitat.
- **Cathlamet Bay** – The area is characterized by some of the most intact and productive tidal marsh and swamp habitat remaining in the estuary; a large portion of Cathlamet Bay is protected by the Lewis and Clark National Wildlife Refuge. The western edge of Cathlamet Bay contains part of the brackish oligohaline zone, which is thought to be important during juvenile anadromous fish transition from fresh to salt water. Portions of Cathlamet Bay have lost substantial acreage of tidal swamp habitat as a result of dike construction; conversely, tidal marsh habitat has formed along the fringe of dredge disposal locations.
- **Upper Estuary** – The area is characterized by deep channels and steep shorelines on both sides of the river. The narrow channel structure produces an area dominated more by tidal swamp habitat and less edge habitat (tidal marsh). The Upper Estuary is typically dominated by freshwater, except during low river flow or large flood tides. Dike construction and clearing of vegetation has resulted in a substantial loss of tidal marsh habitat on Puget Island and within the Skamokawa and Elochoman floodplain.
- **Tidal Freshwater** – The tidal freshwater subsystem is distinct from the estuarine subsystem based on geology, vegetation, and climate. This region is influenced by major tributaries such as the Willamette, Cowlitz, Lewis, and Kalama Rivers. This area of the Columbia River mainstem is characterized by elongate islands that divide the river and form oxbow lakes, sloughs, and side channels (e.g. Sauvie Island and Scappoose Bay). The tidal freshwater subsystem was historically dominated by a combination of tidal plant communities, ash riparian forests, and marshy lowlands.

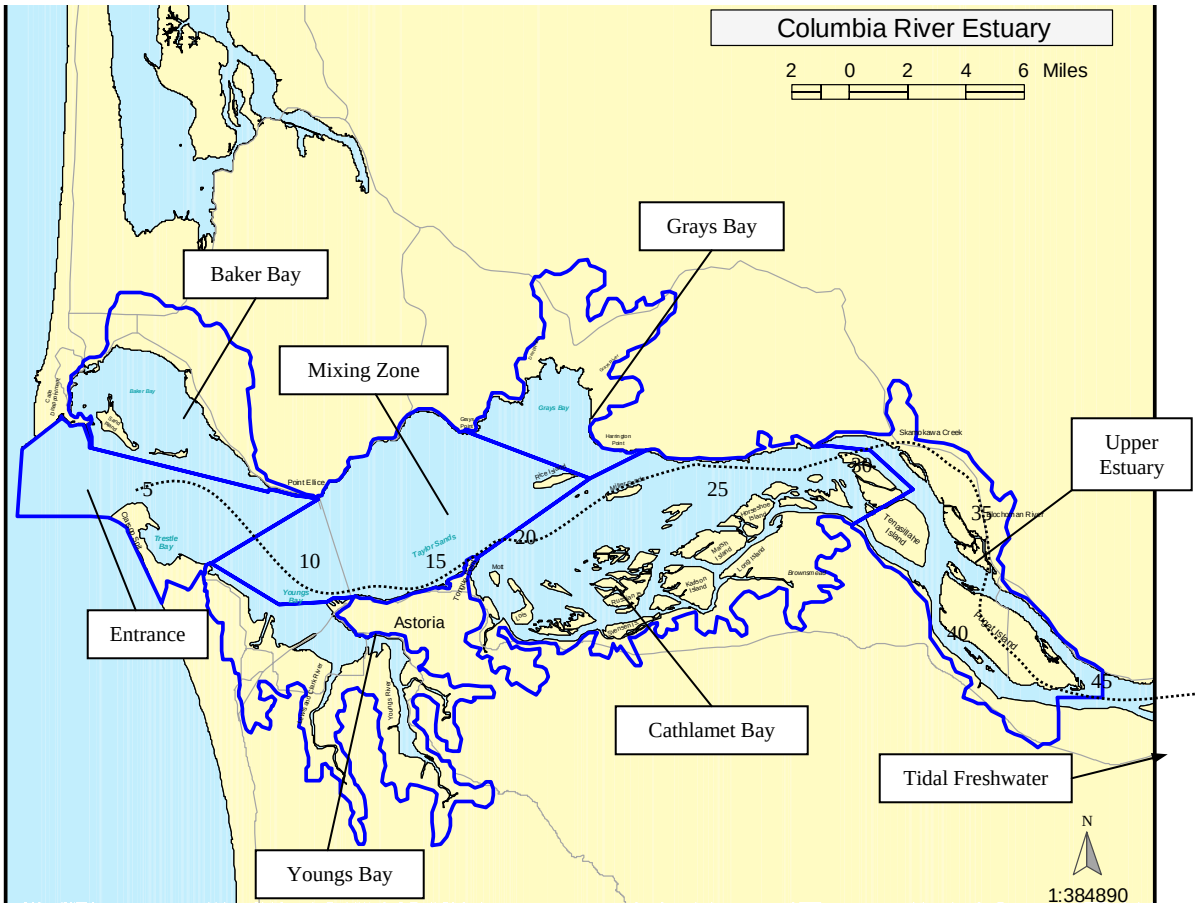


Figure 2-5. Approximate area boundaries of distinct physiographic areas within the Columbia River estuary based on Thomas (1983) and Johnson et al. (2003b). Dashed line represents an approximation of the main channel; numbers along this channel are approximate river mile measurements.

2.1.1.7 Major Land Uses

The size of the subbasin lends itself to an abundance of possible land uses. The area contains multiple population centers and political jurisdictions, including the largest Oregon population center (Portland) and the fourth largest in Washington (Vancouver; Figure 2-1). Nine counties are located wholly or partially within the subbasin as well as 14 port districts. Jurisdictional boundaries of many of these entities overlap. The following list is a brief description of the major land uses within the lower Columbia River mainstem and estuary subbasin (Marriott et al. 2001):

- Approximately 2.5 million people live in the basin; many others visit for recreation or business.
- Hundreds of fish and wildlife species reside in or migrate through the estuary; more than a dozen rare and endangered species utilize the lower river and estuary.
- Bonneville Dam generates power for the region and beyond as part of the Federal Columbia River Power System.
- Five deep-water ports support a shipping industry that transports 30 million tons of goods annually.

- Timber harvest occurs throughout the basin; six major pulp and paper mills contribute to the regions economy.
- Aluminum plants along the river produce 43% of the U.S.'s aluminum.
- Agriculture is widespread throughout the floodplain, including many fruit and vegetable crops as well as beef and dairy cattle.
- Although commercial fishing activity has declined in recent years, the industry continues to play a significant role in the region.
- Primary recreational activities include fishing, boating, hiking, and windsurfing.

2.1.1.8 Areas of Biological Significance

Numerous areas of special biological significance provide critical natural habitats and help maintain the delicate balance of the ecosystem. Since 1870, more than half of the tidal swamp and marsh areas in the lower river have been lost as a result of diking, draining, filling, dredging, and flow regulation. Since 1948, tidal wetland habitats in the lower 46 miles of the river have decreased by as much as 70%. Much of the remaining wetlands are protected by inclusion in the Lewis and Clark and the Julia Butler Hansen National Wildlife Refuges. In addition to the feeding, spawning, nursery, and migratory habitat they provide, these wetlands are critical to flood control and water quality. Specific areas of special biological significance in the Lower Columbia River Estuary Program include:

- Clatsop Spit in Fort Stevens State Park is a significant migratory shorebird feeding and nesting area for sanderlings
- Baker Bay, Youngs Bay, Trestle Bay, Grays Bay and Cathlamet Bay are especially productive areas for benthic organisms, anadromous fish and waterfowl
- Bald eagle nesting sites in the lower estuary
- High-quality wetlands in Pacific County
- Lewis and Clark National Wildlife Refuge, which includes most of the islands and the open water between RM 18 and 25; managed primarily for waterfowl
- Julia Butler Hansen National Wildlife Refuge, which includes the lower Elochoman River area in Washington
- Tenasillahee Island Research Natural Area; the upstream tip of the island consists of a spruce swamp that is a remnant of a once widespread habitat type in the program study area
- Puget Island Natural Area Preserve
- White Island Natural Area Preserve, black cottonwood-willow community, and high-quality surge-plain wetlands in Wahkiakum County
- Ridgefield National Wildlife Refuge
- Vancouver Lake Lowlands, including Shillapoo Wildlife Recreation Area
- Sauvie Island Wildlife Management Area
- Steigerwald Lake Wildlife Refuge
- Franz Lake Wildlife Refuge
- Pierce Island Natural Area Preserve and a high-quality, black cottonwood-Oregon ash community, both in Skamania County

- Pierce Ranch Wildlife Refuge

Other areas of special biological significance include: Bradwood Cliffs; Kerry Island; Big and Little Creek Estuary; Tansy Point; Tongue Point; Cooperage Slough; Russian Point Marsh; East Sand Island; Gnat Creek Marsh; Blind Slough Spruce Swamp; Burnside Marsh; Deer Island; Wallace Island; Prescott and Carr Slough; Wapato Bay; Scappoose Flats; Sandy Island; Burlington Bottom; Smith and Bybee Lakes; Virginia Lake; McGuire Island; Sandy River Delta; Gary, Flat, and Chatham Islands; Horsetail Creek Wetlands; and Rooster Rock State Park wetlands.

2.1.2 *Focal Species*

Focal species are those species that have special legal, ecological, cultural, or local status and are used to evaluate the health of the ecosystem and the effectiveness of management actions. In this section, we describe the process by which the focal species list was created (Section 2.1.2.1) and provide a brief description of each focal species life history and abundance trends (Sections 2.1.2.2 through 2.1.2.14).

2.1.2.1 Selection Process

Focal species selection followed the NPCC's *Technical Guide for Subbasin Planners* (NPCC 2001). The *Technical Guide* indicates that the assessment of focal species serves two functions:

It provides insight on the status of species that warrant legal consideration because of Endangered Species Act (ESA) or treaty right considerations; and

It serves a diagnostic function, with certain species used as an indicator of broad ecological health.

Further, focal species are used to evaluate the effectiveness of management actions and the health of the ecosystem. The *Technical Guide* offers four criteria for selecting focal species (in order of importance):

- Designation as Federal endangered or threatened species;
- Ecological significance;
- Cultural significance; and
- Local significance.

Within the Lower Columbia and Estuary subbasins, identification and selection of species has been a thoughtful and deliberative facet of the subbasin planning process. Early in 2001, the Lower Columbia Fish Recovery Board (LCFRB), together with the Washington Department of Fish and Wildlife, considered an initial set of 21 species for the 11 subbasins on the Washington State side of the Lower Columbia Region, including the mainstem and estuary. In 2003, the Lower Columbia River Estuary Program (LCREP; now called the Lower Columbia River Estuary Partnership) entered into an agreement with Oregon to participate with the LCFRB in the co-development of a subbasin plan for the Columbia Estuary and Lower Columbia Subbasins. The Planning Group added three additional species not contemplated by the LCFRB

(river otter, osprey, and bald eagle). Table 2-4 depicts the selection of species for the estuary/mainstem subbasin assessment and their relationship to selection criteria.

Table 2-4. Species Selection and Planning Context.

Species	ESA	Ecological[1]	Cultural	Economic[2]	Recreation[3]
Species of Primary Interest (Focal Species)					
Fall Chinook	X	X	X	X	X
Chum	X	X	X	X	X
Spring Chinook	X	X	X	X	X
Winter Steelhead	X	X	X	X	X
Summer Steelhead	X	X	X	X	X
Coho	X	X	X	X	X
Pacific Lamprey	X	X	X		
Bald Eagle	X	X	X		
CWT Deer	X	X[4]	X		
Green Sturgeon		X	X		
White Sturgeon		X	X	X	X
Species of Ecological Significance					
N. Pikeminnow		X		X[8]	X
Shad		X[7]		X	X
River Otter		X[9]			
Eulachon		X	X	X	X
Caspian Tern		X[6]		X	
Osprey		X			
Yellow Warbler		X[10]			
Red-eyed Vireo		X[10]			
Species of Management Interest					
Dusky Canada Goose				X[5]	
Sandhill Crane	X			X[5]	
Species of Recreational Significance					
Walleye		X[7]			X
Smallmouth Bass		X[7]			X
Channel Catfish		X[7]			X

1 May be positive or negative ecological impact; this column only indicates relative significance.
2 May be positive or negative economic impact; this column only indicates relative significance.
3Active recreation potential (e.g., harvest).
4 Likely historically ecologically important.
5 Seasonal crop damage.
6 Historically not present in estuary.
7 Non-native species.
8 Some economic importance for control program.
9 Indicator of ecosystem health.
10 Indicator of habitat type.

In the species selection process, it became evident that individual species were important to the subbasin planning process for different purposes and significance at the subbasin- and

Columbia River Basin-scale. Some species, like summer steelhead, have basin-wide significance in terms of their legal, ecological, cultural, economic, and recreational significance. Other species, like the river otter, are of interest because of their value as an indicator of ecosystem health. Still others, like yellow warblers, are indicators of a specific habitat type.

The Planning Group decided to organize the list of species into broad categories that help convey the purpose and significance that individual species play in the planning process. All species will be addressed in the management plan and will have biological objectives and strategies developed for them, although the structure of the biological objectives and strategies may take different form due to inherent differences in their significance, ecological interactions, information available, and management structures in place.

Species of Primary Interest (Focal Species): This category of species will receive the highest level of attention and are considered the focal species for purposes of developing a subbasin plan that adheres to the standards of the Council. The ocean-type and stream-type salmonids play a major role in structure and content of the subbasin assessment because of their importance to all of the selection criteria, the absence of management plans in the estuary/mainstem, and the far-reaching implications of their life cycle requirements to various landscape-level processes and habitat conditions within and outside of the subbasins. Well developed recovery or management plans exist for bald eagle, CWT deer, pacific lamprey, and the green/white sturgeon. The plans augment this assessment and provide the basis for developing biological objectives and strategies for these species. The subbasin management plan will address the integration of the various species-specific management plans into a balanced approach for all focal species.

Species of Ecological Interest: This category of species is intended to inform subbasin planners of the general health of the estuary/mainstem in terms of quality of the environment, habitat diversity, or management issues. Each of these species will be addressed in the management plan. Native species include: Northern Pikeminnow, River Otter, eulachon, Caspian terns, Osprey, yellow warbler, and red-eyed vireo; non-native species include shad.

Species of Management Interest: This category of species is important from a management perspective and is indicative of a habitat type that is not represented elsewhere in the planning process (e.g. agricultural lands). Species include the Dusky Canada Goose and the Sandhill Crane (federally listed).

Species of Recreational Interest: This category of non-native species has recreational interest in the estuary/mainstem, as well as poorly understood ecological interactions with salmonids. They include walleye, smallmouth bass, and channel catfish.

Detailed descriptions of the biology and life history of each species are found elsewhere in the Technical Foundation (Appendix A). The following sections are intended to briefly describe the life history of each focal species as it relates to potential use of lower Columbia River mainstem and estuary habitats.

2.1.2.2 Ocean-type Salmonids

Ocean-type salmonids represent the life history strategy that migrates downstream from the spawning area within days to months of emergence from the gravel. Early migrants may only be 30-40 mm fork length, while later migrants are usually larger, ranging from 50-80 mm fork length; subyearling migrants from the mid-Columbia and further up the basin tend to be

considerably larger, ranging from 70-100 mm fork length (NMFS 2002). Ocean-type salmonid populations in the lower Columbia River include fall chinook and chum salmon. Ocean-type juvenile salmon commonly spend weeks to months rearing in the lower mainstem and estuary prior to reaching the requisite size for ocean entry and survival. Ocean-type salmon are oriented to low velocity, near-shore habitats; riparian/wetland areas in the mainstem and tidal marsh habitats in the estuary that are connected to the lower river (i.e. access not blocked via dikes) provide essential cover and feeding requirements of ocean-type juvenile salmon (Simenstad and Cordell 2000 as cited in USACE 2001, Bottom et al. 2001). They are often associated with substrates consisting of fines and sands, although this may be an artifact of the low velocity preference rather than a partiality for fine-grained substrates. As fish grow, ocean-type juvenile salmon utilize other habitat types (e.g. water column habitat) and are not as strongly associated with near-shore habitats.

2.1.2.2.1 Fall Chinook

Chinook salmon (*Oncorhynchus tshawytscha*) are the largest and most diverse of the Pacific salmon. Two runs of fall chinook return to Washington lower Columbia River tributaries: "tule" fall chinook, and "bright" late fall chinook. Tule fall Chinook return from August through November to spawn almost immediately, typically in large tributary mainstems. Fall Chinook have ocean-type life histories where juveniles gradually migrate downstream as subyearlings during their first spring and summer. Most tule fall Chinook adults return after 2 to 3 years in the ocean where they range along the coasts of Washington, Oregon, and British Columbia. Bright late fall Chinook return from August through October and spawn November through January. Life history is otherwise similar to tule fall Chinook except the lower river bright fall run migrates farther north, and may spend up to four years in the ocean before returning.

Lower Columbia River Chinook populations were listed as threatened in 1999. Chinook salmon were historically present in all Washington lower Columbia tributaries. Tule fall Chinook were widely distributed while bright fall Chinook were limited to the Lewis River, and perhaps the mainstem Columbia near the present Bonneville Dam site. The Willamette/Lower Columbia Technical Recovery Team has identified 31 historical populations of Chinook salmon in the Columbia River ESU. Washington accounts for 13 of 20 tule fall and one of two late fall Chinook populations in this ESU; the other Chinook populations originate in Oregon waters. All Washington lower Columbia Chinook populations are below proposed recovery targets with the possible exceptions of Lewis late fall, Coweeman fall, and East Fork Lewis fall population. Current runs of tule fall Chinook are dominated by hatchery-produced fish.

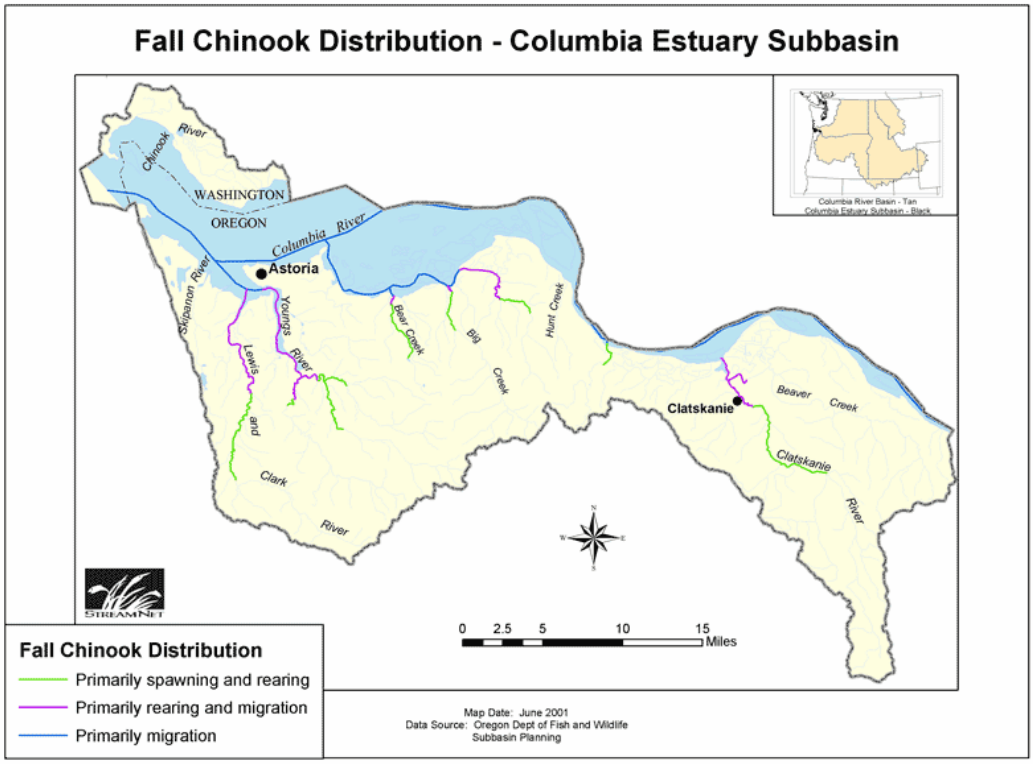
Fall Chinook exhibit some variability in their timing of migration to the estuary. Some fall Chinook fry migrate to the ocean soon after yolk resorption at 30-45 mm in length (Lister et al. 1971, Healey 1991). In most river systems, however, fry migrate at 60–150 days post-hatching or as fingerling in the late summer or autumn of their first year. When environmental conditions are not conducive to subyearling migration, ocean-type Chinook salmon may remain in freshwater for their entire first year.

In the Columbia River estuary, subyearling Chinook salmon were captured in every month of the year and were distributed throughout freshwater, estuarine, and marine regions (Bottom et al. 1984). Reimers (1973), working in the Sixes River, Oregon, suggested that estuarine rearing is critical to fall chinook survival. Subyearling Chinook were one of the most abundant species collected in the Columbia River estuary. Bottom et al. (1984) suggested that subyearling Chinook abundance was partially related to their slow migration through the estuary

(i.e. subyearling Chinook were available for long periods of time in a variety of estuarine habitats). For example, subyearling Chinook tagged and released in April and May were captured in the estuary through October (Bottom et al. 1984). Subyearling Chinook moved through the estuary slower than other salmonids; in fact, migration rate appeared to decrease for about half the hatchery groups when they entered the estuary (Bottom et al. 1984). Generally, juvenile hatchery subyearling Chinook released further upstream in the basin migrated at a faster rate than juveniles released lower in the system (Bottom et al. 1984). Subyearling Chinook abundance was highest in the spring and summer months; during spring and summer, subyearling Chinook were most frequently associated with water column and nearshore habitats while in the winter, they were more frequently associated with nearshore, shoals, and bay habitats (Bottom et al. 1984). Subyearling Chinook represented 68% of the total catch of juvenile salmonids in the estuary (Bottom et al. 1984).

Diet of juvenile fall chinook varies considerably based on fish size and location in the river, estuary, and nearshore habitats (see Craddock et al. 1976, McConnell et al. 1978, Levy and Northcote 1982, McCabe et al. 1983, Bottom et al. 1984, Dawley et al. 1986, McCabe et al. 1986, Bottom and Jones 1990, Sherwood et al. 1990, Brodeur 1992, Miller and Simenstad 1997, Simenstad and Cordell 2000). For young Chinook in the lower mainstem, Craddock et al. (1976) determined that diptera were the primary prey species during the winter and spring while zooplankton (primarily *Daphnia*) were the major prey item from July to October; similarly, Bottom et al. (1984) and Bottom and Jones (1990) reported that young chinook in the estuary primarily ate amphipods (*Corophium*), cladocerans (*Daphnia*), and diptera, with *Corophium* dominant in winter and spring and *Daphnia* dominant in summer.

Adult fall Chinook primarily use the Columbia River estuary and lower mainstem as a migratory route to spawning areas (Figure 2-6). There is evidence of fall Chinook spawning and subsequent rearing in Oregon tributaries in the estuary region and in Washington tributaries in the tidal freshwater region near Bonneville Dam (Figure 2-6). Recent spawning surveys indicate fall Chinook spawning in the Columbia River mainstem below Bonneville Dam; however, these fish are expected to be hatchery strays and the National Marine Fisheries Service (NMFS) does not consider them to be part of the lower Columbia River fall Chinook ESU. (For more information regarding the fall Chinook life cycle, refer to the Technical Foundation, Volume I, section 3.2). Additional background information on fall Chinook is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.



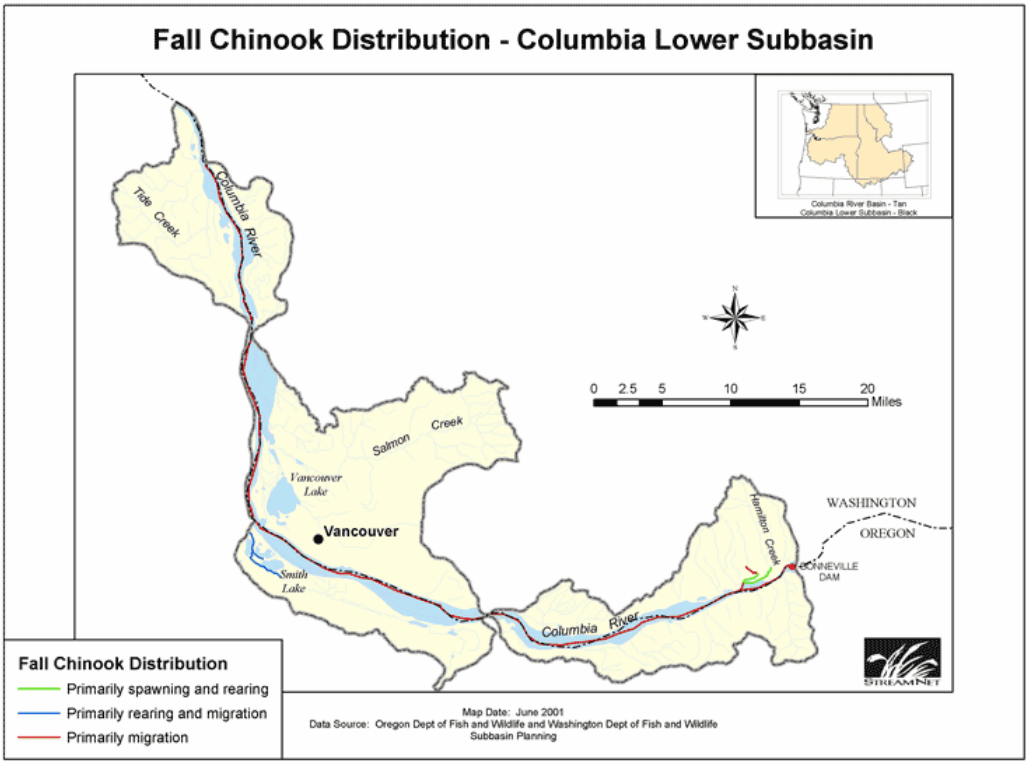


Figure 2-6. Adult fall Chinook distribution in the Columbia Estuary and Columbia Lower Subbasins.

2.1.2.2.2 Chum Salmon

Chum salmon (*Oncorhynchus keta*) return during fall (generally October/November) to spawn in the lowermost reaches of the Columbia River tributaries often just above tidewater. Chum fry migrate downstream almost immediately after emergence and spend most of their life in the estuary or ocean. Runs of over one million chum are believed to have once returned to the Columbia River. Annual runs now average 4,000 fish, about 3% of the historical run size. All naturally produced chum populations in the Columbia River and its tributaries in Oregon and Washington were listed as threatened in August 1999.

Chum salmon once migrated as far upstream as the Walla Walla River. Today, production is generally limited to areas downstream of Bonneville Dam, including Grays River, Hardy Creek, and Hamilton Creek, and in the mainstem Columbia River near Ives Island. The latter three populations are located immediately downstream of Bonneville Dam. The Willamette/Lower Columbia Technical Recovery Team has identified 16 historical populations of chum salmon in the Columbia River ESU. Of these, eight occur only in Washington, six occur only in Oregon, and two are shared between states. Chum populations have been largely extirpated for 14 of 16 historical populations. Significant populations exist only in the Grays River and the lower Columbia River Gorge tributaries and mainstem. All chum populations are below the lower bound of proposed recovery planning targets with the possible exception of the lower Gorge population.

The period of estuarine residence appears to be the most critical phase in the life history of chum salmon and may play a major role in determining the size of the subsequent adult run back to fresh water (Mazer and Shepard 1962, Bakkala 1970, Mathews and Senn 1975, Fraser et al. 1978, Peterman 1978, Sakuramoto and Yamada 1980, Martin et al. 1986, Healey 1982, Bax 1983, Salo 1991).

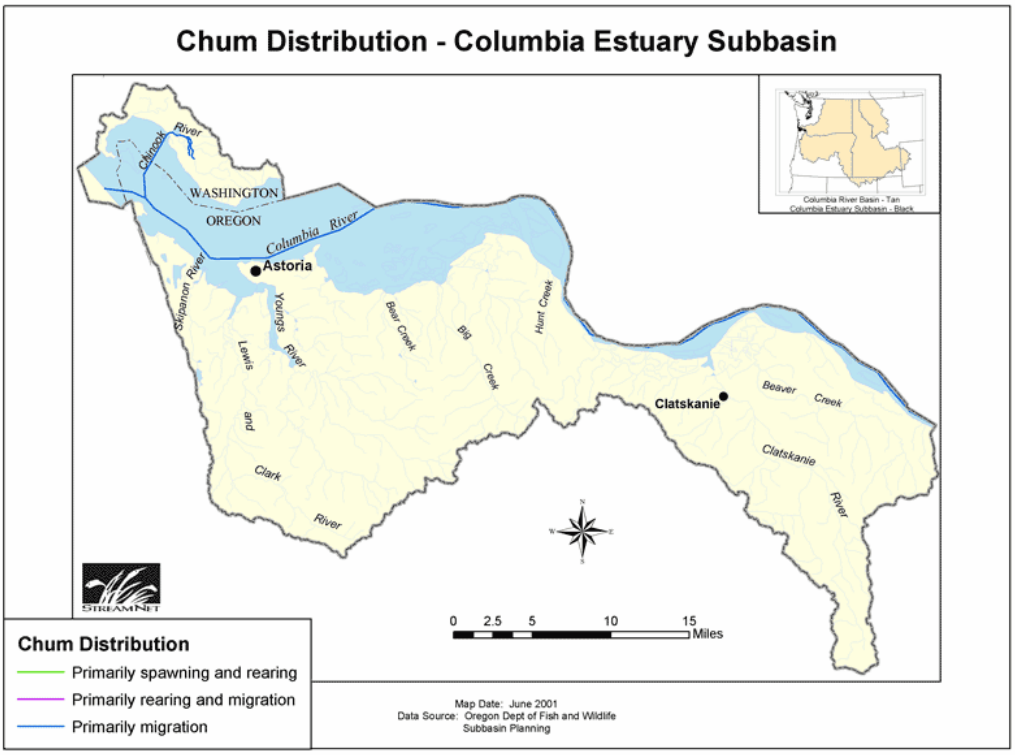
Chum fry generally emigrate shortly after emergence; several factors influence the timing of downstream migration, including time of adult spawning, stream temperatures during egg incubation and after hatching, fry size and nutritional condition, population density, food availability, stream discharge volume and turbidity, physiological changes in the fry, tidal cycles, and day length (Simenstad et al. 1982, Salo 1991). In Washington, chum may reside in fresh water for as long as a month (Salo and Noble 1953, Bostick 1955, Beall 1972).

In the Columbia River estuary, juvenile chum salmon were a minor portion of the catch during sampling efforts of Bottom et al. (1984); chum, sockeye, and cutthroat collectively represented 1% of the total juvenile salmonid catch. Chum salmon juveniles were captured in the estuary during April and May during both years of the study; chum salmon were present in the estuary from February through June (Bottom et al. 1984). Juvenile chum salmon were primarily distributed within the freshwater or estuarine regions of the estuary, although there was one occurrence in the marine region (Bottom et al. 1984).

Diet varies considerably based on fish size and location in the river, estuary, and nearshore habitats (see Craddock et al. 1976, McConnell et al. 1978, Levy and Northcote 1982, McCabe et al. 1983, Bottom et al. 1984, Dawley et al. 1986, McCabe et al. 1986, Bottom and Jones 1990, Sherwood et al. 1990, Brodeur 1992, Miller and Simenstad 1997, Simenstad and Cordell 2000).

Chum salmon adults utilize the Columbia River estuary and lower mainstem for migration to spawning areas. Chum salmon are known to spawn in Washington tributaries

associated with the Mainstem Lower Columbia and Columbia River Estuary Subbasins, such as the Chinook River or Hamilton Creek (Figure 2-7). Further, spawning and outmigration surveys have documented successful chum spawning in the lower mainstem Columbia River below Bonneville Dam along the north bank near the I-205 bridge. (For more information regarding the chum salmon life cycle, refer to the Species Technical Foundation, Appendix A)



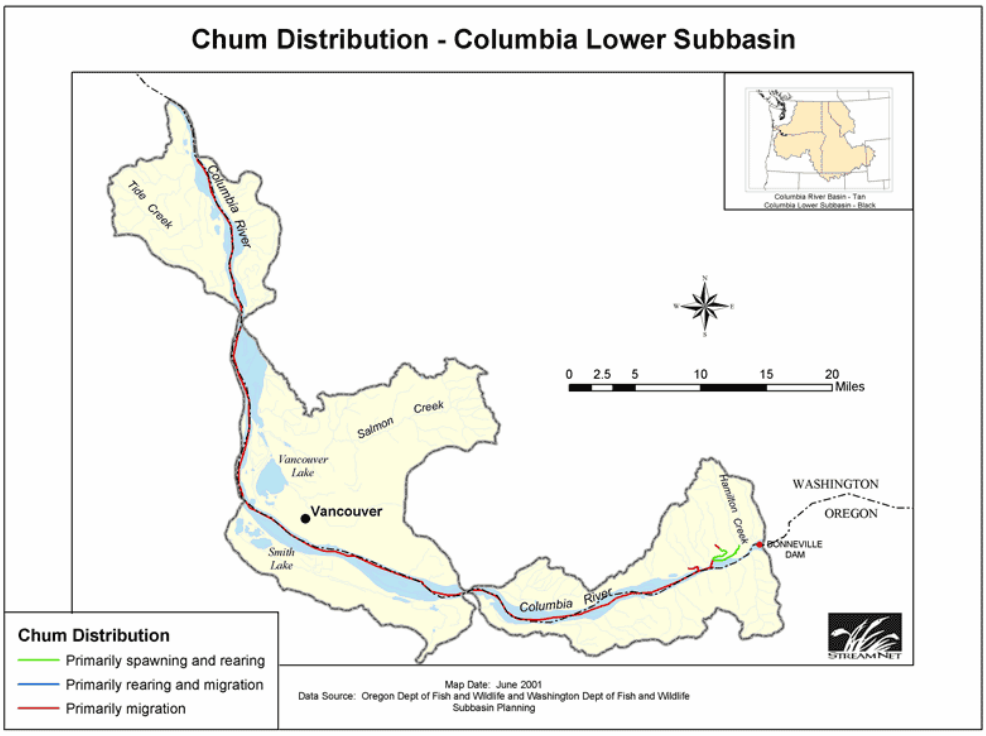


Figure 2-7. Adult chum salmon distribution in the Columbia Estuary and Columbia Lower Subbasins.

2.1.2.3 Stream-Type Salmonids

Stream-type salmonids represent the life history strategy that rear within the natal stream for months or years after emergence from the gravel and outmigrate during their second year of life. In general, stream-type juvenile salmon reach the lower mainstem and estuary at a relatively large size (> 80mm) and commonly spend less time than ocean-type salmonids rearing in the lower mainstem and estuary. Stream-type juvenile salmonids actively migrate through the lower Columbia River mainstem and estuary. Stream-type salmon are oriented to water column habitats and are typically found throughout the near surface water column (i.e. top 6 m); they tend to avoid low-velocity areas and are not associated with any specific substrate type. Stream-type salmonid populations in the lower Columbia River include spring Chinook, winter steelhead, summer steelhead, and coho salmon.

Yearling salmonids have been documented eating the same types of organisms as subyearlings, although the composition and specific diet items differ. For example, Bottom et al. (1984) noted that adult *Diptera* and *Corophium spp*. were major prey items of both yearling and subyearling Chinook; however, *Diptera* accounted for about 55% of yearling Chinook diet while it accounted for about 8% of the diet of subyearling Chinook. In the lower Columbia River and estuary, Dawley et al. (1986) and Bottom and Jones (1990) observed yearlings salmonids consuming diptera, cladocerans, and amphipods.

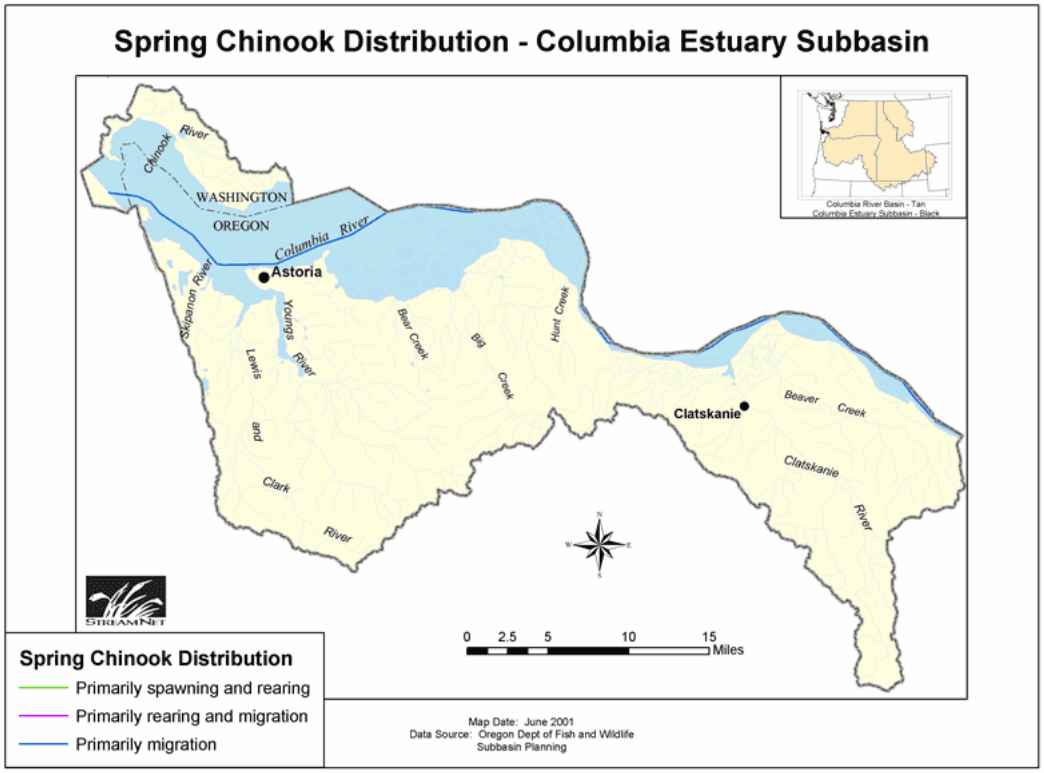
2.1.2.3.1 Spring Chinook

Chinook salmon (*Oncorhynchus tshawytscha*) are the largest and most diverse of the Pacific salmon. Spring Chinook typically return to freshwater in March and April and migrate into small headwater streams to spawn in late summer. Spring Chinook exhibit a stream-type life history where juveniles rear in tributary streams for one year before rapidly migrating downstream on the spring freshet. Most adults return after two to four years in the ocean where they migrate far to the north off Canada and Alaska.

Lower Columbia River Chinook populations were listed as threatened in 1999. Chinook salmon were historically present in all Washington lower Columbia tributaries; spring Chinook were present in the larger Cascade subbasins. The Willamette/Lower Columbia Technical Recovery Team has identified 31 historical populations of Chinook salmon in the Columbia River ESU. Washington accounts for seven of nine spring Chinook populations in this ESU; the other chinook populations originate in Oregon waters. All Washington lower Columbia spring Chinook populations are below proposed recovery targets. Current runs of spring chinook are dominated by hatchery-produced fish.

Yearling Chinook salmon were present in the estuary most months of the year and were distributed throughout the freshwater, estuarine, and marine regions (Bottom et al. 1984). Yearling Chinook abundance was highest in April and May and was relatively low for most other months; they represented 8% of the catch of juvenile salmonids (Bottom et al. 1984). Yearling Chinook were most frequently associated with water column and nearshore habitats; they were most susceptible to purse seine harvest in main channel sampling stations, indicating an affinity to water column habitat (Bottom et al. 1984). Yearling Chinook migrated through the estuary faster than subyearlings but slower than steelhead (Bottom et al. 1984). More than half of the hatchery groups of yearling Chinook appeared to decrease their migration rate through the estuary, however, only about a third increased in mean fork length (Bottom et al. 1984). As with other salmonids, juvenile hatchery yearling Chinook released further upstream in the basin migrated at a faster rate than juveniles released lower in the system (Bottom et al. 1984).

Adult spring Chinook utilize the estuary and lower mainstem primarily as a migration route to spawning locations. There is no evidence of spring Chinook spawning in the lower mainstem or in tributaries of the Columbia Estuary and Lower Columbia subbasins Additional background information on spring Chinook is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.



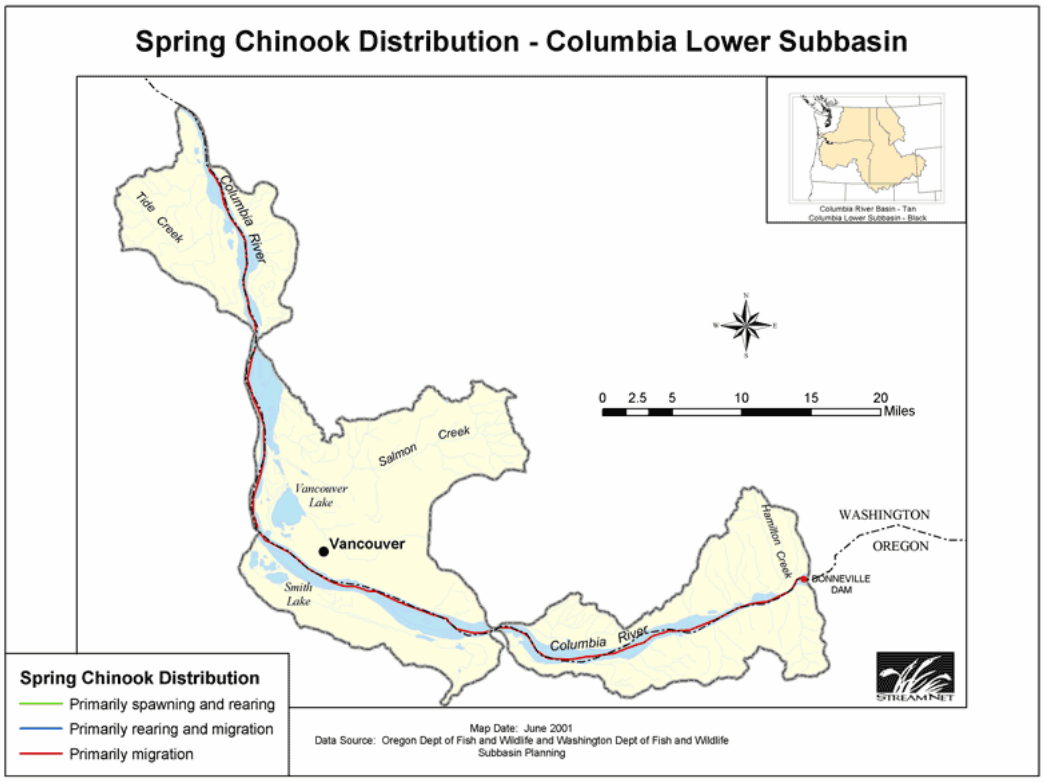


Figure 2-8. Adult spring chinook distribution in the Columbia Estuary and Lower Columbia Subbasins.

2.1.2.3.2 Steelhead

Steelhead (*Oncorhynchus mykiss*) are rainbow trout that migrate to and from the ocean. Resident and anadromous life histories are often found in the same population. Steelhead exhibit tremendous variability in life history with juveniles rearing for 1 to 4 years in freshwater before migrating seaward and as adults spending 1 to 3 years in the ocean. Steelhead generally migrate northward along the coast of Canada and Alaska before dispersing far out into the North Pacific.

Lower Columbia River steelheadare listed as threatened under the ESA. The Willamette/Lower Columbia Technical Recovery Team has identified 23 historical populations of steelhead in the Columbia River ESU. Washington accounts for 14 of 17 winter run steelhead and five of six summer run steelhead populations in this ESU. Three additional winter run populations of the unlisted Washington Coast ESU occur in lower Columbia subbasins included in this planning process. Small but significant steelhead populations remain in most Washington subbasins where they were historically present. All Washington lower Columbia winter steelhead populations are below proposed recovery planning targets with the possible exception of the Kalama winter steelhead population. All Washington lower Columbia summer steelhead populations are below proposed recovery planning targets with the possible exception of the Wind summer population.

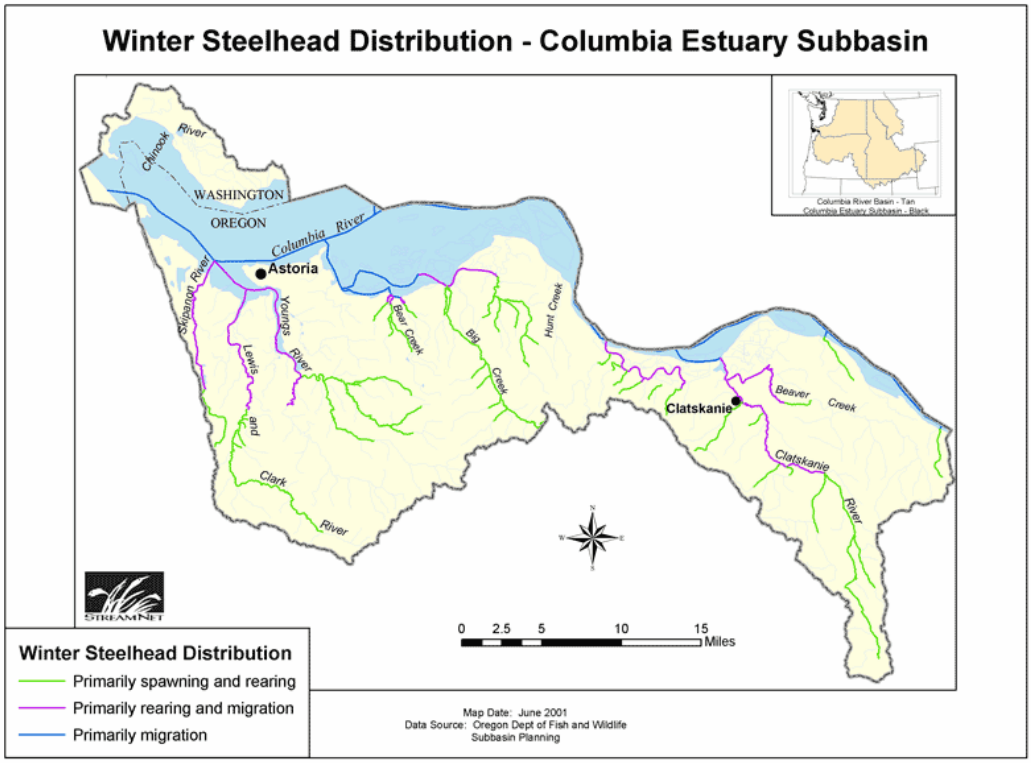
Steelhead in the Columbia River estuary consumed a relatively even proportion of *Corophium salmonis* (amphipod), *Corbicula manilensis* (bivalve), and adult *Diptera* (Bottom et al. 1984).

Juvenile steelhead were present in the Columbia River estuary from February to July of each year of sampling by Bottom et al. (1984); steelhead abundance was greatest in May and relatively low for other months (Bottom et al. 1984). Juvenile steelhead constituted 5% of the total juvenile salmonid catch (Bottom et al. 1984). Steelhead juveniles were distributed throughout the freshwater, estuarine, and marine regions of the estuary; they were most frequently associated with water column habitats (Bottom et al. 1984). Juvenile steelhead moved through the estuary more rapidly than other salmonids; based on catch data, they were present in the estuary for the shortest duration of any of the salmonid group (Bottom et al. 1984). Winter steelhead have been found to migrate at an average rate of 3.3 km/hr, traveling 134-143 km in 32 to 90 hours (Durkin 1982, Dawley et al. 1986 as cited in USACE 2001). Migration rate of many hatchery groups of juvenile steelhead increased through the estuary (Bottom et al. 1984). As with other salmonids, juvenile hatchery steelhead released further upstream in the basin migrated at a faster rate than juveniles released lower in the system (Bottom et al. 1984).

.2.1.2.3.2.1 Winter Steelhead

Winter steelhead return to freshwater between December and May and generally spawn in late April and early May. Winter steelhead returned to the Cowlitz, Kalama, NF and EF Lewis, Washougal, and Wind. Where winter and summer runs occur in the same stream, winter steelhead tend to spawn lower in the watershed than summer steelhead.

Adult winter steelhead use the Columbia River estuary and lower mainstem for migration to spawning areas. Further, winter steelhead are known to spawn and rear in numerous small tributaries associated with the Columbia Estuary and Lower Columbia Subbasins (Figure 2-9). Additional background information on winter steelhead is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.



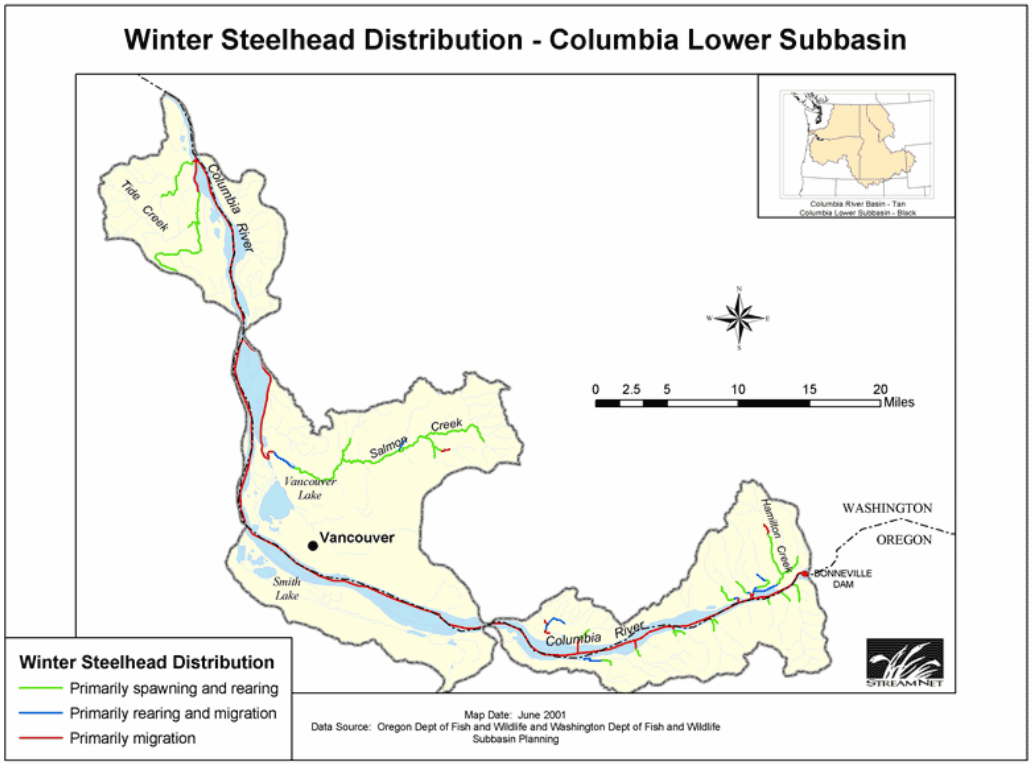
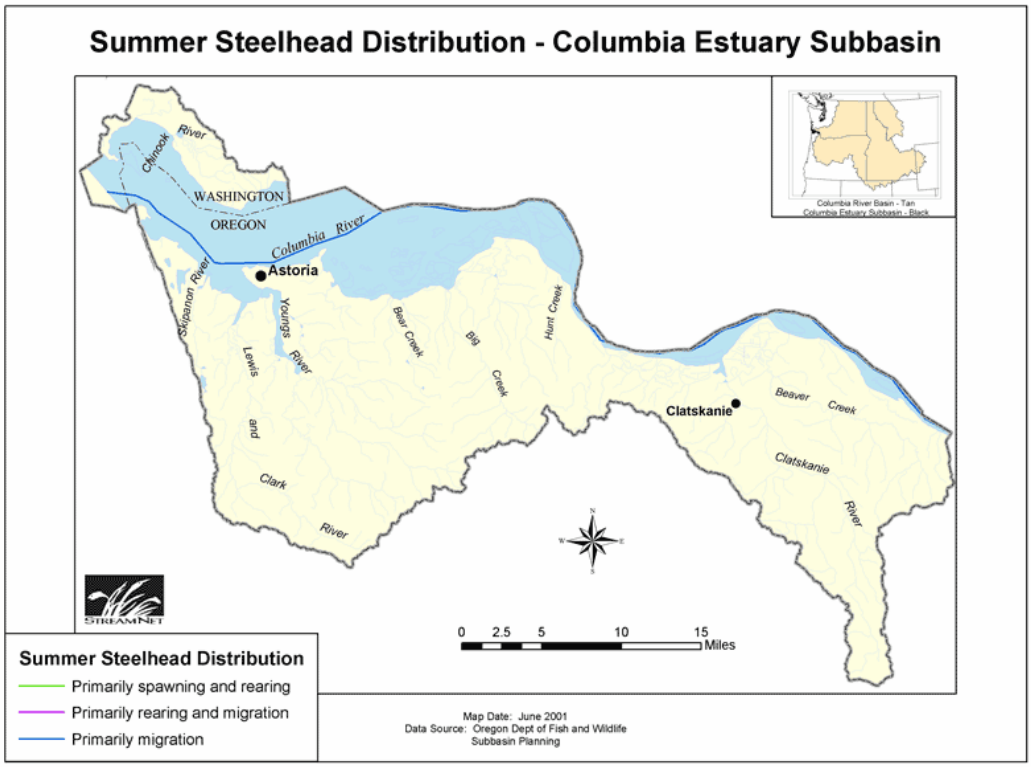


Figure 2-9. Adult winter steelhead distribution in the Columbia Estuary and Lower Columbia Subbasins.

.2.1.2.3.2.2 Summer Steelhead

Summer steelhead return from the ocean between May and October and generally spawn between late February and early April. Watersheds that historically supported summer steelhead included the Kalama, North Fork Lewis, East Fork Lewis, Washougal, and Wind. Where summer and winter runs occur in the same stream, summer steelhead tend to spawn higher in the watershed than winter steelhead.

Adult summer steelhead use the Columbia River estuary and lower mainstem for migration to spawning areas. Further, there is evidence of summer steelhead spawning and rearing in small Oregon tributaries associated with the Lower Columbia Subbasin (Figure 2-10). (For more information regarding the summer steelhead life cycle, refer to the Technical Foundation, Volume I, Section 3.4.)



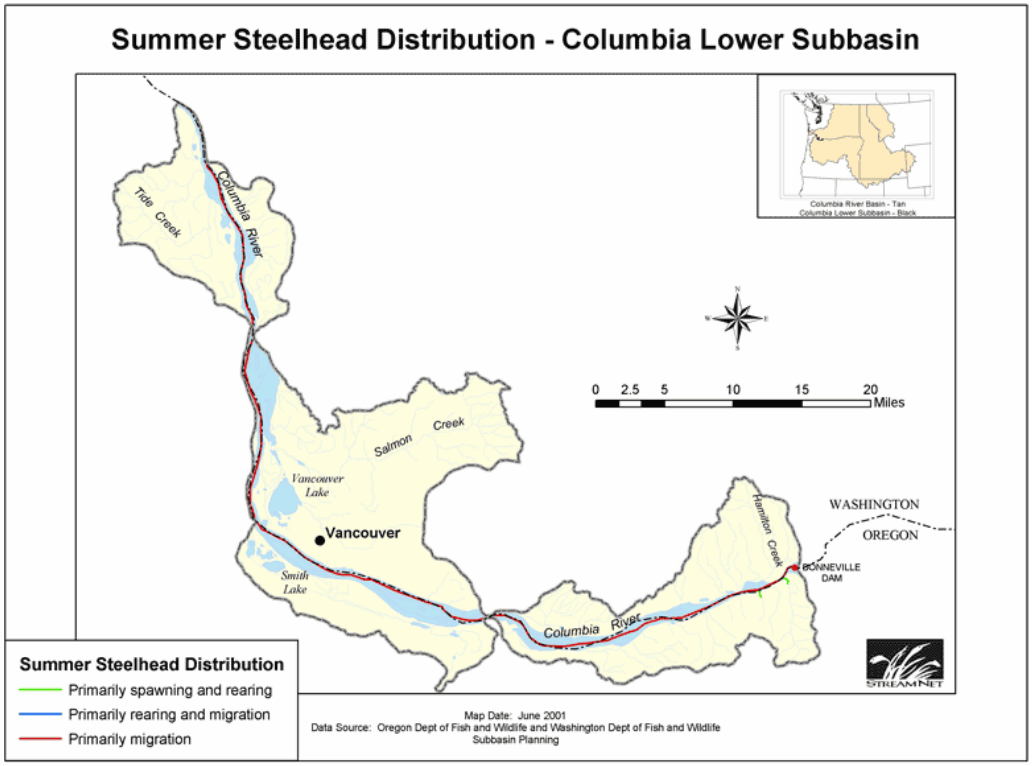


Figure 2-10. Adult summer steelhead distribution in the Columbia Estuary and Lower Columbia Subbasins.

2.1.2.3.3 Coho Salmon

Coho (Oncorhynchus kisutch) salmon spawn during fall in small streams with the onset of spawning typically tied to fall freshets in September and October. Coho adults are almost entirely three-year olds although a few jacks return at age two. Juvenile coho rear in freshwater for one year prior to migration during spring. Lower Columbia River coho runs include early and late returning stocks. Most early-run fish migrate south to mature in coastal Oregon waters. Most late-run coho migrate north into Washington coastal waters.

Coho are currently a candidate for listing under the ESA. Coho salmon historically returned to spawn in all accessible tributary reaches in the lower Columbia River basin. Today, coho populations in Washington tributaries of the lower Columbia River have been heavily influenced by extensive hatchery releases. Past fishery impacts were excessive for coho, however, current fishing impacts are relatively low as a result of implementation of selective fisheries. Tributary hydropower development has blocked significant coho habitat in the Cowlitz and Lewis basins. Current stream habitat conditions severely limit coho production.

Recent numbers of natural coho spawners are generally unknown although most wild populations are thought to have been extirpated or consist of no more than a few hundred fish. Approximately 13 Washington lower Columbia River subbasins were historically used by coho salmon according to the NOAA Fisheries status review and Washington's salmon stock inventory. Recovery targets have not yet been proposed for coho because of incomplete habitat and status information on which they could be based.

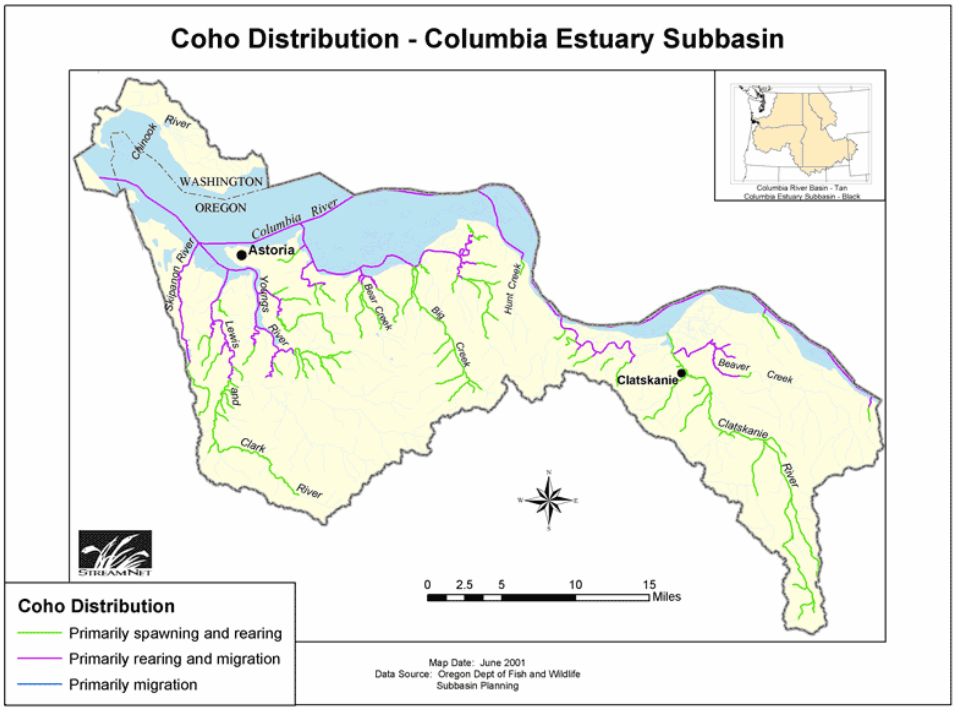
Most juvenile coho, in the region south of central British Columbia, migrate seaward as smolts in late spring, typically during their second year. Factors that tend to affect the time of migration include: the size of the fish, flow conditions, water temperature, dissolved oxygen levels, day length, and the availability of food (Shapovalov and Taft 1954). The size of coho smolts is fairly consistent over the species' geographic range; a FL of 100 mm seems to be the threshold for smoltification (Gribanov 1948).

Juvenile coho salmon were present in the Columbia River estuary from March to August of each year of sampling by Bottom et al. (1984); coho abundance was greatest in May and June and relatively low for other months (Bottom et al. 1984). Juvenile coho salmon comprised 18% of the total juvenile salmonid catch (Bottom et al. 1984). Coho juveniles were distributed throughout the freshwater, estuarine, and marine regions of the estuary; they were most frequently associated with water column habitats, however, tagged hatchery coho released in the lower Columbia (i.e. Grays River (rm 34) and Big Creek (rm 29)) were more likely to be found in shallow bays and intertidal areas than upriver coho (Bottom et al. 1984). Juvenile coho salmon moved through the estuary relatively quickly and appeared to increase their migration rate through the estuary (Bottom et al. 1984). As with other salmonids, juvenile hatchery coho released further upstream in the basin migrated at a faster rate than juveniles released lower in the system (Bottom et al. 1984).

The most common prey items of coho salmon in the Columbia River estuary were *Corophium salmonis* and *Corophium spinicorne* (amphipods) and adult *Diptera*; *Corophium salmonis* constituted over half of the coho diet (Bottom et al. 1984).

Adult coho salmon use the Columbia River estuary and lower mainstem for migration to spawning areas. Further, coho salmon are known to spawn and rear in numerous small tributaries associated with the Columbia Estuary and Lower Columbia Subbasins. Additional

background information on coho is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement).



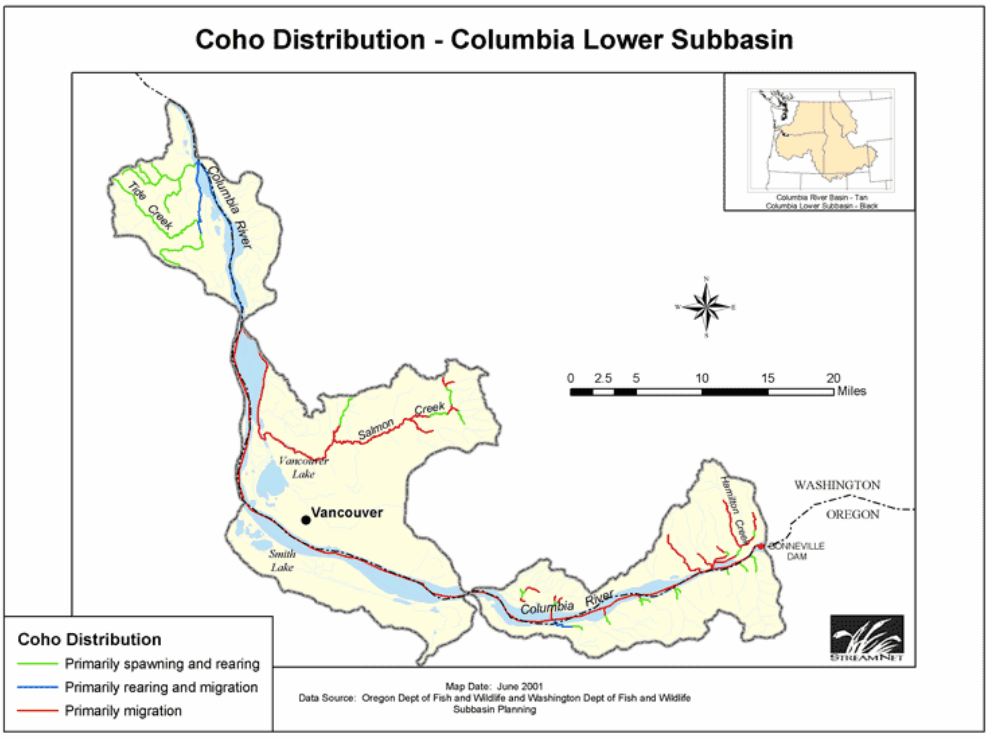


Figure 2-11. Adult coho salmon distribution in the Columbia Estuary and Lower Columbia Subbasins.

2.1.2.4 Pacific Lamprey

Pacific lamprey (*Lampetra tridentata*) are a native anadromous inhabitant of Pacific Northwest rivers including the Columbia. Lamprey spawn in small tributaries, historically as far upstream as Idaho and British Columbia, and die after spawning. Young lamprey, called ammocoetes, are algae filter feeders that burrow in sandy stream margins and side channels for up to six years before migrating downstream. Adults are predators that feed only in the ocean and attach themselves to their prey with suction mouths.

Lamprey were historically an important food source for native peoples and a significant component of the Columbia River ecosystem. Spawning adults are a source of marine-derived nutrients in the freshwater and an important prey item for sturgeon and marine mammals. In fresh water, at least seven aquatic and five avian species prey on juvenile lamprey. Relatively little is known about status and biology of Pacific lamprey. Most data suggests that populations in the Columbia basin have been declining concurrent with hydroelectric development and other habitat changes. Although adult lamprey can negotiate waterfalls, they apparently have difficulty in dam passage and juveniles migrating downstream do not appear to benefit from juvenile passage systems.

Adult Pacific lamprey entry into freshwater can vary from February (Kan 1975) to September (Beamish 1980, Scott and Crossman 1973). Habitat utilization of the lower Columbia River mainstem and estuary by adult lampreys is not known; likely, the lower Columbia River serves primarily as a migration corridor. Further, similar to most adult salmonids, lamprey feeding ceases during upstream migrations (Scott and Crossman 1973). The first juvenile life stage of lampreys, ammocoetes, burrow into sand and silt substrates after hatching, where they filter feed on algae (Scott and Crossman 1973, Kostow 2002). Ammocoetes spend approximately six years rearing in freshwater. Rearing begins downstream of the nest and, as ammocoetes grow, they gradually move downstream, generally at night, continuing to burrow and filter feed in fine substrates (Scott and Crossman 1973, Kostow 2002, Claire 2003). Because of this burrowing activity, ammocoetes may be an indicator of water quality or contaminants (Gustavo Bisbal, USFWS, personal communication). Older ammocoetes generally occupy the lower portions of river basins, and thus, may be found throughout the tidal freshwater portion of the lower Columbia. Pacific lamprey ammocoetes metamorphose into macrothalmia (physiological equivalent of a smolt) and begin the seaward migration. During this transformation, Pacific lamprey survive on lipid reserves and do not feed (Kostow 2002).

In the Columbia River estuary, juvenile Pacific lamprey were present from December to June; Pacific lamprey abundance was highest in December and was extremely low for the remainder of the year (Bottom et al. 1984). Juvenile Pacific lamprey abundance in the Columbia River estuary is relatively low compared to most other species captured (Bottom et al. 1984). Pacific lamprey juveniles were distributed throughout the freshwater, estuarine, and marine regions of the estuary, however, presence in the marine region was limited. In an analysis of estuary feeding groups, juvenile Pacific lamprey were grouped with white sturgeon, however, no data were collected regarding lamprey diet composition. This is consistent with the life history data presented above that indicates Pacific lamprey do not feed during their downstream migration to saltwater. Pacific lamprey life history data suggests use of Columbia River estuarine habitats is limited. Additional background information on Pacific lamprey is available in the Species Technical Foundation (Appendix A), and in the Management Plan Supplement.

2.1.2.5 Sturgeon

2.1.2.5.1 White Sturgeon

White sturgeon (*Acipenser transmontanus*) live in large rivers along the Pacific coast of North America and move freely between freshwater and the ocean where they may remain for variable but prolonged periods. Large sizes (over 12 feet and 1000 pounds) and long life spans (100 years or more) allow them to negotiate heavy current and outlast good and bad periods. These fish are bottom-oriented feeders that eat primarily shrimp and clams as young but graduate to a live fish diet as they get larger.

Sturgeon are an ancient order of fishes that have existed for hundreds of millions of years. Sturgeon species are found in most major river systems of the Northern Hemisphere but have been widely decimated by over fishing and dam construction. Their long lifespan and late age of maturity make sturgeon particularly susceptible to over fishing. Columbia River white sturgeon were severely over fished during the late 1800's prior to the adoption of significant fishery restrictions and recovery required decades. Mainstem dams block movements, fragment the habitat, and reduce anadromous prey. Sturgeon rarely use fish ladders which were engineered to pass the more surface-oriented salmon.

White sturgeon historically ranged all the way to the Canadian headwaters of the Columbia River and to Shoshone Falls in the upper Snake River. The lower Columbia population is among the largest and most productive sturgeon populations in the world and sustains excellent sport and commercial fisheries. However, many upriver populations have declined or disappeared. Bonneville reservoir continues to support a significant white sturgeon population although numbers and sizes are substantially less than in the lower river. Only the Kootenai River subpopulation of white sturgeon has been listed under the Endangered Species Act (endangered).

White sturgeon move freely between fresh and saltwater environments (DeVore et al. 1999); as a result, individual white sturgeon in the Columbia River below Bonneville Dam may exhibit any number of life history strategies (Bemis and Kynard 1997, Kynard 1997). Movements of adult white sturgeon in freshwater vary considerably and appear to be a function of access and seasonal food availability (Beamesderfer et al. 1995). In the lower Columbia River, DeVore and Grimes (1993) reported that adults often migrated upstream during the fall, downstream during spring, and congregated at the Columbia River estuary during summer, presumably in relation to food availability, with such movements exceeding 62 miles (100 km). DeVore et al. (1999) reported of 471 white sturgeon were originally tagged in the unimpounded lower Columbia River downstream from Bonneville Dam, sturgeon were recaptured in 23 separate locations outside the Columbia River Basin from the Fraser River, B.C., to the Sacramento River, CA, from 1976–97. Thus, adult white sturgeon may be found anytime throughout the lower Columbia River mainstem and estuary; extensive seasonal use of the estuary during summer is likely. White sturgeon often concentrate in deep water habitats, but are known to freely feed in a wide range of habitats throughout its range.

White sturgeon are communal, broadcast spawners (Wang et al. 1985; Conte et al. 1988; Paragamian et al. 2001, and references therein) that generally spawn in high velocity areas associated with gravel and larger substrates (Wydowski and Whitney 1979; Simpson and Wallace 1981; RL&L 1994, 1996; Perrin et al. 1999; Parsley et al. 2002; Paragamian et al. 2001; Golder Associates 2003, IPC 2003). Hard-bottom, high-velocity, structured habitats with adequate interstitial space are critical as spawning and incubation substrate and predation refuge

areas for broadcast-spawning white sturgeon (Parsley et al. 1993; Perrin et al. 1999; Parsley et al. 2002; Secor et al. 2002). In the lower Columbia River mainstem, white sturgeon are known to spawn in the free-flowing reach of the Columbia River Gorge below Bonneville Dam. Adhesive embryos settle to the substrate; white sturgeon larvae remain in the substrate until the yolk is absorbed (Brannon et al. 1985). White sturgeon that burrow into fine sediments commonly die as a result of suffocation. The larval swim-up dispersal stage of white sturgeon enter the water column and are subject to the influences of current (Brannon et al. 1985). Larvae seek substrates that provide cover and remain associated with these substrate until the yolk is absorbed and feeding is initiated (Brannon et al. 1985). Larvae begin exogenous feeding and metamorphose into juveniles at about 3-4 months after fertilization (Parsley et al. 2002). Juveniles feed on a variety of prey items, including chironomid larvae, amphipods, and mysis shrimp (Scott and Crossman 1973, Wydowski and Whitney 1979, Sprague et al. 1993). Thus, juvenile white sturgeon also may be found anytime throughout the lower Columbia River mainstem and estuary in a variety of different habitats.

In the Columbia River estuary, white sturgeon were part of a large group of benthic and epibenthic feeders present during the summer (Bottom et al. 1984). *Corophium salmonis* (amphipod) comprised the majority of the white sturgeon diet; other important diet items included *Neomysis mercedis* and *Macoma balthica* (Bottom et al. 1984).

In the Columbia River estuary, white sturgeon were captured all months of the year during sampling efforts by Bottom et al. (1984); catch was twice as high in the summer compared to the rest of the year. Although, white sturgeon catch was relatively low compared to other species present in the estuary (Bottom et al. 1984). White sturgeon distribution was limited to the freshwater and estuarine regions of the estuary; white sturgeon were not captured in the marine region of the estuary (Bottom et al. 1984). In the spring, white sturgeon were most frequently associated with channel bottom habitats in the freshwater region of the estuary; in the summer, white sturgeon were most frequently associated with water column and channel bottom habitats in the freshwater and estuarine regions of the estuary. Additional background information on White sturgeon is available in the Species Technical Foundation (Appendix A), and in the Management Plan Supplement.

2.1.2.5.2 Green Sturgeon

Green sturgeon (*Acipenser medirostris*) occur in the lower Columbia River but do not typically range far upstream from the estuary. NOAA Fisheries completed a status review for green sturgeon in 2003 and determined that listing under the Endangered Species Act was not warranted.

Green sturgeon is an anadromous species that spawn in several West Coast rivers but spend most of their life in near-shore marine and estuarine waters from Mexico to southeast Alaska (Houston 1988; Moyle et al. 1995). While green sturgeon do not spawn in the Columbia Basin, significant populations of subadults and adults are present in the estuary during summer and early fall. Green sturgeon are occasionally observed as far upriver as Bonneville Dam. Reasons for concentrations in the Columbia River are unclear; no spawning occurs in the system and all of the green sturgeon stomachs examined to date have been empty. These fish may be seeking warmer summer river waters in the northern part of their range.

Adult green sturgeon typically migrate into fresh water beginning in late February (Moyle et al. 1995). Spawning occurs in deep turbulent river mainstems. Klamath and Rogue River populations appear to spawn within 100 miles of the ocean, while the Sacramento

spawning run may travel over 200 miles. Spawning occurs from March–July, with peak activity from April–June (Moyle et al. 1995).

Specific spawning habitat preferences are unclear, but eggs likely are broadcast over large cobble where they settle into the cracks (Moyle et al. 1995). The adhesiveness of green sturgeon eggs is poor compared to white sturgeon (Van Eenennaam et al. 2001), which may be explained by the reduced thickness of the outer layer of the chorion of green sturgeon eggs (approximately half the thickness of that in white sturgeon; Deng et al. 2002). Optimum flow and temperature requirements for spawning and incubation are unclear, but spawning success in most sturgeons is related to these factors (Dettlaff et al. 1993). Temperatures above 68°F (20ºC) were lethal to embryos in laboratory experiments (Cech et al. 2000).

Green sturgeon larvae are distinguished from other sturgeon by the absence of a swim-up or post-hatching pelagic stage. They can be distinguished from white sturgeon by their size (longer and larger), light pigmentation, and size and shape of the yolk-sac (Deng et al. 2002). Larvae hatched in the laboratory are photonegative, exhibiting hiding behavior (Deng et al. 2002), and after the onset of exogenous feeding, green sturgeon larvae and juveniles appear to be nocturnal (Cech et al. 2000). This development pattern and behavior may be an adaptation suited for avoiding downstream displacement. Juveniles appear to spend up from 1–4 years in fresh and estuarine waters and disperse into salt water at lengths of 1-2.5 feet. Green sturgeon are benthic feeders on invertebrates including shrimp and amphipods, small fish, and possibly mollusks (Houston 1988).

Time series data on green sturgeon abundance and size composition are limited to fishery landing statistics; these do not provide a consistent index of green sturgeon abundance. Columbia River harvest per unit effort and size composition data suggest an increasing rather than decreasing trend in green sturgeon abundance. Current data indicate that: green sturgeon still spawn in most systems where they were historically present, significant numbers of spawners are present in several systems, and geographic range of spawning green sturgeon is currently stable or increasing. The wide distribution of green sturgeon, large numbers seasonally observed in some areas, and projections based on demographic rates suggest that total green sturgeon numbers are at least in the tens of thousands. Additional background information on green sturgeon is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.

2.1.2.6 Northern Pikeminnow

The northern pikeminnow *(Ptychocheilus oregonensis)* is native to freshwater lakes and rivers of the Pacific slope of western North America from Oregon to northern British Columbia. This opportunistic species has flourished with habitat changes in the mainstem Columbia River and its tributaries. Pikeminnow are of particular interest for their predation on juvenile salmon. Salmonids are an important food for large pikeminnow and millions of juvenile salmonids are estimated to fall prey each year. Predation can be especially intense in dam forebays and tailraces where normal smolt migration behavior is disrupted by dam passage. A pikeminnow management program has been implemented in the Columbia and Snake rivers in an attempt to reduce predation mortality by reducing numbers of the large, old pikeminnow that account for most of the losses. A bounty fishery program for recreational anglers is aimed at balancing pikeminnow numbers rather than eliminating the species and also has stimulated development of a popular fishery.

Northern pikeminnow are large (10-20 inches), long-lived (10-15 years), slow-growing predaceous minnows (Cyprinidae). Northern pikeminnow have successfully evolved in a range of dynamic lentic and lotic ecosystems and successfully adapted to their varied habitat conditions; they are considered opportunistic generalists that inhabit slow to moderately flowing streams and lakes. Based on known distribution and habitat usage, all life stages of northern pikeminnow may be found in many habitat types throughout the lower Columbia River mainstem; however, usage of estuarine habitats is minimal because of low salinity tolerance. This is consistent with data collected by Bottom et al. (1984). Northern pikeminnow distribution was limited to the freshwater region of the estuary; pikeminnow were not captured in the marine or estuarine regions of the estuary. Northern pikeminnow were present in the freshwater region of the estuary from June to October; pikeminnow abundance in the estuary was very low relative to other species captured (Bottom et al. 1984).

Beamesderfer (1992) attributed the widespread distribution and resiliency of northern pikeminnow to their relatively broad spawning and rearing habitat requirements. In the Columbia River downstream from its confluence with the Snake River, northern pikeminnow abundance is highest in the approximately 186 miles (300 km) from the estuary to The Dalles Dam (2,580-3,020 fish/km) and decreases significantly in the 100 miles (161 km) from The Dalles Dam to McNary Reservoir (550-690 fish/km; Beamesderfer et al. 1996). Spawning generally occurs during June and July in large aggregations that broadcast eggs over clean rocky substrate in slow-moving water at a range of depths in rivers, lake tributaries, lake/stream outlets, and shallow and deep littoral areas (Beamesderfer 1992). Wydoski and Whitney (1979) reported that eggs hatch in seven days at 65°F water, and that the young become free swimming within 14 days. Newly-emerged larval northern pikeminnow in the Columbia River drift downriver during July, generally at night. Although pikeminnow adapted to a variety of habitats, age-0 northern pikeminnow rearing in littoral habitats of the upper John Day Reservoir had significantly greater growth and lower mortality in 1994, a year with low flows, abundant instream vegetation, and high near-shore water temperatures. Parker et al. (1995) observed a similar relationship in pikeminnow age two and older; sex-specific growth coefficients were higher and sex-specific annual mortality rates were lower for pikeminnow in Columbia River reservoirs compared the free-flowing reach below Bonneville Dam. However, this may be a function of greater density of northern pikeminnow in the lower mainstem compared to the mainstem reservoirs.

The diet of northern pikeminnow varies with their size (Ricker 1941; Falter 1969; Olney 1975; Buchanan et al. 1981). In the Columbia River, invertebrates dominate the diets of northern pikeminnow that are smaller than 11.8 in (300 mm) FL, with fishes and crayfish increasing in importance as fish size increases (Thompson 1959; Kirn et al. 1986; Poe et al. 1991, 1994). Additional background information on northern pikeminnow is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.

2.1.2.7 Eulachon

Eulachon is the official common name for smelt (*Thaleichthys pacificus*) which swarm into the lower Columbia River and tributaries to spawn during winter and early spring. Eulachon are a small, anadromous forage fish inhabiting the northeastern Pacific Ocean from Monterey Bay, California, to the Bering Sea and the Pribilof Islands. Adults are typically 5 to 8 inches long and 3-5 years old. Most eulachon die after spawning. Huge schools of smelt spawn in the

Columbia and Cowlitz mainstems during most years. Pulses of spawners are also seen sporadically in other tributaries including the Grays, Lewis, and Sandy Rivers.

Smelt support a popular sport and commercial dip net fishery in the tributaries, as well as a commercial gillnet fishery in the Columbia. They are used for food and are also favored as sturgeon bait. Smelt are also eaten in large numbers by other fishes including sturgeon, birds, and marine mammals. Smelt numbers and run patterns can be quite variable and low runs during the 1990's were a source of considerable concern by fishery agencies. Current patterns show a substantial increase in run size compared to the 1990's. The low returns in the 1990's are suspected to be primarily a result of low ocean productivity.

Eulachon typically enter the Columbia River system from December to May with peak entry and spawning during February and March (WDFW 2001). Eulachon spawn in the main tributaries of the Columbia River and in the mainstem of the Columbia River. Water temperature plays an important role in upstream migration for spawning eulachon. Past studies have shown that the optimum water temperature for upstream migration is 40F (Smith and Saalfeld 1955). The colder the water, the longer the delay for spawning runs.

Eulachon spawn primarily at night. Each female deposits approximately 17,000 to 60,000 eggs, depending on its size (Morrow 1980). Fertilized eggs are adhesive and attach to particles of coarse sand or other river substrate like pea-sized gravel or sticks (Smith and Saalfeld 1955). Eulachon eggs have been observed in water from eight to 20 feet in depth. Water temperature influences the length of time to hatching. In temperatures of 6.5-9.0°C, eggs will hatch in about 22 days. At colder temperatures of 4.4-7.2°C, as found in the Cowlitz River, eulachon eggs will hatch in 30 to 40 days (Garrison and Miller 1982).

Newly hatched larvae are transparent and 4-7 mm in length. They have poor swimming ability and migrate downstream at the mercy of river currents. Eulachon fry have been recorded within 20 miles seaward of the Columbia River mouth. The result of several plankton hauls conducted in 1946 showed no fry had developed beyond yolk-sac stage; therefore, it is probable no feeding occurs in fresh water during outbound migration (Smith and Saalfeld 1955). After the yolksac is depleted eulachon will feed on pelagic plankton. Stomach samples of juvenile eulachon contained euphausiids (Barraclough 1964). Eulachon rear in near-shore marine areas from shallow to moderate depths. Eulachon will move into deeper water, up to depths of 625 m, as they grow (Allen and Smith 1988). Eulachon are an important link in the food chain between zooplankton and larger organisms.

Eulachon spend the majority of life in salt water and little is known about this saltwater phase. Eulachon feed on plankton in salt water, but stop feeding when returning to fresh water. The sex ratio of spawning adults is an average of 4.5 males to 1 female in the Columbia River and tributaries supporting eulachon. The male to female ratio has been recorded as high as 10.5 males to 1 female in the Cowlitz River (Smith and Saalfeld 1955). Additional background information on eulachon is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.

River Otter

The river otter (*Lutra canadensis*) is a top predator of most aquatic food chains that has adapted to a wide variety of aquatic habitats, from marine environments to high mountain lakes of North America (Toweill and Tabor 1982, Melquist and Hornocker 1983, Melquist and Dronkert 1987). The river otter is a year-round resident of the lower Columbia River mainstem and estuary (Howerton et al. 1984, Henny et al. 1996), although field observations and trapper data indicate that population numbers are relatively low (Howerton et al. 1984). Otters on the lower Columbia River concentrate their time in shallow, tidal influenced back waters, sloughs, and streams throughout the estuary. River otters exhibit differing degrees of social and spatial structure based on available habitat, shelter, and food (Reid et al. 1994b). Otter home ranges (approximately 11 river miles) are largely defined by local topography and overlap extensively within and among sexes, exhibiting varying degrees of mutual avoidance and tolerance depending on seasonal dispersion and availability of food and shelter (Reid et al. 1994b). However, otters do maintain territories within home ranges that are delineated by scent marking and latrine sites. Areas within territories are used almost exclusively by the defending otter, who excludes other otters of the same sex (i.e., females otter excludes other females and family groups while males exclude other males). Female river otters mate immediately after parturition during the months of March and April, with estrous lasting up to 46 days (Wright 1963, Melquist and Hornocker 1983). Fertilized eggs develop to the blastocyst stage and are arrested in development (delayed implantation) for up to 10 months (Hamilton and Eadie 1964, Tabor and Wight 1977). The duration of pregnancy after implantation occurs is approximately 2 months. Otter diets vary seasonally and generally consist of a wide variety of fish species and aquatic invertebrates such as crabs, crayfish, and mussels (Toweill 1974, Toweill and Tabor 1982, Melquist and Dronkert 1987, Reid et al. 1994a).

2.1.2.8 Columbian White-tailed Deer

The Columbian White-tailed deer (*Odocoileus virginianus leucurus*), a subspecies of the white-tailed deer, is on the federal Endangered Species List and is classified as endangered under Washington and Oregon state laws. This deer once ranged from Puget Sound to southern Oregon, where it lived in floodplain and riverside habitat. The conversion of much of its habitat to agriculture and unrestricted hunting reduced its numbers to a just a few hundred in the early 20th century. A few scattered populations remain and numbers have climbed to approximately 300-500 in the lower Columbia and 5,000 in the Roseburg area. Habitat conversion and losses coupled with the low productivity of the population are the currently the most important threats to population viability. Recovery goals identify the need to secure additional habitat for population re-introduction.

Columbian White-tailed deer are present in low-lying mainland areas and islands in the Columbia River upper estuary and along the river corridor. They are most closely associated with Westside oak/dry Douglas fir forest within 200m of a stream or river; however, Columbian White Taileds can be found breeding or feeding in any number of habitats (Westside lowland conifer-hardwood forest, Westside grasslands, Westside riparian wetlands, herbaceous wetlands, agriculture/pastures/mixed environments, urban/mixed environments; Johnson and O'Neil 2001). Columbian White-tailed deer are non-migratory; in the Columbian White-tailed Deer National Wildlife Refuge, mean home range for females was about 390 acres and for males was 475 acres, with daily movements considerably smaller than these ranges (Gavin et al. 1984). The peak of breeding activity is generally around mid-November and peak of fawning is about mid-June

(USFWS 1976). Columbian White-tailed deer diet consists of browse, forbs, and grasses; generally, browse is chosen in summer, fall, and winter, forbs are most heavily utilized in spring, summer, and early fall, while grasses are not preferred at any time of the year but are eaten in proportion to their availability only in the early spring (Dublin 1980). Additional background information on Columbian White Taileded deer is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.

2.1.2.9 Caspian Tern

Caspian terns (*Sterna caspia*) are highly migratory species that are distributed throughout the world and are currently present in large numbers in the Columbia River estuary. The species is not listed, but is of conservation concern because there are relatively few breeding sites and because of significant predation of listed Columbia River salmonids.

Caspian terns have become increasingly abundant in the Columbia River estuary in recent years, becoming the largest breeding colony in North America (Carter et al. 1995). Breeding colony preference is for newly formed, flat, sandy, mid-channel islands, such as those formed via dredge spoils or accretion. There is considerable concern regarding Caspian tern consumption of juvenile salmonids, however, we have no mechanism to measure whether current tern predation differs significantly from historical predation. Further, management actions to discourage breeding on Rice Island and encourage breeding on East Sand Island appears to be decreasing the amount of tern predation on juvenile salmonids.

Caspian terns are highly migratory and exhibit cosmopolitan distribution (Harrison 1984). There were no terns in the estuary before 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds moved to Rice Island in 1987; the area used by Caspian terns was created from dredge spoils from the navigational channel (Roby et al. 1998). The combined total of the reestablished East Sand Island colony and the Rice Island colony has since expanded to approximately 10,000 pairs (the largest colony in North America) (Caspian Tern Working Group 1999). Recent management actions have successfully discouraged breeding on Rice Island while encouraging breeding on other estuary islands. Spring migrants first arrive at breeding sites between mid-March to mid-May depending on latitude, elevation, and coastal or interior location (Cuthbert and Wires 1999). The timing of southward migration varies with region (Cuthbert and Wires 1999); typically, the peak of fall migration occurs between mid-July and mid-September (Cuthbert and Wires 1999) with stragglers leaving by the end of November (Gilligan et al. 1994, Peterjohn 2001).

Caspian terns breed in colonies and typically locate their colonies close to a source of abundant fish in relatively shallow estuarine or inshore marine habitats or in inland freshwater lakes, rivers, marshes, sloughs, reservoirs, irrigation canals, and (low-salinity) saline lakes (Cuthbert and Wires 1999). Nest substrates vary from sand, sand-gravel, spongy marshy soil, or dead or decaying vegetation to hard soil, shell banks, limestone, or bedrock, but terns seem to preferred sand (Quinn and Sirdevan 1998). Caspian terns have been reported to fly up to 38 miles from the breeding colony while foraging (Gill 1976, Ryan et al. 2001, 2002); the Columbia River estuary colony appear to feed within the estuary (Collis et al. 1999, Collis et al. 2001). Caspian terns are piscivorous (Harrison 1984); fish may constitute up to 98% of the diet, particularly during periods of high fish abundance such as the peak of smolt outmigration (Roby et al. 1998). Breeding Caspian terns require one-third of their body weight of fish per day during the nesting season, which also coincides with the peak of smolt migration. Diet of the Rice Island colony is dominated by juvenile salmonids (Roby et al. 1998, Roby et al. 2002) while diet

of the East Sand Island colony was primarily non-salmonids (Roby et al. 2002). Studies in 1990 and 1991 revealed that eggs of Caspian terns nesting at Rice and East Sand Islands were contaminanted with organochlorine compounds, including PCBs, DDE, dioxins, and furans, suggesting that their food source (primarily juvenile salmonids) may be contaminated with these coumpounds as well (USFWS 2002). Additional background information on Caspian tern is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.

2.1.2.10 Bald Eagle

Bald eagles (*Haliaeetus leucocephalus*) are distributed throughout North America, breeding in most of its range; abundance is highest along coastal areas of the northern conterminous states, Canada, Alaska, as well as Florida and South Carolina. Eagles have been observed to reach a maximum age of about 28 years in the wild (Schempf 1997 as cited in Stinson et al. 2001); captive birds have lived to age 47 (Stalmaster 1987 as cited in Stinson et al. 2001). In general, southern areas within this range are more important as wintering areas than breeding areas. In Washington, bald eagles are substantially more abundant in the cool, maritime region west of the Cascade Mountain range (Stinson et al. 2001).

Depending on the level of competition for food and nest sites, bald eagles may attempt to breed at age 3 or as late as age 8 (Gerrard et al. 1992, Bowman et al. 1995, Buehler 2000 as cited in Stinson et al. 2001). Bald eagles develop pair bonds that generally last until one eagle dies (Jenkins and Jackman 1993 as cited in Stinson et al. 2001). Eagles usually return annually to a nesting territory near a reliable food source; breeding adults will defend their territories from intruding eagles. As with breeding site fidelity, bald eagles seem to exhibit a relatively high annual fidelity to wintering areas (Harmata and Stahlecker 1993, Buehler 2000 as cited in Stinson et al. 2001). Communal night roosts are an important component of bald eagle wintering habitat. Eagles also may roost singly, in pairs or gather in large congregations of as many as 500 individuals at locations that are used year-after-year. Roosts may vary widely but studies have shown that communal night roosts provide a microclimate more favorable than available elsewhere in the vicinity (Keister et al. 1985, Stalmaster 1981, Knight et al. 1983, Stellini 1987 as cited in Stinson et al. 2001).

Bald eagle populations throughout its range exhibited a slow decline because of habitat loss, decreased abundance of winter foods, and harassment/hunting since the time of European settlement. Despite protection with the Bald Eagle Protection Act of 1940, harassment by humans continued because of misidentification with golden eagles, poisoning of bald eagles in conjunction with livestock predator control programs, and collection of bald eagle parts for black market collectors or native American ceremonial uses. The population decline accelerated dramatically after the early 1940s with the widespread use of organochlorine pesticides, particularly DDT (Elliot and Harris 2001-2002). By the 1960s, less than 700 breeding pairs were estimated to exist in the lower 48 states and bald eagles had been extripated from at least seven states within its historical range (Stinson et al. 2001).

The ban of DDT, habitat protection, reduced persecution, and reintroduction projects have aided in recovery of the North American population (Stinson et al. 2001). During the preceeding 25 years, the bald eagle population has doubled every 7-8 years. Most known populations have reached regional recovery goals where applicable, but populations remain below pre-European settlement abundance (Buehler 2000 as cited in Stinson et al. 2001). In Washington the most recent (1998) statewide survey recorded 664 occupied nest sites; this

accounts for 12% of the known bald eagle territories across the lower 48 states (Stinson et al. 2001). A recent decline in nest occupancy rate and the occurrence of nest sites in developed areas suggests that nesting habitat in areas of western Washington is approaching saturation (Stinson et al. 2001).

Historically, bald eagles were common and locally abundant throughout Washington; accounts from 1890 indicate that bald eagles were especially abundant near the mouth of the Columbia River (Stinson et al. 2001). No historical population abundance or density estimates are available for bald eagles in Washington. The Washington and Oregon bald eagle populations were included for federal listing as endangered under the Endangered Species Act in 1978. Threats to the population identified at the time of listing included reproductive failure caused by organochlorine pesticides, widespread loss of suitable nesting habitat resulting from logging, housing development, and recreation, and persecution (primarily illegal shooting (USFWS 1978 as cited in Stinson et al. 2001). In 1994, the USFWS proposed to reclassify the bald eagle from endangered to threatened throughout its range; this reclassification was finalized in 1995. In 1999, the USFWS proposed to delist the bald eagle throughout its range, however, this delisting has not been finalized.

Breeding bald eagles require large trees near open water that is not subject to intense human activity and will generally select one of the largest trees in a stand for nesting (Anthony et al. 1982 as cited in Stinson et al. 2001). In Washington, 99% of all bald eagle nests are within one mile of a lake, river, or marine shoreline. The distance to open water varies somewhat with shore type; nests tend to be closer to marine shores and rivers than to lake shores. Eagles also require perches distributed throughout their nest territories; perches are prominent points which provide a view of the common foraging area. Because eagles exhibit consistent daily foraging patterns, they often use the same perches (Stalmaster 1987, Gerrard and Bortolotti 1988 as cited in Stinson et al. 2001).

Bald eagles breeding in the lower Columbia River region are year-yound residents and do not migrate during the winter (Garrett et al. 1988). All bald eagle nest sites in this area have been monitored for productivity since the late 1970s, and in recent years there were 96 occupied breeding territories (Isaacs and Anthony 2003). In addition, the area supports an additional wintering population of over 100 eagles. Studies in the early 1980's in the Columbia River estuary indicated eagle diet consisted of 90% fish, 7% birds, and 3% mammals (Watson et al. 1991 as cited in Stinson et al. 2001). Waterfowl were the most common avian prey in nests, while suckers (*Catostomus spp*.), American shad (*Alosa sapidissima*), and carp (*Cyprinus carpio*) were the most common fish prey items. Bald eagles will often steal prey from osprey and gulls, and have even been observed stealing marine invertebrates from sea otters (Watt et al. 1995 as cited in Stinson et al. 2001), and fish from river otters (Taylor 1992 as cited in Stinson et al. 2001). Diet of bald eagles can vary considerably, depending on the geographic location or the methods used to determine diet composition (Knight et al. 1990 as cited in Stinson et al. 2001).

The lower Columbia River bald eagle population is one of only two regional populations in Washington that has exhibited low reproductive success representative of a decreasing population (the other regional population was in Hood Canal). Significant concentrations of DDE, PCB, and dioxins were found in bald eagle eggs on the lower Columbia River (Anthony et al. 1993, USFWS 1999b, Mahaffy et al. 2001 as cited in Stinson et al. 2001); concentrations of these contaminants were above no-effect levels estimated for the species. Despite low reproduction success, the lower Columbia River bald eagle population has increased, likely as a

result of recruitment of new adults from other areas. Although, the reproductive health of the lower Columbia population appears to be improving based on recent linear trend analysis (Stinson et al. 2001), bald eagle productivity and breeding success of pairs nesting below river mile 60 remains low, especially for those pairs nesting between river mile 13 to 31 (USFWS 1999b, Isaacs and Anthony 2003).

The density of nesting eagles depends on many factors that determine habitat quality, such as prey populations, human disturbance, and perhaps the availability of nest and perch trees. Occupied nests of adjacent nesting pairs are generally spaced closer in areas of high quality habitat. The seasonal home range that contains the foraging and nesting habitat of a pair averages about 2.6 mi^2 in the Puget Sound region (Watson and Pierce 1998 as cited in Stinson et al. 2001) and about 8.5 mi^2 in the Columbia River Estuary (Garrett et al. 1993 as cited in Stinson et al. 2001). However, most eagle activity in the lower Columbia River occurs within 0.2 mi^2 of the nest site (Garrett et al. 1993).

2.1.2.11 Osprey

The osprey (*Pandion haliaetus*) is a large piscivorous bird of prey that nests and feeds along the lower Columbia River in spring and summer. Ospreys have nearly worldwide breeding distribution; birds that breed in the Pacific Northwest migrate to wintering grounds in southern Mexico and northern Central America (Martell et al. 2001). Ospreys nest in forested riparian areas along lakes, rivers, or coastlines; nests are situated atop trees, rock pinnacles, or artificial structures such as channel markers or power/light poles (Poole et al. 2002, Henny et al. 2003a). Adult pairs are thought to mate for life and return to the same area annually for breeding (Poole et al. 2002). Generally, adults spend approximately one month on the breeding grounds before egg laying (Henny et al. 2003a); egg incubation takes about five weeks and nestlings are ready to fly approximately 7-8 weeks after hatching (Poole et al. 2002). Along the lower Columbia River during 1997 and 1998, osprey productivity was estimated at 1.64 young/active nest, which is higher than the generally recognized 0.80 young/active nest needed to maintain a stable population (Henny et al. 2003a). Ospreys feed almost exclusively on fish and are not particular about the species of fish they consume (Poole et al. 2002). In the lower Columbia and Willamette Rivers, largescale suckers are an important part of the osprey's diet; ospreys remain close to the nest for feeding (Henny et al. 2003a, 2003b).

The osprey has several advantages as a monitoring species for the health of the Columbia River. The osprey population was studied in detail in 1997 and 1998, and the population nests all along the river up to Umatilla. These earlier data (size of nesting population by river segment, reproductive performance, and residue concentrations in eggs) provide the baseline for comparison with similar data collected in the future to help address contaminant trends over time. Furthermore, residue concentrations in eggs can be compared among locations along the river, such as above and below dams, cities, or other point sources of contaminants. For example, higher PCB concentrations in osprey eggs were detected below Bonneville Dam compared to concentrations above the dam. Other advantages for having the fish-eating osprey as a contaminant monitoring species include:

- Osprey feed primarily on fish close to their nest sites and integrates contaminant exposure in the local area,

- Osprey are at the top of the food chain and are susceptible to biomagnification effects of contaminants (e.g. many contaminants biomagnify from 10 to 100 fold from fish to osprey eggs (Henny et al. 2003b), and
- Productivity of conspicuous nesters can be monitored in an attempt to establish a response that is linked to population processes.

Additional background information on osprey is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.

2.1.2.12 Sandhill Crane

Historically, sandhill cranes (*Grus canadensis*) occupied a larger North American range than they do today. In Washington, sandhill cranes were historically described as "not common summer resident both sides of the Cascades" (Dawson and Bowles 1909). Evidence of breeding sandhill cranes in Washington was absent from 1941 to 1972, when a pair appeared at Conboy Lake NWR. Sandhill crane breeding habitat in Washington is limited when compared to the large wetland complexes in southern Oregon, northern California, or elsewhere in its range; thus, the potential breeding production in Washington is relatively small compared to other breeding locations. Sandhill cranes have been a state listed endangered species in Washington since 1981. The Yakama Indian Nation has listed the sandhill crane as sensitive (BIA 1993); it is also considered a species of cultural importance. In Oregon, the greater sandhill crane is categorized as vulnerable on the sensitive species list and in California, the greater sandhill crane is listed as threatened.

Sandhill cranes are represented by three subspecies: greater, Canadian, and lesser. The greater sandhill crane is the only subspecies that nests in Washington. The only known breeding sites in Washington are: Conboy Lake NWR and Panakanic Valley, Klickitat County; Polo Field/Signal Peak on Yakama Indian Nation lands, Yakima County; and Deer Creek on WDNR lands in Yakima County (Engler and Brady 2000). The only wintering area for sandhill cranes in Washington is the lower Columbia bottomlands near Vancouver, Ridgefield, and Woodland. All cranes observed wintering at Ridgefield NWR and Sauvie Island Wildlife Area, Oregon, in late November 2001 and February 2002 were Canadian sandhills, and based on observations of marked birds, wintering cranes regularly move back and forth between these areas (Ivey et al. in prep.). Though not known to be a historical wintering area, an average of few hundred, but up to 1,000 cranes have wintered in the area during the last seven or eight years (J. Engler, personal communication). In winter, birds generally concentrate in agricultural regions with extensive areas of small grain crops. However, associated wetlands are still used for some feeding, as well as for nighttime roosting and midday loafing (Littlefield and Ivey 2000). Generally, the species can be categorized as an opportunistic omnivore (Armbruster 1987), feeding on a variety of food items including roots, bulbs, grains, berries, snails, earthworms, insects, amphibians, lizards, snakes, mice, and greens (Ridgway 1895, Barrows 1912, Bent 1926, Gabrielson and Jewett 1940, Brown 1942). Additional background information on sandhill cranes is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement.

2.1.2.13 Yellow Warbler

Within Washington, yellow warblers (*Dendroica petechia*) are apparently secure and are not of conservation concern. Yellow warblers are an excellent indicator of riparian zone structure and function.

The yellow warbler is a long-distance neotropical migrant; spring migrants begin to arrive in the Pacific Northwest region in April but the peak of spring migration in the region is in late May (Gilligan et al. 1994). Southward migration begins in late July, and peaks in late August to early September; very few migrants remain in the region in October (Lowther et al. 1999). The yellow warbler is a riparian obligate species most strongly associated with wetland habitats that contain Douglas spirea and deciduous tree cover (Rolph 1998). Biological objectives for this species in the lowlands of western Oregon and western Washington include providing habitats that meet the following definition: >70% cover in shrub layer (<3 m) and subcanopy layer (>3 m and below the canopy foliage) with subcanopy layer contributing >40% of the total; shrub layer cover 30-60% (includes shrubs and small saplings); and a shrub layer height >2 m (Altman 2001). Yellow warblers are a locally common breeder at lower elevations along rivers and creeks in the Columbia Basin, although only possible breeding evidence has been observed along the lower Columbia River mainstem and estuary (Smith et al. 1997). Yellow warblers capture and consume a variety of insect and arthropod species, as well as wild berries, by gleaning from subcanopy vegetation Additional background information on yellow warbler is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement

2.1.2.14 Red-eyed Vireo

The red-eyed vireo (*Vireo olivaceus*) is common in western Washington. This songbird has been one of the most abundant birds in North America, although its numbers seem to have declined recently, possibly as a result of the destruction of wintering habitat in the neotropics, fragmentation of northern breeding forests, or other causes. The red-eyed vireo is secure, particularly in the eastern United States. Within Washington, the red-eyed vireo is common, more widespread in northeastern and southeastern Washington, and not a conservation concern. The red-eyed vireo is an excellent indicator of riparian zone structure and function.

The red-eyed vireo is a long-distance neotropical migrant; it breeds throughout North America and winters in South America (Bent 1965). The red-eyed vireo is locally common in riparian growth and strongly associated with tall, somewhat extensive, closed canopy forests of cottonwood, maple, or alder in the Puget Lowlands (C. Chappell pers. comm.) and along the Columbia River in Clark, Skamania, and Klickitat Counties; presence in the Columbia River estuary is not well documented. Biological objectives for this species in the lowlands of western Oregon and western Washington include providing habitats that meet the following definition: mean canopy tree height >50 ft (15 m), mean canopy closure >60%, young (recruitment) sapling trees >10% cover in the understory, and riparian woodland >164 ft (50 m) wide (Altman 2001). Vireos are primarily insectivorous, with 85% of their diet composed of insects and only 15% of vegetable material, mostly fruits and berries eaten in August–October. Additional background information on red-eyed vireo is available in the Species Technical Foundation; (Appendix A), and in the Management Plan Supplement

2.1.3 *Habitat*

The habitat discussion is divided into three sections: 2.1.3.1 Habitat-Forming Processes, 2.1.3.2 Habitat Change, 2.1.3.3 Historical vs. Current Habitat Condition. Section 2.1.3.1 Habitat-Forming Processes describes the physical processes that determine habitat formation in the Columbia River estuary and lower mainstem. Section 2.1.3.2 Habitat Change identifies the natural and anthropogenic factors that have contributed to habitat changes in the subbasin. Section 2.1.3.3 Historical vs. Current Habitat Condition describes estimates of acreage change of specific estuary and lower mainstem habitats, presenting results from multiple habitat mapping efforts and discussing the similarities and differences among the mapping efforts.

2.1.3.1 Habitat-Forming Processes

An estuary is the portion of a river that is influenced by ocean tides. The estuary is a complex interaction of river and tidal forces, a high-energy and dynamic physical and biological system, with high temporal variability in circulation, sedimentation and biological processes (Sherwood and Creager 1990). Habitat formation in the lower Columbia River mainstem and estuary are controlled by opposing hydrologic forces of ocean processes (tides) and river processes (discharge) as depicted in the conceptual model (Figure 2-12). As each of these hydrologic processes interacts, the habitats that form are a function of time. These processes may be disturbed by storms, extreme hydrologic events, or catastrophic events such as earthquakes or volcano eruptions. Tides introduce marine-derived sediments to the estuary while river discharge carries freshwater sediments via bedload and suspended sediment. This supply of sediments influences the bathymetry of the estuary through the processes of erosion and accretion. Suspended sediment, along with the production of organic matter, determines the degree of water turbidity. The opposing processes of estuary outflow (river discharge) and inflow (tides) determine the salinity gradient and the type and location of available nutrients. River discharge also directly affects the level of woody debris recruitment to the estuary. Finally, the main components of the habitat formation process (bathymetry, water turbidity, salinity, nutrients, and woody debris) determine the location and type of habitats that form and persist throughout the estuary and lower mainstem.

The habitat-forming processes of accretion, erosion, salinity, and turbidity affect the distribution of plants throughout the estuary. Vegetation within each habitat comprises the majority of primary production in the estuary, via the production of organic matter within plant tissue and the export of dissolved organic matter. Primary productivity is driven by light; as turbidity increases, light through the water column decreases, which can result in less phytoplankton growth and can limit the depth of submerged plants.

Elevation partially controls the types of habitat created and maintained through the various habitat-forming processes (USACE 2001). There is a continuous elevation gradient from tidal swamp to water column habitat, with some elevation overlap between each habitat type. Defined elevation ranges for each habitat type (tidal swamp, tidal marsh, tidal flats, and water column) are presented in Thomas (1983). At a given elevation, there is an overriding influence of salinity in the development of each type of habitat which controls the vegetation assemblage.

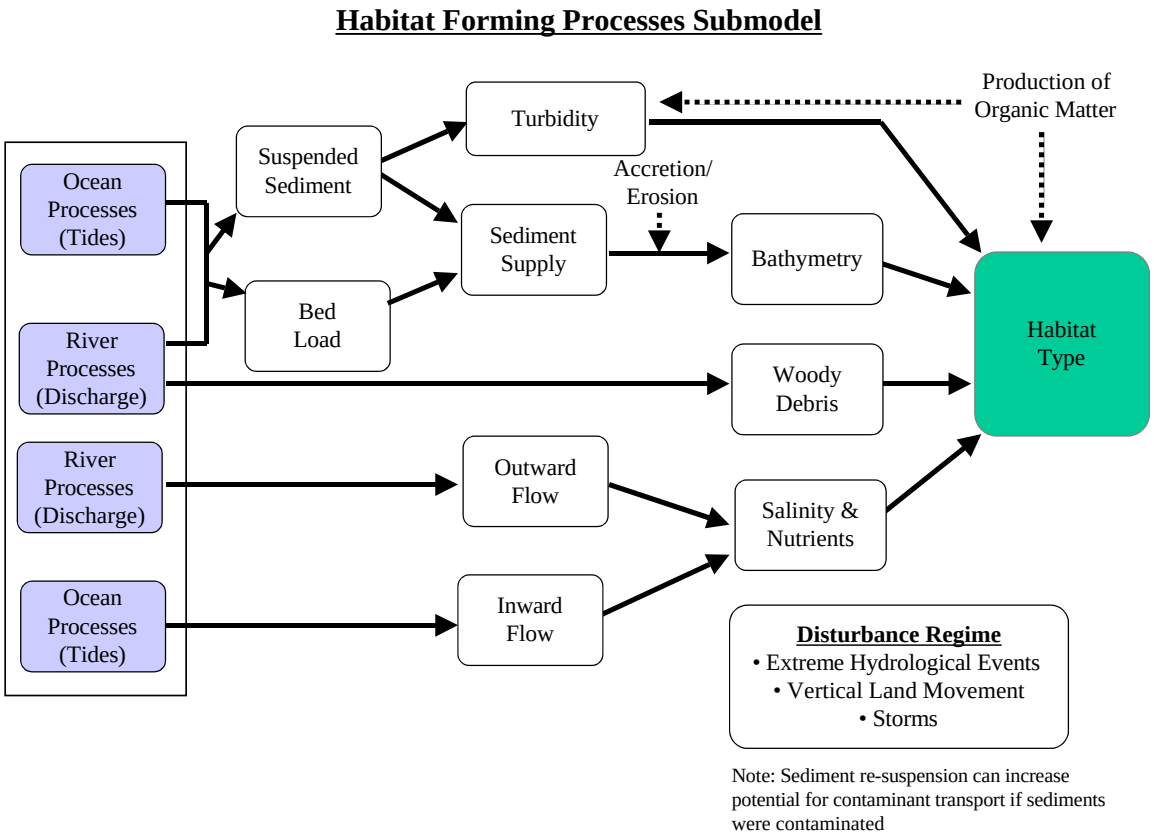


Figure 2-12. Conceptual model of habitat-forming processes in the Columbia River estuary (adapted from USACE 2001). Note that the function of time is not included in this particular model and time is an important controlling factor in the formation of habitat.

2.1.3.1.1 Hydrological Conditions

Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuarine habitats and have resulted in changes to estuarine circulation, deposition of sediments, and biological processes (ISAB 2000, Bottom et al. 2001, USACE 2001, Johnson et al. 2003b). Flow regulation in the Columbia River basin has been a major contributor to the changes that have occurred in the estuary from historical conditions. The 21 dams built in the Columbia and Snake Rivers since 1933 have caused river flows to be altered substantially. Water losses from irrigation, reservoir evaporation, and climate change have resulted in annual flows at The Dalles, Oregon that are about 17% less than 19th century virgin flows (Bottom et al. 2001). Thus, the predevelopment flow cycle of the Columbia River has been modified by hydropower water regulation and irrigation withdrawal (Thomas 1983, Sherwood et al. 1990 as cited in Nez Perce et al. 1995, Weitkamp 1994, NMFS 2000c, Williams et al. 2000, Bottom et al. 2001, USACE 2001).

Spring freshet properties have been more highly altered than mean flow. Spring freshets are very important to the outmigration of juvenile salmonids; freshet flows stimulate salmon downstream migration and provide a mechanism for rapid migrations. Also, spring freshets (especially overbank flows) provide habitat, increase turbidity thereby limiting predation, and

maintain favorable water temperatures during spring and early summer. Further, organic matter supplied by the river during the freshet season is a major factor maintaining the detritus-based food web. Additionally, reductions in freshet flows combined with flood-control diking and wetland development have disconnected the lower river from its floodplain. Consequently, substantial over-bank flows are rare compared to predevelopment flooding frequency, resulting in reduced large woody debris recruitment and riverine sediment transport to the estuary. Flow regulation in the Columbia has decreased spring freshet magnitude and increased flows over the rest of the year as a result of winter drawdown of reservoirs and filling of the reservoirs during the spring runoff season. The best historical record of Columbia River flow exists at The Dalles, Oregon, where a gauging station has recorded flow since 1878. About 97% of the flow of the total Columbia River flow passes the gauge at The Dalles. Average spring freshet flows at The Dalles since 1969 have been reduced by 50-55%, and winter flows (October–March) have increased by 35% (Bottom et al. 2001; Figure 2-13). This same pattern has been observed at Bonneville Dam (USACE 2001; Figure 2-14). Further, most of the spring freshet flow reduction is attributed to flow reduction, about 20% is a result of irrigation withdrawals, and only a small portion (5%) is connected to climatic change (Bottom et al. 2001).

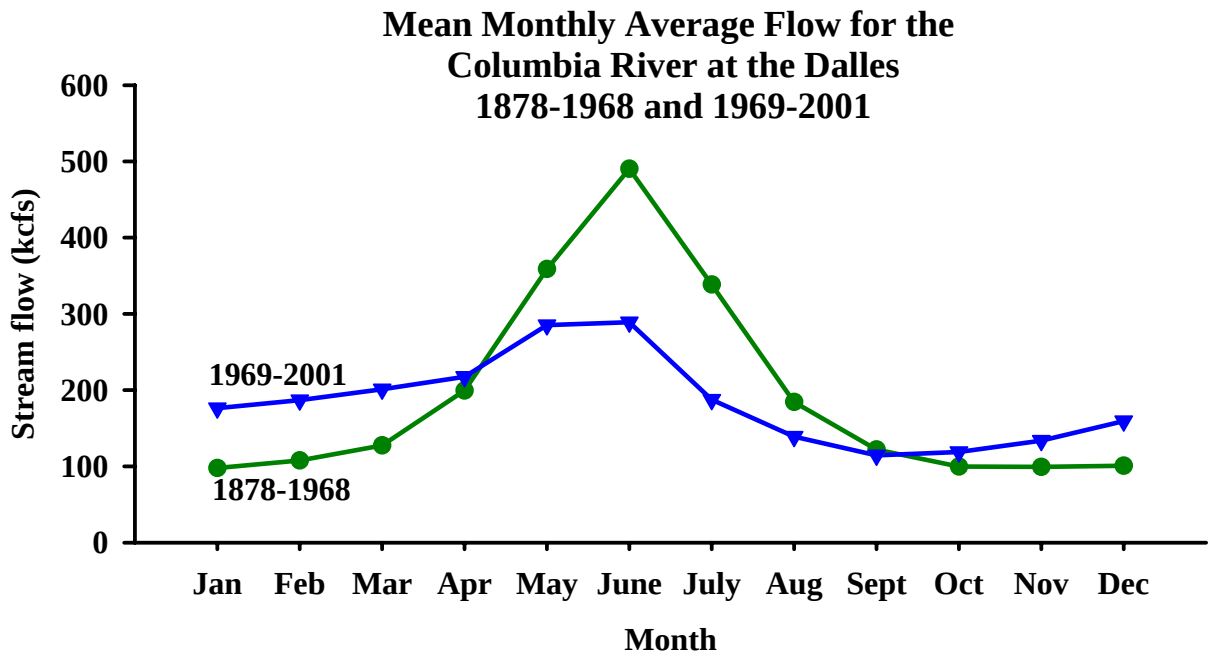


Figure 2-13. Mean monthly average flow at The Dalles. Construction of flow regulating dams has resulted in modification of the annual hydrograph of the Columbia River.

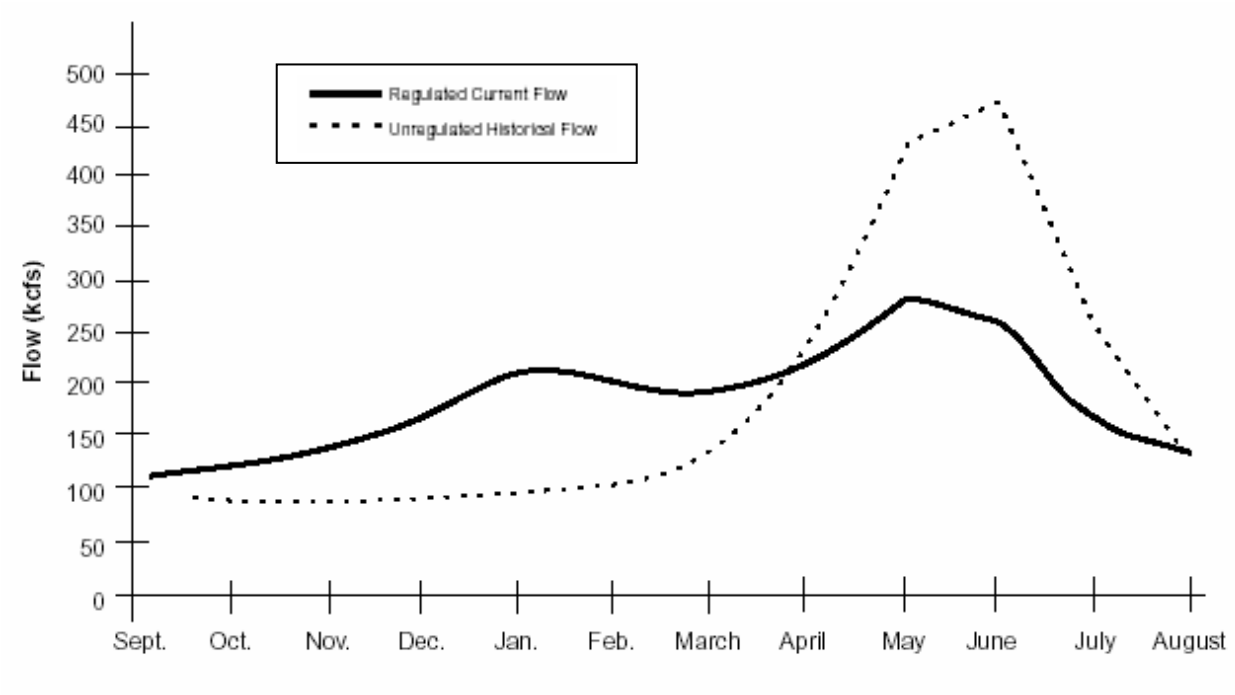


Figure 2-14. Current regulated mean monthly flow compared to historical unregulated mean monthly flow at Bonneville Dam (USACE 2001).

In addition to magnitude, the timing of maximum spring freshet flow also has changed as a result of hydropower operations and irrigation withdrawals. The mean predevelopment maximum spring freshet flow date was June 12 compared to the present mean date of May 29, an approximate two week shift in maximum spring freshet flow (Bottom et al. 2001, Jay and Naik 2002).

Finally, freshet styles have been affected by climate and human actions. There are three primary types of spring freshets based on the source of flow: large winter snowpack without considerable spring rain, normal winter snowpack with considerable spring rains, and large winter snowpack with considerable spring rains. The largest freshet flows on record have been associated with rain-on-snow events. Flow regulation is relatively effective in dampening freshets associated solely with snowpack; winter reservoir drawdown provides storage capacity for the steadily melting snowpack. However, heavy spring rains are more difficult to predict and flows are difficult to control because snowmelt rate is substantially higher. Although, the gradual warming of the region has made accumulation of low elevation spring snowpack less likely, decreasing the probability of spring freshets resulting from rain-on-snow events (Bottom et al. 2001, Jay and Naik 2002).

Total mainstem freshwater input at the head of the Columbia River estuary is best measured at Beaver, Oregon; flows at Beaver are the sum of flows for the interior and western Columbia River subbasins. The gauge there includes inputs from some substantial basins downstream of The Dalles (Willamette, White Salmon, Sandy, Lewis, etc.). Because dams from Bonneville upstream capture spring runoff in impoundments, flows from lower Columbia tributaries below Bonneville have become more important contributors to estuary flow during spring and winter runoff periods (Bottom et al. 2001). Average flow at Beaver is now substantially lower than pre-dam flows (Bottom et al. 2001; Figure 2-15).

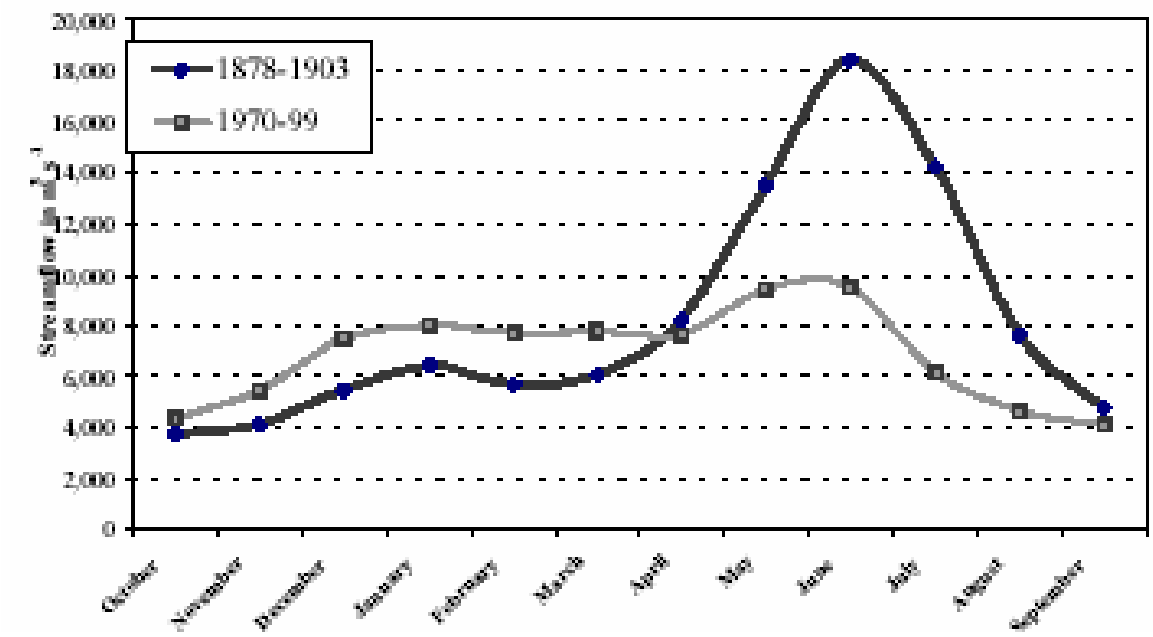


Figure 2-15. Comparison of historical (1878-1903 [data missing]) and recent (1970-1999) Columbia River annual flow cycle measured at Beaver, OR (Bottom et al. 2001).

Reduction of maximum flow levels, dredged material deposition, and diking measures have all but eliminated overbank flows in the Columbia River (Bottom et al. 2001). Overbank flows were historically a vital source of new habitats. Moreover, springtime overbank flows greatly increased habitat opportunity into areas that at other times are forested swamps or other seasonal wetlands. Historical bankfull flow level for the mainstem Columbia River below Vancouver was approximately 18,000 cubic meters per second (cms); current bankfull level is determined by the hydropower project flood level of about 24,000 cms. Historical bankfull flow levels were common prior to 1975 but are rare today; current bankfull flows have only been exceeded four times since 1948 (Figure 2-16). Further, the season when overbank flow is most likely to occur today has shifted from spring to winter, as western subbasin winter floods (not interior subbasin spring freshets) are now the major source of peak flows (Bottom et al. 2001, Jay and Naik 2002).

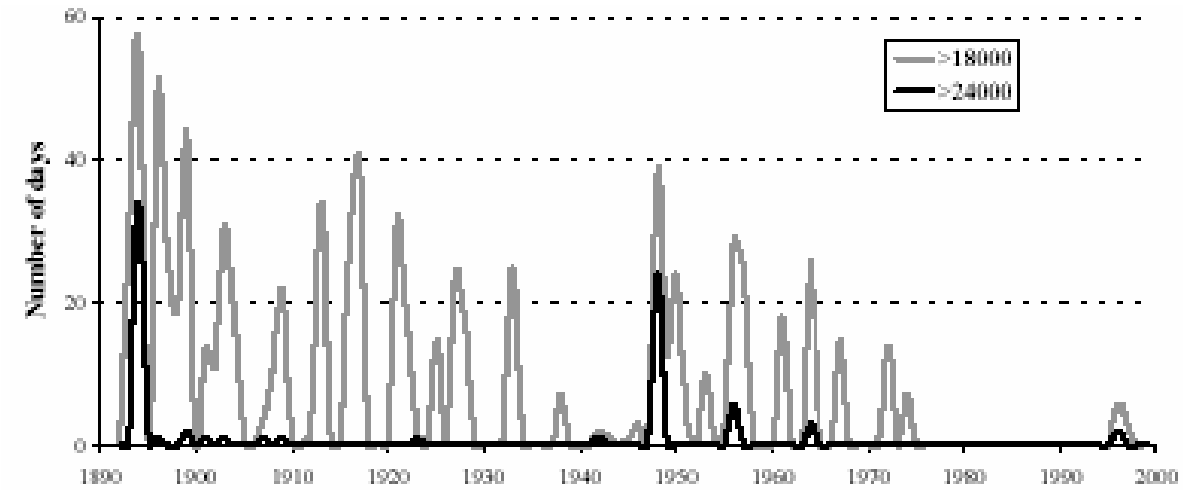


Figure 2-16. Frequency of mainstem Columbia River flow above historical bankfull (18,000 cms) and current bankfull (24,000 cms) flow levels.

2.1.3.1.2 Sediment Transport

Sediments in the estuary may be marine or freshwater derived; throughout the entire estuary, sediments comprise gravel (1%), sand (84%), silt (13%), and clay (2%) (Hubbell and Glenn 1973, Roy 1982 as cited in Moritz et al. 1999). Sediment transport in the lower mainstem and estuary is largely driven by the Columbia River's hydrologic cycle; most sediment transport coincides with the spring freshet, although high sediment concentrations also can be transported during infrequent winter floods (USACE 2002). Sediments are transported via sediment suspended in the water column or bed load movement. These mechanisms of sediment transport determine the sediment supply to the estuary, which determines the bathymetry of the estuary through the processes of erosion and accretion. Estuary bathymetry is one of the primary factors determing the types of habitat present in the estuary (USACE 2001; Figure 2-12). The following discussion is a brief synopsis of sediment transport mechanisms in the lower Columbia River and estuary; more detailed descriptions of sediment transport processes and estimates of lower Columbia River and estuary sediment budgets can be found in Whetten et al. (1969), Sherwood et al. (1984), Sherwood et al. (1990), Gelfenbaum et al. (1999), Moritz et al. (1999), USACE (1999), Buijsman (2000), Bottom et al. (2001), Kaminsky et al. (2002b), and USACE (2002), to name a few.

The entire Columbia River basin has two principal sediment sources: the upper watershed above the Snake River confluence that produces fine sediments from surficial deposits and the Cascades that supply coarse sediments (sand) resulting from erosion of volcanic material (Whetten et al. 1969 as cited in USACE 2002). Under average flow conditions, each sediment source was independently transported and deposited, with the upper basin sediments transported primarily as suspended sediment and the Cascade sediments transported primarily as bedload (Whetten et al. 1969 as cited in USACE 2002). Thus, sediment from either source may be present in the lower Columbia River and estuary.

Suspended sediment is supported by buoyancy and turbulence within the water column; because particles travel about the same speed as river velocity, they generally move substantial distances before depositing (USACE 2002). There are two main categories of suspended sediments: wash load and bed sediment load (USACE 2002). Wash load comprises silt and clay particles and is often generated from outside sources such as tributaries and local runoff (USACE 2002). Bed sediment load is composed of larger particles such as sand and is governed by the combination of the river's transport potential, the available particle (sand) supply, and the settling properties of the particles (USACE 2002). Sand constitutes about 95% of the total bed material found in the estuary and lower Columbia River mainstem (USACE 2002). However, sand typically constitutes less than 15% of the suspended sediment load, which is generally comprised of about 70-90% fine materials such as silt and clay (USACE 2002). The sand component of the suspended sediment may increase to over 30% when discharge exceeds 400,000 cfs (USACE 2002); however, flows of this magnitude are rare in the present era of water management.

Bed load movement describes the process of larger particles, such as sand or gravel, rolling or bouncing along the riverbed (USACE 2002). Because water velocity at the surface of the riverbed is slower than in the water column, bed load particles move slower than suspended sediments (USACE 2002). Further, bed load particles typically move intermittently and cover short distances during each movement (USACE 2002). Bed load movement typically occurs in a layer only a few sand grains thick (USACE 2002). Bed load movement shapes the riverbed into a series of sand waves; these waves continually move downstream as sand particles are eroded from the upstream face and deposited in the downstream trough (USACE 2002). Therefore, through this continually downstream movement, all the sand particles in a sand wave are eroded, transported, deposited, buried, and eventually eroded again (USACE 2002).

Currently, the most important sediment deposition conditions present in the estuary include shoaling in the navigation channel and deposition/accumulation of sand in low energy areas in the estuary and along the coast (USACE 2002). Shoaling in the navigation channel is a redistribution of bed sediments, rather than an accumulation of sediments, because it does not change the volume of bed material within a given reach (USACE 2002). Sediments generally accumulate in bays and shallow areas throughout the estuary (USACE 2002). Hubbell and Glenn (1973, as cited in USACE 2002) indicated that over 80% of the accumulated sediments was comprised of sand; although the percentage of accumulated silt increases in estuary bays relative to other shallow areas, sand was still the dominant material deposited.

Because sand sediments are vital to natural habitat formation and maintenance in the estuary, dredging and disposal of sand and gravel have been one of the major causes of estuarine habitat loss over the last century (Bottom et al. 2001); estimates of dredging volumes over time are depicted for different reaches in the lower Columbia River (Figure 2-17 and

Figure 2-18). From 1958-1997, supply of sand to the estuary from upriver sources was estimated at 1.4 million cubic meters per year (Mm^3/yr; Gelfenbaum et al. 1999). Meanwhile, from 1956 to 1983, the US Army Corps of Engineers (USACE) removed an average of 0.9 Mm^3/yr from the Columbia River entrance and, from 1984 to 1998, the USACE removed an average of 2.5 Mm^3/yr (Kaminsky et al. 2000). Therefore, it is possible that much of the sand entering the estuary from upriver sources does not remain in the estuary and is disposed of in deep-water ocean sites or upland site outside the of the Columbia River littoral cell (Kaminsky et al. 2000, 2002b, Kaminsky 2002a). Further, because of flow regulation and river dredging operations, the sand removed from the lower river cannot be replenished in the absence of an unmitigated, catastrophic event, such as an extreme flood or volcanic eruption (Kaminsky 2002a). Present conditions of sand transport are one of net sand extraction from the river system, because the net supply of river sand has decreased by a factor of three over the historical period while the removal of sand has increased by a factor of 2.5 (Kaminsky 2002a). Future conditions of sand transport are not likely to improve in the next 20 years, based on the proposed dredging activities of the USACE; continued losses of Columbia River sand transport may exacerbate the present erosion trends in the coast and nearshore zone of the Columbia River littoral cell (Kaminsky 2002a).

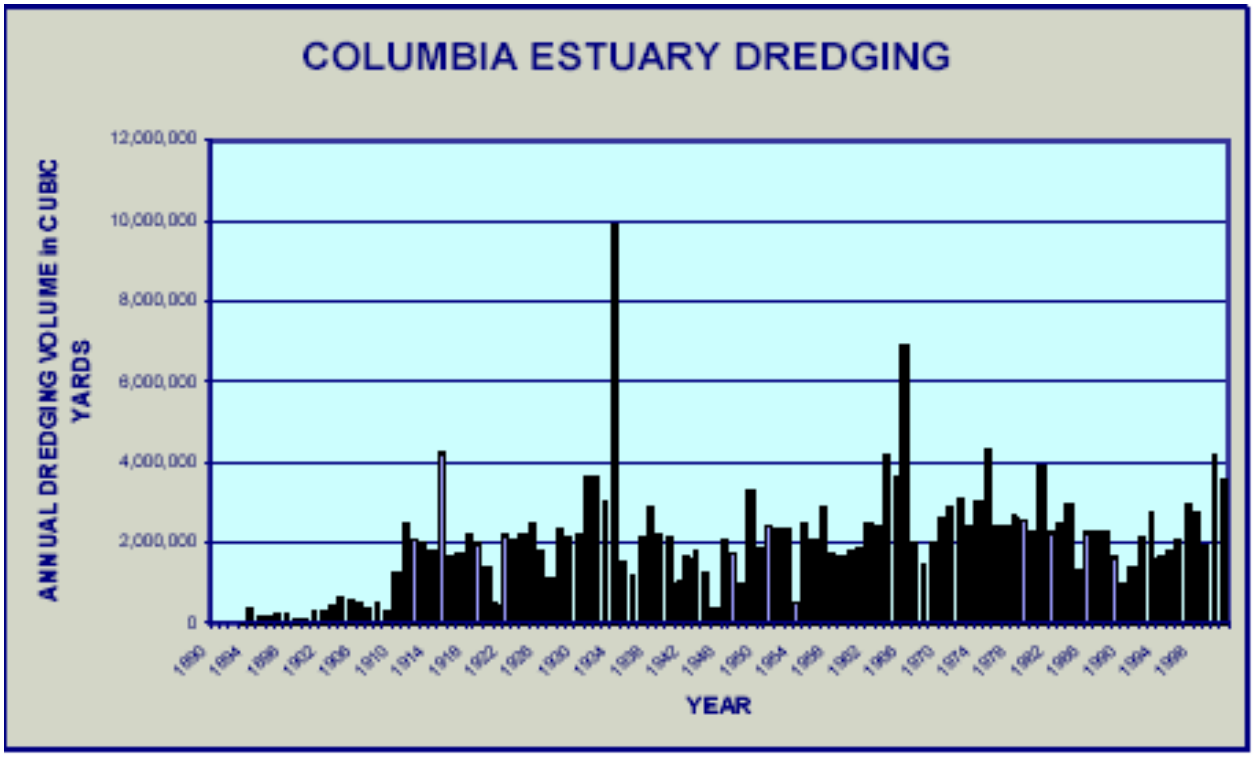


Figure 2-17. Volume of material dredged over time from the Columbia River between rm 3 and 40 (USACE 2002).

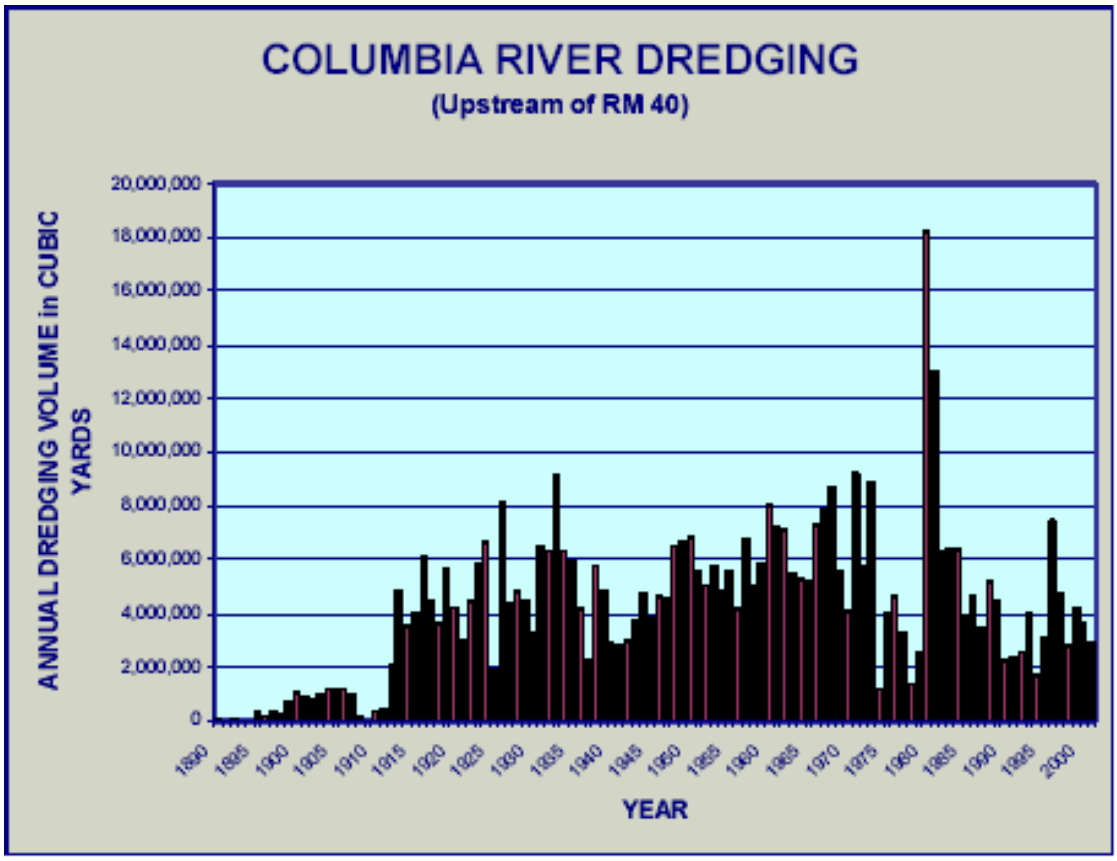


Figure 2-18. Volume of material dredged over time from the Columbia River between rm 40 and 106 (USACE 2002).

Dredging operations at the mouth of the Columbia River have become a topic of considerable debate because of the potential to affect shoreline erosion; consensus regarding the potential erosion effects of this dredging has not been reached (Kaminsky 2002a, 2002b, Kaminsky et al. 2002a, 2002b, Moritz 2002). One hypothesis is that current shoreline erosion cannot be attributed to dredging and disposal practices at the mouth of the Columbia River, as supported by records of dredging and disposal actions (Moritz 2002). For example, from 1905 to 1950, the mouth of the Columbia River navigation channel was maintained at a shallower depth than today and dredging at the mouth was sporadic (Figure 2-19; Moritz 2002). Further, all dredged sand from this time period was deposited either in high flow areas of the estuary or on the ebb-tidal shoal (Moritz 2002). Meanwhile, from 1950 to the present, about four million cubic yards are removed from the navigation channel at the mouth of the river; two thirds of all dredged sediment was placed within active sediment transport zones in the river mouth or in adjacent nearshore areas with a depth less than 18m (Moritz 2002). Moritz (2002) estimated that nearly 90% of all sediment dredged from the navigation channel at the mouth of the Columbia River has been deposited in a location where the sediment benefits littoral areas of the Columbia River littoral cell. In the most recent years (i.e. 1997 to present), 90% of the sand dredged from the navigation channel at the mouth of the Columbia River has been placed in two dispersive nearshore sites on the ebb-tidal shoal (Moritz 2002). To date, 80% of the dredge material deposited at these sites has been dispersed, of which less than 10% has been transported back to the navigation channel. Based on this history of dredge and disposal actions at the mouth of the

Columbia River, Moritz (2002) suggested that dredging and disposal activities have helped maintain the ebb-tidal shoal and minimize shoreline erosion, rather than contribute to current erosion occurring in the Columbia River littoral cell.

The alternate hypothesis is that dredging and disposal practices at the mouth of the Columbia River have contributed to shoreline erosion within the Columbia River littoral cell (Kaminsky 2002a, 2002b, Kaminsky et al. 2002a, 2002b). Estimates of projected dredging operations indicate that about 6.7 million cubic yards of sand will be removed annually from the lower river, while the sand supply from upland sources is estimated at 1.95 million cubic yards annually, resulting in an annual net removal of about 4.75 million cubic yards of sand (Kaminsky 2002a). Sand transported via the Columbia River has previously served as a source for accreting sediments along Long Beach (Gelfenbaum et al. 1999); as the historical Columbia River sand supply decreases, the southern portion of the Long Beach peninsula is predicted to undergo net erosion (Kaminsky 2002a). Since 1997, the Southwest Washington Coastal Erosion Study's morphology beach monitoring program has documented net recession along the southern portion of the Long Beach peninsula (Kaminsky 2002a). Preliminary shoreline change modeling results indicate that current shoreline configuration is changing in response to reduced sediment supply, primarily from the ebb-tidal deltas at the mouths of the Columbia River and Grays Harbor (Kaminsky et al. 2002a, 2002b). Additionally, future shoreline position will likely be a function of sediment supply from the Columbia River, ebb-tidal deltas, and the nearshore ocean lower shoreface (Kaminsky et al. 2002b). Based on proposed future dredge operations and disposal sites, use of upland or deepwater ocean sites for dredge disposal may become more prevalent, which will contribute to the decrease in sediment supply from the Columbia River (Kaminsky et al. 2002b). Strategic utilization of dredged sand from navigation projects in the Columbia River, Willapa Bay, and Grays Harbor may be one of the only viable options for maintaining sediment budgets and natural sediment dispersal pathways to reduce erosion in the Columbia River littoral cell (Kaminsky 2002b).

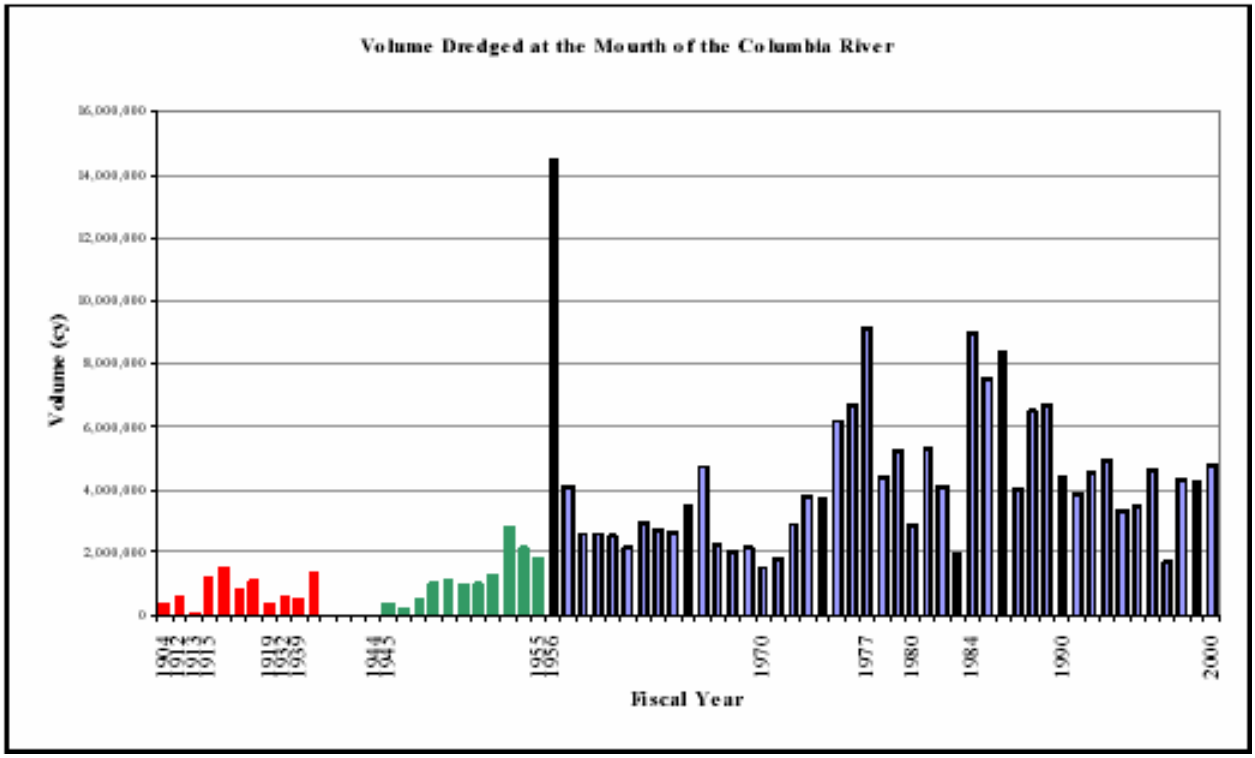


Figure 2-19. Volume of material dredged from the mouth of the Columbia River over time (USACE 2002).

The volume and type of sediment transported by the mainstem Columbia River has profound impacts on the estuary food web and species interactions within the estuary. For example, organic matter associated with the fine sediment supply maintains the majority of estuarine secondary productivity in the food web (Simenstad et al. 1990, 1995 as cited in Bottom et al. 2001). Also, turbidity (as determined by suspended sediments) affects estuary habitat formation, regulates primary production via affects on light penetration, and decreases predation on juvenile salmonids via decreased predator efficiency.

Sediment transport is non-linearly related to flow; thus, it is difficult to accurately apportion causes of sediment transport reductions into climate change, water withdrawal, or flow regulation (Jay and Naik 2002). However, the largest single factor in reduced sediment transport appears to be the reduction of spring freshet flow as a result of water regulation and irrigation withdrawal. Jay and Naik (2002) compared sediment transport data from the Columbia River at Beaver, Oregon, for the pre-1970 and post-1990 periods; they concluded that sand supply in the Columbia River remains available and has not reduced Columbia River sand transport. Findings of the USACE (1999, 2001, 2002) are consistent with this conclusion; they determined that there has been no substantial change in the river's sand supply. Further, the USACE (2002) suggested that sand supply in the Columbia River will unlikely become limiting to sediment transport because the riverbed is underlain by alluvial sand deposits that range in thickness from 100 ft. near Vancouver to 400 ft. in the estuary (Gates 1994 as cited in USACE 2002).

Figure 2-20 depicts the estimated volume of sand transported in the Columbia River at Vancouver, Washington; years of high sand transport volume correspond with high flow years and recent era sand transport volumes are generally lower than historical sand transport volumes as a result of water regulation.

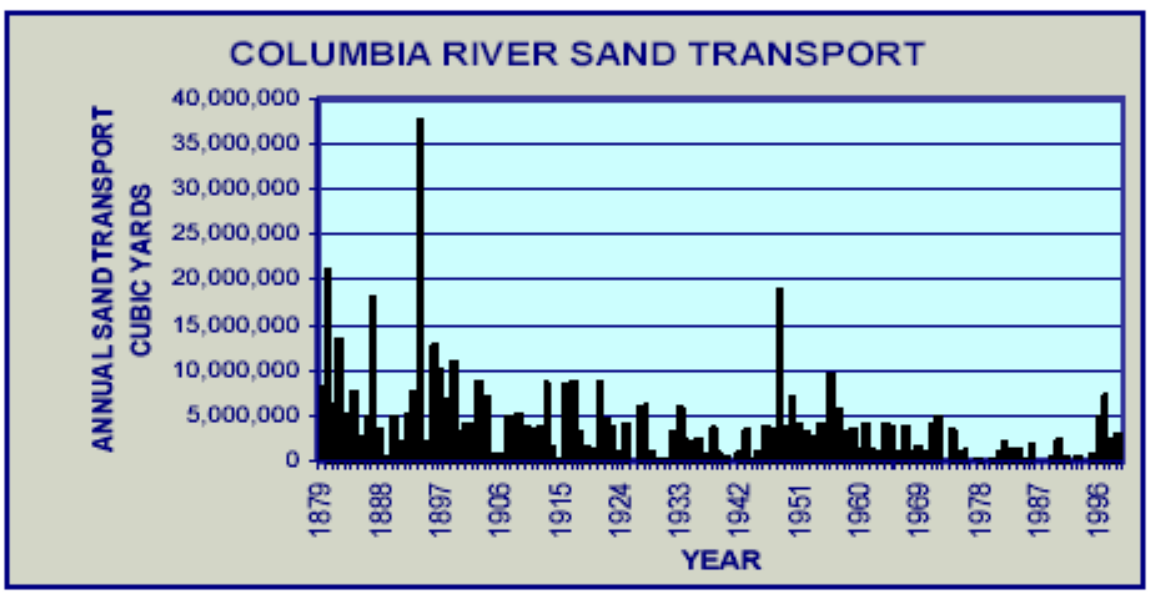


Figure 2-20. Total volume of sand transported annually in the Columbia River at Vancouver, Washington (Cited in USACE 2002; derived from Sherwood et al.

1990 and Bottom et al. 2001).

Recent analyses indicate a two-thirds reduction in sediment-transport capacity of the Columbia River relative to the pre-dam period (Sherwood et al. 1990, Gelfenbaum et al. 1999). Flow reductions affect estuary habitat formation and maintenance by reducing sediment transport (Bottom et al. 2001, USACE 2001). Moreover, the nature of sediments reaching the estuary has been altered. Research indicates that fine materials may be supply limited (which is rare in light of urban development, timber harvest, and agriculture), while sand transport is limited by discharge (Sherwood and Creager 1990). Regulated flows are usually sufficient to transport fine materials (silt, clay, fine sand), but not enough to transport sand and gravels. Thus, under regulated flow conditions, the reduction in sand transported to the estuary is disproportionately greater than reductions in flow and total sediment load (Bottom et al. 2001, Jay and Naik 2002); for example, the reduction in sand and gravel transport has been higher (>70% reduction compared to predevelopment flow) than for silt and clay transport (Bottom et al. 2001). Sand and gravel substrates are important components of preferred salmonid habitat in the estuary while organic matter associated with fine sediments is an important component of the food web.

Because of water velocity reductions, sediments and nutrients that would otherwise have been transported downstream accumulate in reservoirs (Robeck et al. 1954 and Puig et al. 1987 as cited in Weitkamp 1994). Thus, Columbia River reservoir construction has trapped much of the yearly upstream sediment load behind dams. Reservoirs also restrict bedload transport (i.e. movement of sediment along the riverbed when flow is sufficient). Historically, the amount of sediment supplied to the estuary was a function of the type of sediments available and river discharge. Changes in the sources of sedimentation and the regulation of upriver flows, coupled with entrapment of sediment behind dams, have changed sediment supply to the estuary. The idea of mainstem Columbia River reservoirs acting as sediment sinks is contrary to the findings of Whetten et al. (1969, as cited in USACE 2002); they found that sediment generally was not accumulating in mainstem reservoirs as a result of scour by high discharge.

Construction of the north and south jetties significantly increased sediment accretion in marine littoral areas near the mouth of the Columbia River and have decreased the inflow of marine sediments into the estuary. Ocean currents that formerly transported marine sediments into the estuary and Columbia River sediments along the marine littoral areas were disrupted as a result of jetty construction. Accretion, particularly in areas adjacent to the river mouth (i.e. Long Beach, Clatsop Spit), increased significantly in the late 1800s and early 1900s. Sediment accumulation rates have slowed since 1950, potentially as a result of reduced sediment supply from adjacent deltas or the Columbia River (Kaminsky et al. 1999). Because of the decreased sediment supply from the Columbia River and ebb-tidal deltas, recent modeling results indicate that the shorelines immediately north of the historical sediment source areas at the entrance to the Columbia River are susceptible to erosion in the future; accurate estimates of the Columbia River sediment supply are vital to realistic model predictions (Kaminsky et al. 2000). Conversely, Moritz (2002) suggested that the apparent widespread erosion within the Columbia River littoral cell is actually a localized re-distribution of sands resulting from the Columbia River ebb-tidal shoal that was initially pushed offshore after jetty construction and is now being forced toward equilibrium through present day ocean currents/waves.

2.1.3.1.3 Salinity and Nutrients

River discharge (estuary outward flow), tidal processes (estuary inward flow), and channel depth determine the salinity gradient and the type and location of available nutrients

(Figure 2-12). Columbia River flow may seasonally vary by an order of magnitude, which can significantly influence salinity intrusion and salinity stratification; salinity intrusion decreases while salinity stratification increases with higher river flows. Tides have complex effects on salinity; tide-induced turbulent vertical mixing inhibits salinity intrusion, while horizontal transport by tides is the primary salt transport mechanism during strong tides or low river discharge. The dependence of salinity intrusion on channel depth is strong; the controlling channel depth has doubled over the last 120 years. Bathymetric changes have likely caused the greatest changes in salinity intrusion and stratification, but reduced spring freshet flows have also substantially altered salinity intrusion length (Figure 2-21; Bottom et al. 2001).

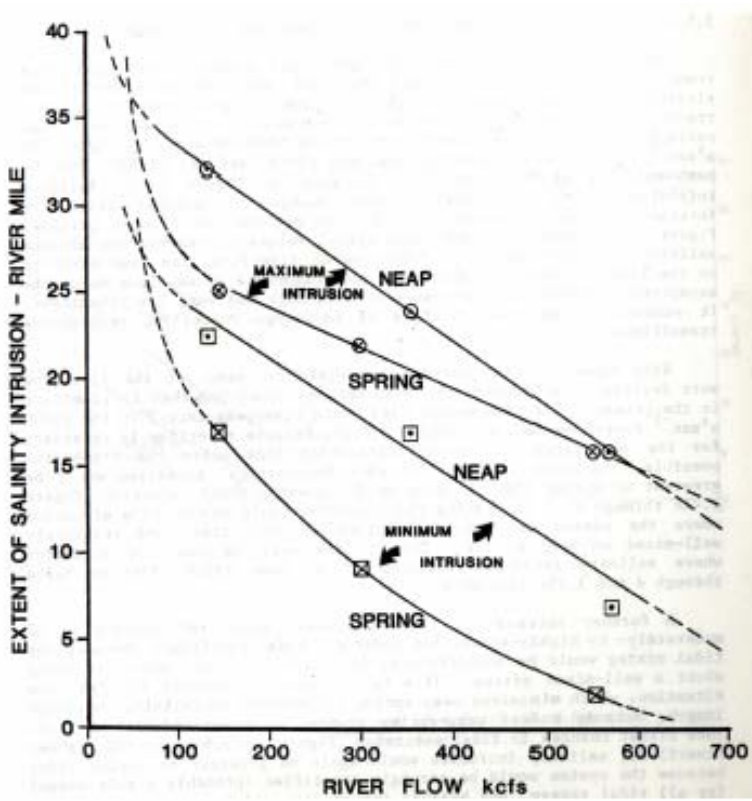


Figure 2-21. Maximum and minimum salinity intrusion distance in the Columbia River estuary, based on 1980 bathymetric conditions (Jay 1984 as cited in Bottom et al. 2001).

Operation of the Columbia River hydrosystem controls river flows and Columbia River flow affects salinity gradients. Increased river flow decreases the extent and duration of intrusion of salt water into the estuary, while decreased river flow does the opposite. Altered estuary bathymetry and flow have affected the extent and pattern of salinity intrusions into the Columbia River; stratification has increased and mixing has decreased (Sherwood et al. 1990 as cited in Williams et al. 2000).

The estuary turbidity maximum (ETM) is an area of elevated levels of suspended particulate material, in particular, river bed sediments, other particulate material, and associated bacteria. Suspension of material in the ETM is a result of turbulence caused by tidal forces

pushing saline water upriver below the outflowing river water (Figure 2-22). The ETM is an critical zone of organic matter accumulation and cycling (Figure 2-23), especially in the current imported microdetritus-based food web as discussed in subsequent sections. In the Columbia River, the ETM appears to move upstream with the leading edge of the salt wedge during flood tides, then retreats with the salt wedge during ebb tides. The combination of tidal energy and river discharge determine the location, size, shape, and salinity gradients of the Columbia River ETM (Figure 2-24). As depicted in this figure, low river flow allows the ETM to migrate further upstream; this is particularly true during neap (flood) tides (Figure 2-24; Scenario 1 and 2). During high flows, river discharge maintains the ETM location closer to the river mouth (Figure 2-24; Scenario 3). The length of the ETM ranges from 0.5 to 3 miles and the location fluctuates up to 9 miles daily, based on river discharge and tide cycle. On the south bank, the ETM generally migrates between Youngs Bay and Tongue Point, while on the north bank, the ETM is usually on either side of Point Ellice (USACE 2001).

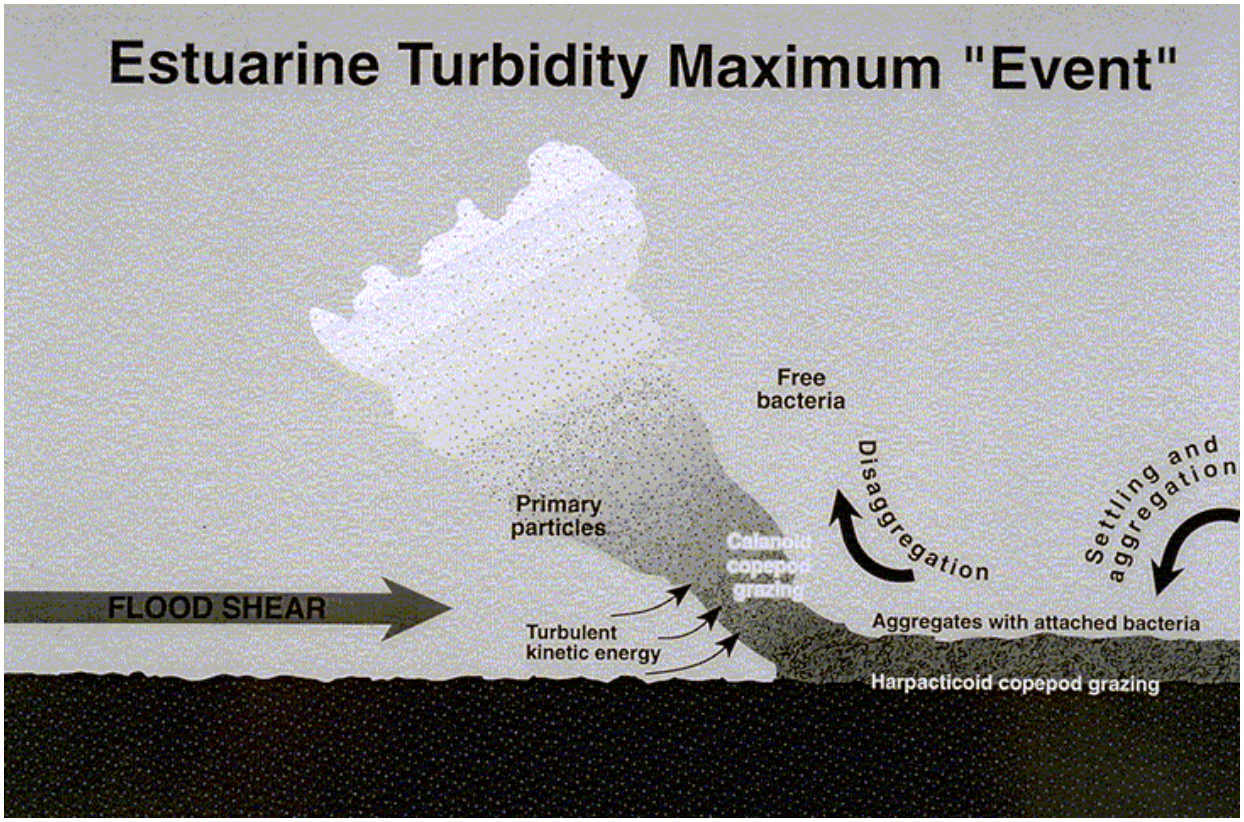


Figure 2-22. Diagram of an ETM "event" as tidal forces push salinity upriver beneath the outflowing river water (NSF 2003).

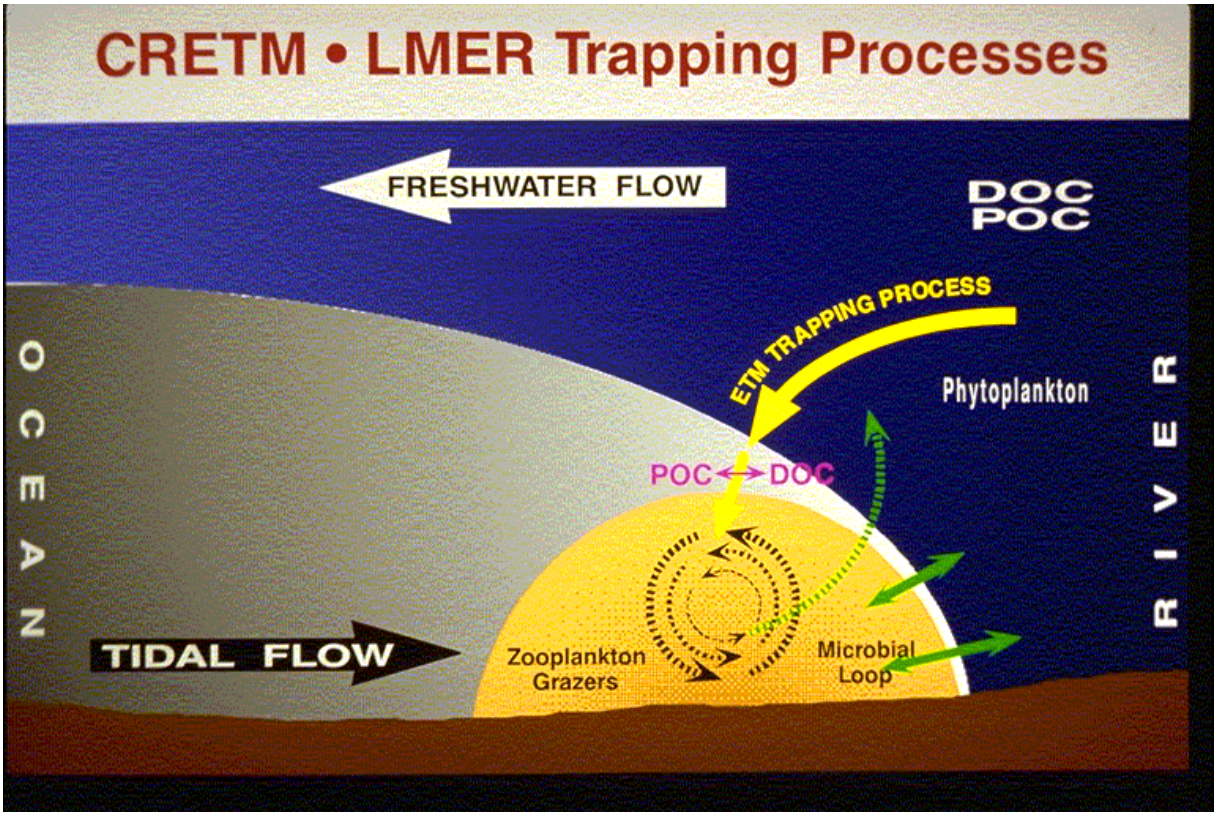


Figure 2-23. Diagram of biological activity within the ETM, illustrating the productivity of this area (NSF 2003).

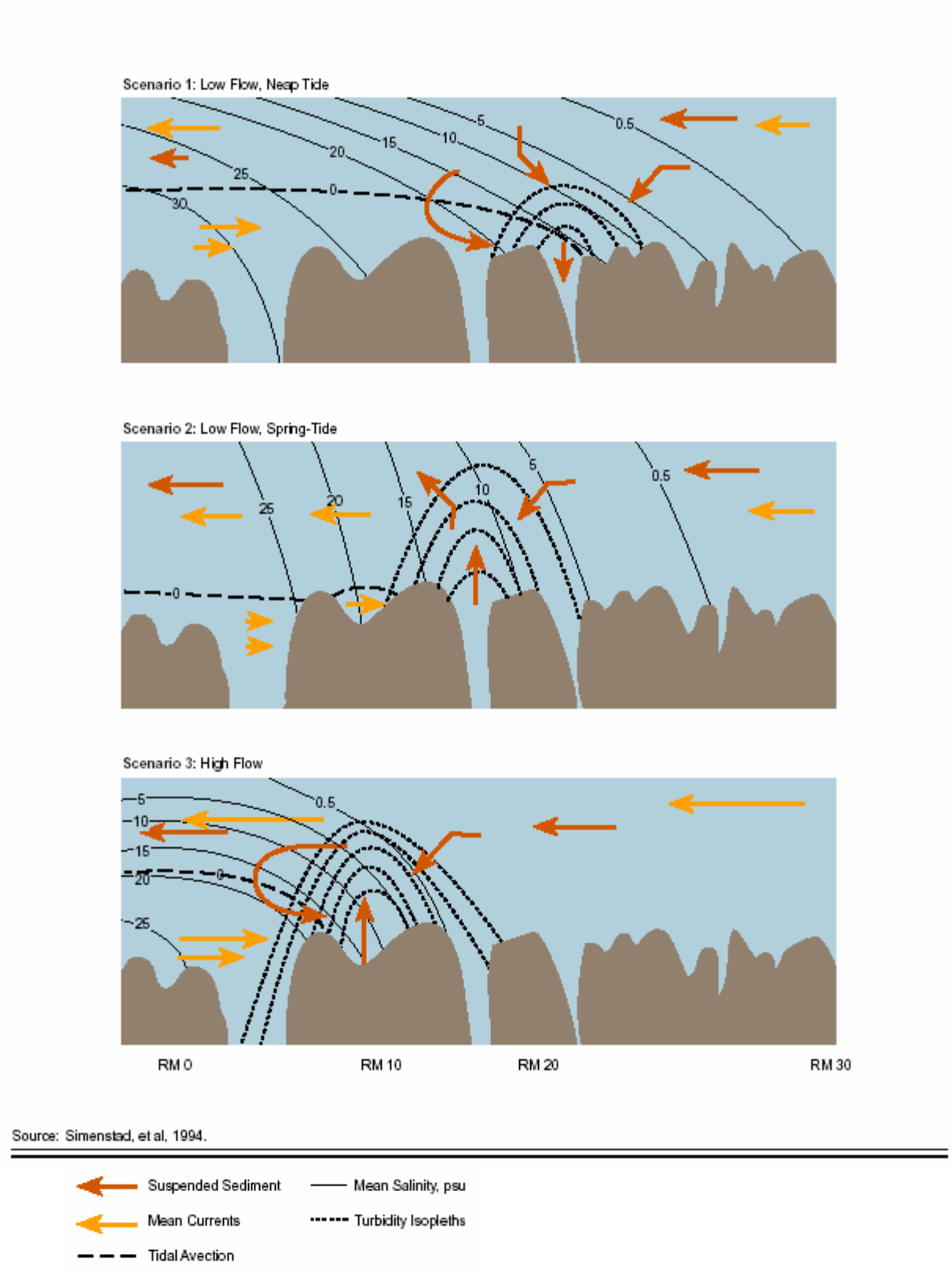


Figure 2-24. Variations in the estuary turbidity maximum (ETM) under different river flow and tide cycle conditions (USACE 2001).

Hydropower generation in the Columbia River has altered the amount and timing of water delivered to the Columbia River plume; the biological effects to juvenile salmonids of this altered flow pattern on the plume environment are largely under-studied (Bisbal and McConnaha 1998; Williams et al. 2000). Prior to hydrosystem operations, the coastal plume had well-defined seasonal directions: in winter, the plume extended toward the north while in the summer, the plume reversed and net transport was in a southwesterly direction, up to 400 km (Ebbesmeyer and Tangborn 1992 as cited in Bisbal and McConnaha 1998). Further, evidence suggests that the shift of freshet flows from the spring to the winter has altered sea surface salinities along a substantial part of the west coast of North America (Ebbesmeyer and Tangborn 1992 as cited in Williams et al. 2000). The nearshore environment, particularly that associated with the Columbia River plume, is important habitat to outmigrating juvenile salmonids (NMFS et al. 1998, Pearcy 1992 as cited in NMFS 2000c). Hydrologic conditions associated with the Columbia River plume creates a highly productive, low salinity zone compared to the surrounding ocean environment. Recent data suggests that juvenile salmonids are concentrated along this productive zone of the Columbia River plume during their early ocean existence (NMFS et al. 1998). Inter-annual variation in ocean recruitment of salmon is high and believed to be associated with annual variation in nearshore ocean physical and biological conditions (NMFS et al. 1998). Anthropogenic factors that may alter this productive plume environment, as well as management actions such as large releases of hatchery salmonids that may create competition for resources, can decrease survival during plume residence (Bisbal and McConnaha 1998).

Decreased spring flows and sediment discharges have reduced the extent, speed of movement, thickness, and turbidity of the Columbia River plume that previously extended far out and south of the river mouth during spring and summer (Ebbesmeyer and Tangborn as cited in Bisbal and McConnaha 1998; Barnes et al. 1972, Cudaback and Jay 1996, Hickey et al. 1998 as cited in NMFS 2000c). Although additional nutrients are available from upwelling during low river flows, low river discharge is unfavorable for juvenile salmonid survival because of reduced turbidity in the Columbia River plume (Pearcy 1992 as cited in NMFS 2000c). Decreased plume turbidity results in increased foraging efficiency of birds and fish predators, increased residence time of fish in the estuary and nearshore ocean environment where predation is high, decreased incidence of fronts with concentrated food resources for juvenile salmonids, and reduced overall total secondary productivity based on upwelled and fluvial nutrients (Pearcy 1992 as cited in NMFS 2000c). Further, decreased estuarine turbidity has allowed for increased predation on juvenile salmonids throughout the estuary (Junge and Oakley 1966, Bottom and Jones 1990 as cited in Nez Perce et al. 1995).

2.1.3.2 Habitat Change

Historically, environmental conditions in the Columbia River mainstem and estuary were controlled by ocean processes, Columbia River Basin landscape conditions, and riverine processes, which were influenced by climate and a host of natural processes and disturbance. The historical mainstem and estuary conditions were highly variable and the magnitude of environmental changes suggest major shifts in estuarine and riverine habitat conditions. Alterations to ocean and riverine processes have changed the amount and types of habitat in the lower Columbia River mainstem and estuary.

2.1.3.2.1 Climate

Variations in Columbia River discharge as a result of climate effects occur in time scales from years to centuries (Chatters and Hoover 1986, 1992 as cited in Bottom et al. 2001); research on climate cycles as they affect ocean productivity and salmonid survival has focused on the Pacific Decadal Oscillation (PDO; typically 40-50 year cycle) and the El Niño-Southern Oscillation (ENSO; typically 3-7 year cycle; Mantua et al. 1997 as cited in Bottom et al. 2001). The Columbia Basin's climate response to these cycles is governed by the basin's latitudinal position; climate in the region displays a strong response to both the PDO and ENSO cycles (Mantua et al. 1997 as cited in Bottom et al. 2001, Mote et al. 2003). Warm phases of ENSO (i.e. El Niño) and PDO cycles correspond with winter and spring weather that is warmer and drier than average; cool phases of ENSO (i.e. La Niña) and PDO typify cooler, wetter weather (Mote et al. 2003). Climate effects of short-term El Niño cycles are strengthened during warm phases of the PDO, while La Niña effects are intensified during a cold PDO phase (Gershunov et al. 1999, Mote et al. 2003). Strong El Niño winters result in Columbia and Willamette River flows that are 91 and 92% of the long-term annual average, respectively; conversely, strong La Niña winters result in Columbia and Willamette River flows that are 110 and 111% of the long-term annual average, respectively (Bottom et al. 2001). When the ENSO and PDO cycle phases are out of sync (i.e. cool ENSO/warm PDO or warm ENSO/cool PDO), streamflow tends to be near the long-term average (Mote et al. 2003).

In addition to the substantial direct affects climate has on river flow, climate indirect effects on other factors are often striking as a result of the relationship between river flow and other factors. For example, sediment discharge increases more than linearly with flow; thus, as climate affects flow, the effects on sediment discharge are amplified (Bottom et al. 2001). Another possible magnification of climate effects is the organic matter supplied during high river discharge; the extent to which this organic matter supports estuarine secondary production depends largely on whether the material is trapped in circulation processes associated with the estuary turbidity maximum (Bottom et al. 2001). Despite our ability to measure changes in climate, Bottom et al. (2001) discussed the difficulty in separating climate versus anthropogenic effects on river discharge and sediment/nutrient discharge.

Current climate projections predict gradual warming of the region, potentially with higher precipitation, particularly in winter (Hamlet and Lettenmaier 1999, Mote et al. 2003); the predicted precipitation changes are well within the 20th century annual variability range. Mote et al. (2003) indicated that, of the predicted precipitation and temperature changes, temperature changes are likely more important because they shift river flow from summer to winter. The Columbia River, being a large, snowmelt-dominated watershed (Neal 1972), is not expected to be susceptible to increased risk of spring flooding, rather, will be strongly influenced by changes in low flow because of limited reservoir storage and anthropogenic demands on water (Callahan et al. 1999 and Miles et al. 2000 as cited in Mote et al. 2003). The predicted future climate conditions will possibly reduce the likelihood of spring freshets caused by heavy spring rain on late snowpack because warmer temperatures will not allow the accumulation of snow late into the spring. This freshet style (rain on snow) has historically produced the most substantial increases in river discharge (Bottom et al. 2001). A potential consequence of this climate change is heightened conflicts over water supply during the critical spring season as a result of increased water demand and decreased natural flows (Hamlet and Lettenmaier 1999, Mote et al. 2003).

Climate has substantial effects on nearshore and ocean productivity; variability in productivity as a result of climate has important implications for many focal species in the subbasin, particularly those that make extensive use of the lower estuary, nearshore ocean, or open ocean environments. For example, the timing of spring upwelling and spring phytoplankton blooms are largely determined by the character of upwelling winds (i.e. variable winds produce more upwelling) and the circulation and stratification of the upper ocean, which is significantly influenced by winter climate (Logerwell et al. 2003 as cited in Mote et al. 2003). Additionally, the PDO cycle has profound effects on ocean nutrient levels. The warm PDO phase results in warmer and more thermally stratified coastal waters off Washington and Oregon, causing poor nutrient conditions; the opposite is true for the cold PDO phase (Mote et al. 2003). It has been suggested that potential oceanic warming that results from the predicted climate change may push the range of some salmon north out of the Pacific Ocean entirely (Welch et al. 1998 as cited in Mote et al. 2003), however, the notion that ocean thermal limits alone determine salmon distribution is likely too simplistic (Walker et al. 2000 as cited in Mote et al. 2003). Thus, minor oceanic warming may not lead to drastic changes in salmonid distribution unless accompanied by substantial changes in the oceanic food web, such as prey distribution (Mote et al. 2003).

2.1.3.2.2 River Flow

The Columbia River has the largest annual flow of any river on the Pacific coast of North America. Historically, unregulated flows at the mouth ranged from 79,000 cfs to over 1 million cfs, with average flows about 273,000 cfs (Marriot et al. 2002). Currently, discharge at the mouth of the river ranges from 100,000 to 500,000 cfs, with an average of about 260,000 cfs (Marriot et al. 2002). Highest flows are experienced during and just after winter storms, generally from December through March. Flows and sediment load have been altered by construction of 31 irrigation and hydropower dams in the basin since 1890. Prior to human influence, the Columbia River estuary had extensive sand beds and variable river flows. However, the construction of upriver hydroelectric dams has dramatically changed the nature of the estuary, as these dams have translated into different flow rates and sediment discharges (Figure 2-13, Figure 2-14, Figure 2-15, and Figure 2-16). Moreover, channel deepening, use of jetties and dredging to stabilize channels, development of perennial wetland areas, and isolation of remaining wetlands from the mainstem river have altered the physical character of the Columbia River estuary and these changes have affected the biological systems that the estuary supports. Introduction of non-native species and degradation of water quality have also impacted the estuarine biota. All of these influences interact in complex ways. The quantitative estimates of habitat loss, however, do not reflect the qualitative losses that have also occurred, and which may have important effects on the salmon rearing capacity of the estuary.

Because of changes to flow and sediment transport and the various habitat alterations that have occurred in the estuary, the availability of shallow (10cm-2m depth), low velocity (<30 cm/s) habitats appears to decrease at a steeper rate with increasing flow compared to historical conditions (see also the physical process description of sediment transport in section 2.1.3.1.2). Further, the resilience of the estuary to increasing water depth with increasing flow appears to have decreased, likely as a result of disconnectedness with the historical floodplain. These conditions have decreased the shallow water refugia for juvenile salmonids and likely contribute to decreased survival during high flow conditions (NMFS 2000c).

Water Temperature

Many factors can cause high stream temperatures, but they are generally related to land-use practices rather than point source discharges. For example, some actions that result in high stream temperatures are the removal of riparian vegetation that directly shade streams, excessive water withdrawals for irrigation or other purposes, and warm irrigation return flows. Loss of wetlands and increases in groundwater withdrawals have decreased stream base flows, which contribute to increases in temperature. Other land uses that create shallower streams can also cause temperature increases. These land uses have occurred in some combination throughout the lower mainstem and estuary; however, the degree of water temperature increase within the lower mainstem and estuary as a result of these land uses is not completely understood. Water temperature alterations affect salmonid metabolism, growth rate, disease resistance, and the timing of adult migrations, fry emergence, and smoltification (NMFS 2000c).

2.1.3.2.3 Channel Confinement

The most significant habitat changes from historical to current conditions have been the loss of tidal marsh and tidal swamp habitat that are critical to juvenile salmonids, particularly small or ocean-type salmonids (Thomas 1983, USACE 2001, Johnson et al. 2003b). Thomas (1983) noted that diking has caused more of the estuary habitat changes documented in the historical/current habitat comparison than any other factor, anthropogenic or natural. This conclusion is consisted with the findings of Kukulka and Jay (2003) who indicated that dike removal alone would restore considerable amounts of shallow water estuary habitats. Further, diking entirely removes habitat from the estuarine system, while other anthropogenic factors change estuary habitats from one type to another (Thomas 1983). The degree to which estuary habitat types have been effected by diking is directly proportional to elevation; thus, the highest elevation habitat type (i.e. tidal swamp) has been impacted by diking the most (Thomas 1983).

Historically, floodwaters of the Columbia River inundated the margins and floodplains along the estuary, allowing juvenile salmon access to a wide expanse of low-velocity marshland and tidal channel habitats (Bottom et al. 2001). Flooding occurred frequently and was important to habitat diversity and complexity. Historical flooding also allowed more flow to off channel habitats (i.e. side channels and bays) and deposited more large woody debris into the ecosystem. Historically, seasonal flooding increased the potential for salmonid feeding and resting areas in the estuary during the spring/summer freshet season by creating significant tidal marsh vegetation and wetland areas throughout the floodplain (Bottom et al. 2001). In general, the river banks were gently sloping, with riparian and wetland vegetation at the higher elevations of the river floodplain becoming salmonid habitat during flooding river flows or flood tides. It is estimated that the historical estuary had 75 percent more tidal swamps than the current estuary because tidal and flood waters could reach floodplain areas that are now diked or otherwise disconnected from the main channel (USACE 2001, Johnson et al. 2003b).

Mainstem habitat in the Columbia and Willamette Rivers have for the most part been reduced to a single channel where floodplains have been reduced in size, off-channel habitat has been lost or disconnected from the main channel, and the amount of large woody debris has been reduced (NMFS 2000c). Most of the remaining mainstem habitats are affected by flow fluctuations associated with reservoir management (NMFS 2000c). Dikes prevent over-bank flow and affect the connectivity of the river and floodplain (Tetra Tech 1996); thus, the diked floodplain is higher than the historical floodplain and inundation of floodplain habitats only occurs during times of extremely high river discharge (Kukulka and Jay 2003). There is a critical

level (i.e. the elevation of the diked floodplain) where water level must reach before substantial floodplain habitat are inundated; this threshold level varies between reaches (Kukulka and Jay 2003). Above this critical water level, large amounts of shallow water floodplain habitats become available with small increases in water level up to an optimum threshold (Kukulka and Jay 2003). With continued floodplain inundation above this threshold, availability of shallow water habitats decrease (Kukulka and Jay 2003), presumably because the shallow water habitats initially created at the critical water level no longer satisfy the depth criteria of shallow water habitat (0.1 to 2.0 m in this case). Under a modern bathymetry and flow regime scenario, the critical river discharge level in which significant shallow water habitats become available through floodplain inundation is relatively high and the frequency of occurrence of this river discharge is rare; thus, floodplain inudation is uncommon and availability of shallow water habitats is limited (Kukulka and Jay 2003). As is the case in the estuary (Bottom et al. 2001), loss of these vital mainstem floodplain habitats has likely reduced the productive capacity of the lower Columbia River for juvenile salmonids (particularly fry and subyearling smolts).

2.1.3.2.4 Channel Modifications

Development of a shipping channel has greatly affected the morphology of the estuary. The extensive use of jetties and diking to maintain the shipping channel has impacted natural flow patterns and large volumes of sediments are dredged annually. Dredged materials are disposed of in-water (in the ocean or in the flow adjacent to the shipping channel), along shorelines, or on upland sites. Annual maintenance dredging since 1976 has averaged 3.5 million cubic yards per year in the estuary. By concentrating flow in one deeper main channel, the development of the navigation channel has reduced flow to side channels and peripheral bays. Saltwater intrusion patterns have been reduced, and habitat types have been altered. Disposal of dredge materials has created barren land or islands that have indirectly increased avian predation on salmonids.

2.1.3.2.5 Contaminants

Industrial and urban development and agricultural practices in the lower Columbia River has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on juvenile salmonids is not clear. In general, contaminants affect survival by increasing stress, predisposing fish to disease, and interrupting physiological processes. Tributary water quality problems contribute to poor water quality where sediment and contaminants from the tributaries settle in mainstem and estuary habitats (NMFS 2000c). Further, the dampening of peak and sustained flood flows by hydrosystem operations has increased the accretion of sediments facilitating the accumulation of pollutants from the entire Columbia River basin in estuarine sediments (Sherwood et al. 1990 as cited in Nez Perce et al. 1996). Less water volume translates to less dilution and higher concentrations of pollutants; any stresses imposed on juvenile fish will be exacerbated by the presence of contaminants (Nez Perce et al. 1995).

The most recent data regarding contaminant effects on juvenile salmonids have been generated through assessment work for the USACE proposed channel deepening project (USFWS 1999a, NWFSC 2001, USACE 2001, NMFS 2002, USFWS 2002). Recent sampling of hatchery and wild juvenile salmon near Sand Island at the mouth of the Columbia River indicated the presence of contaminants in the food chain of juvenile salmonids (NMFS 2002). Elevated concentrations of DDT and PCBs were detected in both whole body and stomach content samples (NMFS 2002). The whole body concentrations of DDT and PCBs were among

the highest concentrations measured at estuarine sites in Washington and Oregon; the whole body DDT levels were greater than and the whole body PCB levels were similar to concentrations detected in juvenile chinook salmon in the Duwamish estuary, which is a heavily contaminated industrial estuary near Seattle (NMFS 2002). Further, the presence of elevated concentrations of DDT and PCBs in stomach content samples is clear evidence that exposure to these contaminants is occurring in the estuary (NMFS 2002).

Studies of sub-lethal exposure of juvenile salmon to contaminants in urban estuaries suggest that these contaminants could affect the survival, growth, and fitness of salmon (Casillas et al. 1996). A series of experiments with natural and laboratory exposure of fall chinook salmon to hydrocarbon pollutants in Puget Sound estuaries demonstrated impaired growth, reduced immune defenses, and increased susceptibility to disease (Stein et al. 1995, Arkoosh et al. 1998a, Arkoosh et al. 1998b, Stehr et al. 2000). Water quality issues could reduce productivity for species that make extensive use of estuarine habitats for rearing, such as subyearling chinook, and chum salmon.

In the case of bald eagles, concentrations of PCBs, pesticides, and dioxins were found in bald eagle eggs collected along the lower Columbia River at concentrations associated with reduced breeding success based on eagles studied elsewhere (Anthony et al. 1993, USFWS 1999b). Reproductive problems for lower Columbia River bald eagles include eggshell thinning and a low number of young produced per occupied nest, which is considered a result of embryo dessication and mortality caused by bioaccumulative organochlorine contaminants such as DDE and PCBs (Anthony et al. 1993, USFWS 1999b). Eggshell thinning, generally attributed to DDE (a DDT derivative), was prevalent in eagle eggs and shell fragments collected along the river (Anthony et al. 1993, USFWS 1999b). Anthony et al. (1993) reported a significant relationship between eggshell thickness and breeding success among lower Columbia breeding pairs, but follow up studies in 1994 and 1995 did not show a significant relationship (USFWS 1999b). The latter studies also showed that the contaminants DDE and total PCBs declined in eggs sampled in 1994 and 1995 compared to eggs sample 10 years earlier. Even though egg concentrations have declined, values still exceeded no-effect levels estimated for the species. Recent increases in productivity and breeding success have been observed in lower Columbia River bald eagles and is likely a result of recruitment of eagles from outside regions and possibly improving contaminant conditions (USFWS 1999b, Isaacs and Anthony 2003). However, lower Columbia River eagles nesting below rm 60 continue to experience poor reproduction compared to bald eagles nesting elsewhere in Oregon and Washington. Productivity is lowest for bald eagles nesting between rm 13 and 31 (USFWS 1999b, Isaacs and Anthony 2003).

Osprey eggs collected in 1997 and 1998 along the lower 410 km of the Columbia River exhibited the highest DDE values reported for osprey in North America during the late 1980s and 1990s; additionally, DDE concentrations in eggs collected along the Columbia River were twice the concentration of eggs collected along the Willamette River in 1993 (Henny et al. 2003a, 2003b). Osprey eggshell thickness followed the classic semi-logarithmic response to DDE, as eggshell thickness decreased with increasing DDE concentration. Reproductive success was higher for nests that contained eggs with DDE concentration below 4,200 μg/kg; at this concentration, DDE results in 15% eggshell thinning (Wiemeyer et al. 1988 as cited in Henny et al. 2003a). Additionally, Henny et al. (2003a) noted that DDE concentrations in largescale suckers (a primary food item of osprey) in the Columbia River was double the levels detected in the Willamette River. Despite contaminant levels in osprey known to cause eggshell thinning, the lower Columbia River osprey population was increasing (Henny et al 2003a), but not as fast

as the population nesting along the Willamette River (Henny et al. 2003b). The other contaminants found in osprey eggs (e.g., PCBs, dioxins, furans, mercury and other organochlorine pesticides), except for one egg with a high total dioxin-like activity calculated from PCBs and dioxins, appeared to be below any known effect levels for ospreys. During 1997 and 1998, osprey productivity was estimated at 1.64 young/active nest, which is higher than the generally recognized 0.80 young/active nest needed to maintain a stable population (Henny et al. 2003a).

Contaminant concentrations above available reference levels have been observed in river otter tissue samples; however, detrimental physiological effects have not been clearly established. For example, concentrations of organochlorines (i.e. PCBs, pesticides, dioxins, and furans) were higher in lower Columbia River otter samples compared to reference sites outside the lower Columbia River basin (Tetra Tech 1996). In general, observed contaminant concentrations in river otters increased with age; also, for age 2+ river otters, tissue contaminant levels decreased from rm 119.5 (near Vancouver/Portland) to rm 11.0 (Tetra Tech 1996). A number of physiological concerns were documented in river otters compared to otters from the reference sites: abnormal liver function, lower baculum weight and length, and lower mean testes weight (Tetra Tech 1996). However, when compared to previous tissue contaminant concentration data (Henny et al. 1981 as cited in Tetra Tech 1996), contaminant levels in river otter tissue in the 1990s indicate a major decline in PCB concentrations (Tetra Tech 1996). Further, data suggests that certain physiological problems may be temporary because organs of older males did not show significant size differences compared to reference animals (Tetra Tech 1996).

In the lower 150 miles of the mainstem Columbia River, the states of Oregon and Washington have found the following contaminants above guidance levels for fish tissue and sediment: organochlorines (including DDT, DDD, DDE, PCB, aldrin, dieldrin, trichlorobenzene, pyrene, and PAHs), and toxic metals (including mercury, cyanide, arsenic, chromium, iron, nickel, silver, zinc, cadmium, and copper; Tetra Tech 1993 as cited in Nez Perce et al. 1995). The U.S. Environmental Protection Agency has identified numerous water quality concerns for the Columbia River mainstem, including temperature, PCBs, dioxins, furans, pesticides, metals, and bacteria in the Columbia River estuary and temperature, PCBs, dioxins, furans, pesticides, metals, bacteria, dissolved oxygen, and total suspended solids in the Columbia River mainstem below Bonneville Dam (Nez Perce et al. 1995). However, two of the more widely known contaminants, DDT and PCBs, were much more prevalent in the lower Columbia River in the 1960s and early 1970s than they are today; their concentrations have continued to decline since 1972, when the use of DDT was banned (USACE 2001).

Data collected in the early to mid 1990s suggest that contaminant concentrations in water, sediment, or biota result in localized impairment throughout the lower Columbia River (i.e. Bonneville Dam to the mouth; Tetra Tech 1996). Metals concentration exceedance of sediment reference levels indicate possible localized effects to benthic organisms; further, some organic compounds (i.e. PCBs, DDT and derivatives, dioxins, and furans) detected in sediment and fish tissue are high enough to biomagnify through the food chain and cause adverse effects to piscivorous organisms (Tetra Tech 1996). In general, contaminant concentrations are higher in resident benthic-dwelling fish (such as largescale sucker) compared to migratory salmonids; thus, potential adverse physiological effects to biota, biomagnification to upper trophic level organisms, and human health risks associated with fish consumption are higher in benthic fish than salmonids (Tetra Tech 1996, USFWS 2003).

For years, the unmitigated flow of deicing agents from the Portland International Airport (PDX) directly into Columbia Slough has been a concern. Although PDX uses deicing agents in limited quantities, untreated flow of deicing agents can cause significant water quality problems. Deicing agents (typically a glycol mixture) are highly biodegradable and exert substantial biological oxygen demand when released to surface water. Biological oxygen demand decreases the dissolved oxygen level in the receiving surface water; decreased dissolved oxygen can stress organisms, making them less competitive and decreasing survival through a host of confounding factors. In 2003, PDX activated a glycol recovery system; the system combines underground monitoring, metering, storage, and aeration, as well as treatment by the City of Portland's wastewater treatment plant. The glycol recovery system is intended to decrease glycol discharge levels to comply with the Oregon Department of Environmental Quality's total maximum daily load requirements for the Columbia Slough.

2.1.3.2.6 Restoration

Habitat actions proposed in the NMFS Biological Opinion on the Operation of the Federal Columbia River Power System (BiOp; NMFS 2000c) are intended to accelerate efforts to improve survival in priority areas while laying the foundation for long-term habitat strategies. The overarching objectives of the habitat strategy are: protect existing high quality habitat, restore degraded habitats and connect them to functioning habitats, and prevent further degradation of habitat and water quality. Specifically, Reasonable and Prudent Alternative (RPA) Actions 158 through 163 of the BiOp detail specific actions related to estuarine habitat while RPA Actions 156 and 157 address habitat issues within the lower mainstem (NMFS 2000c). An "Action Plan" has recently been published that outlines a plan for implementing the above RPA actions related to estuary and mainstem habitat restoration, as well as RPA actions that address planning, modeling, and research, monitoring, and evaluation needs described in the BiOp (BPA and USACE 2003).

Restoration of tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River has been identified as an important component of current and future salmon restoration efforts. RPA Action 160 in the BiOp called for an estuary restoration program with the goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, with the intention of rebuilding productivity for ESA-listed salmon population in the lower 46 miles of the Columbia River. There is considerable uncertainty whether the 10,000 acres is the precise amount needed to produce desired increases in salmonid productivity or if the 10-year schedule is an appropriate time scale for recovery efforts. NMFS (2000c) identified the importance of continued monitoring and evaluation of the estuary restoration program and the 10,000-acre goal to ensure that habitats being restored are important for salmon survival and recovery. NMFS (2000c) also suggested examples of acceptable habitat improvement efforts, including but not limited to: acquiring diked lands, breaching levees, improving plant communities, reestablishing flow patterns, or enhancing connections between lakes, sloughs, side channels, and the main channel.

Dike removal could provide a sizable increase in shallow water habitat, even without restoration of historical flow regimes (Kukulka and Jay 2003). Dike removal alone provided more of an increase in shallow water habitat than flow restoration without dike removal. Restoration of natural flows increases the duration of shallow water habitat inundation in high-flow years, but individually does not restore the large size of the area historically inundated.

Management actions that seek to alter anthropogenic factors and restore natural habitat-forming processes need to be evaluated based on their impact on biological diversity and not simply on production of juvenile salmonids (Bisbal and McConnaha 1998). For example, changes in hydrosystem water management should attempt to provide benefits for the full range of salmonid life history patterns and not just the current majority. Restoration efforts need to move from the practice of management for average biological conditions to management for the full spectrum of possible biological variation (Williams et al. 1996 as cited in Bisbal and McConnaha 1998).

2.1.3.3 Historical vs. Current Habitat Condition

Current ecological conditions in the Columbia River estuary reflect years of anthropogenic impacts that have altered natural ecosystem inputs and processes and affected habitat conditions for all species that utilize the estuary. The extent of change of estuary habitat is highly dependent on location in the estuary and the type of habitat.

Significant effort has focused on quantifying the loss or change of habitats within the estuary and lower Columbia mainstem over time. The two methods employed to quantify habitat change include bathymetry and satellite imagery. Although there is some difficulty in comparing results of the two different methods, the underlying conclusion from both methods is that estuary and mainstem habitats have changed significantly as a result of human influence. Bathymetry is a low resolution method that provides coarse delineations of habitat types; further, bathymetry provides a means to segregate aquatic habitat based on depth criteria. Satellite imagery provides a high resolution habitat mapping method that principally uses vegetative communities to describe habitat types. Because of the use of vegetation, satellite imagery is generally not capable of distinguishing different types of aquatic habitats. Different satellite imagery technology are available that provide different levels of resolution; two of these technologies are compared in Garono et al. (2003b).

Using bathymetric survey maps of the U.S. Coast Survey (now U.S. Geodetic Survey), five major types of estuary (i.e. rm 0-46.5) habitat were defined by the Columbia River Estuary Data Development Program (Thomas 1983) according to elevation and the dominant vegetation: tidal swamps, tidal marshes, shallows/flats, medium depth water, and deep water. Change in acreage from 1870 to 1983 was estimated (Table 2-5). Additionally, Thomas (1983) investigated five categories of non-estuarine habitat (i.e. developed floodplain, natural and filled uplands, non-tidal swamps, non-tidal marshes, and non-tidal water) to identify the fate of floodplain areas that were removed from the estuarine system. Some estuary habitat has been lost and converted to non-estuarine habitat, while other habitats have been lost as result of succession to another estuarine habitat type (Thomas 1983). As a result, the relative proportions of the five estuary habitat types has changed considerably from 1870 to 1983. Also, the significance of loss of certain habitat types has been partially masked by the formation of these habitats elsewhere. Further, the geographic movement of estuary habitats is not clear from the quantification of total acreage change. For example, the total acreage of a certain habitat type within a particular estuary area may not have changed considerably from historical to current conditions, however, the location of this habitat type within the estuary area may be completely different. The habitat change within each estuary region and from one type to the next is discussed in the following subsections.

The Lower Columbia River Estuary Partnership (LCREP) was interested in describing the location and distribution of estuarine and tidal freshwater habitat cover types along the

Columbia River from the mouth to Bonneville Dam using a consistent method and data source (Garono et al 2003c) as well as understanding recent habitat change in the estuary and lower Columbia River mainstem (Garono et al 2003a). The habitat mapping focused on estuarine and tidal freshwater habitats; areas not located along the river and >175 ft elevation (for the eastern dataset) or >100 ft elevation (for the western dataset) were deleted from the habitat classification (Garono et al 2003c). Although habitat change expressed as the percent of the 1992 area indicates considerable change from 1992 to 2000, the percent of total habitat comprised by each land cover class is similar in both 1992 and 2000. Further, it is important to note the losses and gains of each habitat type, as well as the transition among habitat types. For example, most of the loss of shrub-scrub wetland habitat was to either herbaceous or forested wetlands; the absolute loss of the shrub-scrub wetland habitat was offset by substantial transition of herbaceous wetlands to shrub-scrub wetlands. Much of the increase in deciduous forest upland habitat coverage was a result of transition of shrub-scrub upland, coniferous forest upland, or mixed forest upland habitats; this may be indicative of normal successional transitions. A considerable amount of the change in area of habitat cover was potentially explained by either natural habitat succession or error associated with differences in accuracy of the two data sets. In general, if a specific habitat type changed from 1992 to 2000, it remained within the larger designation of wetland or upland, that is, wetlands transitioned to other wetlands while uplands transitioned to other uplands.

Johnson and O'Neil (2001) developed a habitat classification system to describe wildlife habitats present in Washington and Oregon. The habitats described by Johnson and O'Neil (2001) have been used in the NPCC subbasin planning process throughout the Columbia Basin. Maps of many NPCC subbasins depicting the habitat coverage in 1850 and 1999 are currently available through the Interactive Biodiversity Information System (IBIS) website (http://ibis.nwhi.org).

Comparison of estuary and lower mainstem habitats describe by the three primary classification systems and mapping efforts (Thomas 1983, Johnson and O'Neil (2001)/IBIS (2003), Garono et al. 2003c) is difficult because of the different purposes of each effort. Further, each effort covered a different geographic area, encompassed different time periods, and utilized a different method or resolution. These differences may contribute to different results obtained during each effort. Nevertheless, we attempt to describe the changes in habitat in the Columbia River estuary and lower mainstem based on the findings of these habitat mapping projects. Regardless of the differences, each mapping project reached the conclusion that estuary and mainstem habitats have changed significantly as a result of human influence.

Other habitat inventory efforts include that of Christy and Putera (1992) and Graves et al. (1995) who extended the work of Thomas (1983); these mapping efforts used Geographic Information Systems methods (GIS) to delineated Thomas' (1983) estuary habitat types from rm 46.5 to rm 105. Finally, Johnson et al. (2003b) summarized many of the habitat inventory efforts to date (Thomas 1983, Graves et al. 1995, USACE 1996, Garono et al. 2002) to describe habitat changes in the Columbia River estuary and lower mainstem up to Bonneville Dam. A qualitative change in habitat characteristics by estuary area is included in Table 2-6. These studies are identified here primarily to inform the reader that other habitat mapping projects exists for the Columbia River estuary and lower mainstem.

Table 2-5. Estimated change in estuary habitats by region within the Columbia River estuary from rm 0 to rm 46 (Thomas 1983).

HABITAT TYPE Estuary Region	1870 Acreage	1983 Acreage	Change
DEEP WATER			
Entrance	8,900	10,580	+1,680 (19%)
Mixing Zone	8,450	8,360	-90 (1%)
Youngs Bay	810	850	+40 (5%)
Baker Bay	1,800	450	-1,350 (75%)
Grays Bay	2,270	1,690	-580 (26%)
Cathlamet Bay	6,390	5,590	-800 (13%)
Upper Estuary	6,520	5,060	-1,460 (22%)
TOTAL	**35,140**	**32,580**	**-2,560 (7%)**
MEDIUM DEPTH WATER			
Entrance	4,480	2,640	-1,840 (41%)
Mixing Zone	10,780	10,330	-450 (4%)
Youngs Bay	1,120	870	-250 (22%)
Baker Bay	4,700	1,350	-3,350 (71%)
Grays Bay	2,230	2,040	-190 (9%)
Cathlamet Bay	8,190	5,700	-2,490 (30%)
Upper Estuary	2,710	2,790	+80 (3%)
TOTAL	**34,210**	**25,720**	**-8,490 (25%)**
SHALLOW/TIDAL FLATS			
Entrance	2,980	1,680	-1,300 (44%)
Mixing Zone	9,540	9,490	-50 (1%)
Youngs Bay	4,400	3,860	-540 (12%)
Baker Bay	4,830	8,450	+3,620 (75%)
Grays Bay	3,790	4,330	+540 (14%)
Cathlamet Bay	13,330	14,250	+920 (7%)
Upper Estuary	1,770	2,710	+940 (53%)
TOTAL	**40,640**	**44,770**	**+4,130 (10%)**
TIDAL MARSH			
Entrance	0	250	+250
Mixing Zone	10	10	0
Youngs Bay	7,210	980	-6,230 (86%)
Baker Bay	1,640	730	-910 (56%)
Grays Bay	310	760	+450 (145%)
Cathlamet Bay	5,580	5,960	+380 (7%)
Upper Estuary	1,430	510	-920 (64%)
TOTAL	**16,180**	**9,200**	**-6,980 (43%)**
TIDAL SWAMP			
Entrance	0	0	0
Mixing Zone	0	0	0

HABITAT TYPE Estuary Region	1870 Acreage	1983 Acreage	Change
Youngs Bay	3,000	130	-2,870 (96%)
Baker Bay	3,480	0	-3,480 (100%)
Grays Bay	4,410	510	-3,900 (88%)
Cathlamet Bay	7,950	4,060	-3,890 (49%)
Upper Estuary	11,180	2,250	-8,930 (80%)
TOTAL	**30,020**	**6,950**	**-23,070 (77%)**
TOTAL ESTUARY	**156,190**	**119,220**	**-36,970 (24%)**

Table 2-6. Qualitative description of the change in habitat characteristics from historical to current conditions by area, including a judgment of relative importance (adapted from Johnson et al. 2003b; L, M, and H refer to Low, Medium, and High).

Area	Tidal Exchange	Bathymetry	Salinity
Entrance	***L***-only a small area of historical marshes and swamps	***H***-very large increases in deep water area, and loss of medium and shallow depth areas	***L***-probably somewhat less dynamic, but still ocean-dominated
Mixing Zone	***L***-only a small area of historical marshes and swamps	***L***-little change in area, although high degree of shifting of locations	***M***-very dynamic salinity zone, probably altered by flow regulation
Youngs Bay	***H***-substantial loss of tidal marsh and swamp	***M***-loss of medium and shallow depth areas	***M***-very dynamic salinity zone, probably altered by flow regulation
Baker Bay	***H***-substantial loss of tidal marsh and swamp	***H***-substantial loss of deep and medium deep areas, and increase in shallow areas	***M***-very dynamic salinity zone, probably altered by flow regulation
Grays Bay	***H***-substantial loss of tidal swamp	***M***-shift from deepwater area to shallow flats	***L***-a small change in dilute salinity dynamics
Cathlamet Bay	***M***-loss of tidal swamps, but gain in tidal marsh	***M***-loss of deep and medium deep areas	***L***-a small change in dilute salinity dynamics
Upper Estuary	***H***-substantial loss of tidal swamp and marsh	***H***-loss of deep and gain in medium deep area, and substantial increase in shallow areas	***L***-a small change in dilute salinity dynamics
Tidal Freshwater Middle Reach (RM46-102)	***H***-substantial loss of tidal swamp and marsh, and non-tidal wetland	***H***-loss of shallow area, and gain in deep area	***L***-salinity not a factor
Tidal Freshwater Upper Reach (RM 102-146)	***H***-substantial loss of tidal swamp and marsh suspected, and gain in non-tidal wetland	***H***-loss of shallow area, and gain in deep area	***L***-salinity not a factor

2.1.3.3.1 Deep Water Habitat

Thomas (1983) documented a total loss of 2,560 acres of deep water habitat from 1870 to 1983; this represents a 7% loss of the 1870 acreage (Table 2-5). The most substantial losses of deep water habitat include 1,350 acres in the Baker Bay and 1,450 acres in the Upper Estuary. Loss of deep water habitat in Baker Bay represents the migration of Sand Island from the Entrance area to Baker Bay, which had occurred naturally by 1885. Jetty construction moderated the variability in water movement within the Entrance area, causing the retention of Sand Island in its present location (Thomas 1983). Further, maintenance dredging activities of the river bar and navigation channel in the Entrance area have contributed to increases of deep water habitat in this area (Thomas 1983). Although little change of deep water habitat acreage was observed in the Mixing Zone and Youngs Bay areas, location of deep water habitats in these areas has shifted as a result of migration of the channel (Thomas 1983). Loss of deepwater habitats in the subareas furthest upstream (Grays Bay, Cathlamet Bay, and Upper Estuary) was primarily a result of accretion that converted these habitats to medium depth or shallow/flats habitat. Deep water habitat losses were complemented by a 1,680 acre gain in the Entrance area; this increase in deep water habitat was also related to the migration of Sand Island.

In the Columbia Estuary Subbasin, there has been close to a complete loss of open water habitat from 1850 to 1999; as of 1999, only 878 acres of this habitat type remained in the subbasin (Table 2-7 and Figure 2-25). The open water habitat type does not have a water depth designation, thus, it is not clear which open water habitats comprise deep, medium, or shallow depths. Much of the historical open water habitat type was converted to the bays and estuaries habitat type (Table 2-7 and Figure 2-25). In the Columbia Lower Subbasin, a similar loss of open water habitat and conversion to bays and estuaries habitat occurred from the historical to current conditions (Table 2-8 and Figure 2-26). The apparent conversion of open water habitat to bays/estuaries habitat in these subbasins is a function of the different mapping data and methods used for the current and historical maps rather than an actual habitat conversion (Thomas O'Neil, Northwest Habitat Institute, personal communication). In the historical era mapping effort, the focus was on terrestrial habitats and the bays/estuaries habitat type was not even included in the habitat classification. Thus, although bays/estuaries habitat may have been present historically, location this habitat type was not mapped and much of the Columbia River corridor was classified as open water habitat. During the current era mapping effort, bays/estuaries habitat was classified and included in the terrestrial layer of the map while open water was included in the aquatic map layer. Because the terrestrial layer was overlayed on the aquatic layer, any bays/estuaries habitat in the same location as open water habitat would override the open water habitat type. Thus, on the current era map, bays/estuaries habitat may be overestimated and open water habitat may be underestimated.

In an analysis of recent habitat change, Garono et al (2003a) observed very little change in water habitat from 1992 to 2000 (Table 2-9). Again, there is no water depth designation to this water habitat type, so it is not clear which water habitats comprise deep, medium, or shallow depths.

2.1.3.3.2 Medium Depth Habitat

Except for the Upper Estuary area, Thomas (1983) documented a loss of medium depth water habitat in all areas of the estuary from 1870 to 1983 (Table 2-5). The collective loss of medium depth water habitat in the estuary was 8,490 acres, which represents about 25% of the 1870 acreage (Table 2-5). Substantial acreages of medium depth water were converted to deep water in the Entrance Subarea and to tidal flats in the Baker Bay Subarea; this is consistent with

the migration of Sand Island and the maintenance of the navigation channel as described above. In Cathlamet Bay, considerable acreage of medium depth habitats was converted to shallows/flats through the process of accretion.

2.1.3.3.3 Shallow Water/Flats Habitat

The shallow water/flats habitat type is the only habitat where an estuary-wide increase in acreage occurred from 1870 to 1983 (Table 2-5). There are two basic processes by which shallow water/flats habitat can be created: accretion in deep/medium depth water habitats or erosion of tidal marsh or tidal swamp habitat (Thomas 1983). Formation of shallow water/flats habitat in the estuary from 1870 to 1983 have primarily been a result of the former process (Thomas 1983). The Entrance area showed the only substantial loss of shallow water/flats habitat while a large increase of this habitat type was observed in Baker Bay; these changes are consistent with the natural migration of Sand Island (Thomas 1983). Further, construction of the South Jetty resulted in considerable accretion of sand in the Entrance area; as a result, sand dunes have formed in areas that were formerly shallow water/flats habitat (Thomas 1983). In the more upstream areas (Grays Bay, Cathlamet Bay, and the Upper Estuary), losses of former medium and deep water habitats resulting from accretion have contributed to the increases in shallow water/flats habitat (Thomas 1983).

The shallow water/flats habitat defined by Thomas (1983) may have been mapped as open water, or bays/estuaries by Johnson and O'Neil (2001) and IBIS (2003) or as water by Garono et al. (2003c). As previously discussed, there is no depth designation to the general water habitat types of Johnson and O'Neil (2001) and Garono et al. (2003c); thus, comparison to the specific depth water habitats of Thomas (1983) is not appropriate. The bays and estuaries habitat type (Johnson and O'Neil 2001) was previously discussed in section 2.1.3.3.1; this habitat type appeared to replace much of the open water habitat in the estuary and lower mainstem (Figure 2-25 and Figure 2-26; IBIS 2003).

2.1.3.3.4 Tidal Marsh Habitat

Approximately 10,500 acres of 1870 tidal marsh acreage have been lost, however, the formation of about 3,500 acres of new tidal marsh resulted in the net loss of about 7,000 acres (Table 2-5). The 1870 estimate of tidal marsh acreage was difficult to determine because tidal marsh often occurred in a mosaic with tidal swamp habitat (Thomas 1983). In general, tidal marsh habitat loss is a result of extensive diking; high elevation tidal marshes have been diked more than lower elevation marshes (Thomas 1983). New tidal marsh formation has resulted primarily from vegetative colonization of disposed dredge material, but colonization has also occurred along natural shorelines and in shallow water/flats habitat (Thomas 1983). The location of tidal marsh habitat within each estuary area has changed as a result of modified flow regime, modified tidal action, and/or shipping channel development and maintenance.

In the Entrance area, the small gain of tidal marsh habitat has resulted from changes to wave action as a result of jetty construction (Thomas 1983). Formerly, wave action in the Entrance area prevented vegetative colonization (Thomas 1983). The jetties have resulted in decreased wave action, allowing the formation of tidal marsh habitat in the now sheltered area of Trestle Bay (Thomas 1983). In Baker Bay, the historical tidal marsh habitats have all been diked and therefore considered as lost (Thomas 1983). The 730 acres of tidal marsh habitat in Baker Bay in 1983 was all recently formed along shorelines in areas that were formerly exposed to wave action where vegetation could not colonize (Thomas 1983). A similar situation has occurred in Youngs Bay, where much of the historical tidal marsh habitat has been lost to diking and close to half of the 1983 tidal marsh habitat was recently formed (Thomas 1983). In Grays Bay, diking has not affected tidal marsh acreage because most diked areas were formerly tidal swamp; the gain of tidal marsh habitat in the Grays Bay area resulted from accretion in tide flats followed by bulrush colonization (Thomas 1983). A similar situation has occurred in Cathlamet Bay, however, the formation of tidal marsh habitats has occurred primarily in areas of dredge spoils deposition (Thomas 1983). In the Upper Estuary area, the net loss of tidal marsh habitat was the product of substantial losses of tidal marsh habitat on Tenasillahe Island as a result of diking that were offset by tidal marsh formation in areas of dredge spoils deposition (Thomas 1983).

The tidal marsh habitat defined by Thomas (1983) may have been mapped as herbaceous wetlands by Johnson and O'Neil (2001) and IBIS (2003; Table 2-3). In the Columbia Estuary Subbasin, almost 31,000 acres of herbaceous wetlands have been lost from 1850 to 1999; this represents a 67% loss of the 1850 acreage of herbaceous wetlands (Table 2-7 and Figure 2-25). In the Columbia Lower Subbasin, approximately 140,000 acres of herbaceous wetlands have been lost from 1850 to 1999; this represents a 94% loss of the 1850 acreage of herbaceous wetlands (Table 2-8 and Figure 2-26). The percentage and absolute acreage loss of herbaceous wetlands determined by IBIS (2003) are considerably higher than the results of Thomas (1983); regardless, both mapping efforts document a substantial loss of the tidal marsh or herbaceous wetland habitat type.

The tidal marsh habitat defined by Thomas (1983) may have been mapped as herbaceous wetlands or scrub-shrub wetlands by Garono et al. (2003a;Table 2-3)). The recent habitat change analysis by Garono et al. (2003a) documented an increase of 8,495 acres of herbaceous wetland habitat from 1992 to 2000; this increase represents 17% of the 1992 acreage (Table 2-9). Most of the herbaceous wetland habitat in 2000 was formerly scrub-shrub wetland (44%), forested wetland (31%), or urban areas (24%). Garono et al. (2003a) felt it was unlikely that

urban habitats had converted to herbaceous wetlands from 1992 to 2000; rather, this result may be a function of the ability of the 2000 data set to better discriminate between actual urban areas and vegetated areas within and around urban areas. Conversely, Garono et al. (2003a) observed a loss of about 9,000 acres of scrub-shrub wetlands, which represent about 36% of the 1992 habitat acreage (Table 2-9). Most of the habitat loss of scrub-shrub wetlands was a result of conversion to herbaceous wetlands (44%) or forested wetlands (21%) (Garono et al. 2003a).

2.1.3.3.5 Tidal Swamp Habitat

Tidal swamp habitat was by far the most impacted estuarine habitat type; almost all of the 1870 tidal swamp habitat has been converted to one of the diked floodplain/non-tidal habitats described below (Thomas 1983). Loss of tidal swamp habitat alone was responsible for 62% of the total estuary habitat loss (Thomas 1983). Thomas (1983) reasoned that, because of their elevation and/or irregular tidal influence, tidal swamp habitat is the estuarine habitat most susceptible to diking. Historically, few tidal swamps were present in the Entrance and Mixing Zone areas, thus little change has been observed in these areas (Thomas 1983). There has been almost complete loss of all 1870 tidal swamp habitat from the Youngs Bay and Baker Bay areas; as a result, brackish water tidal swamps have been essentially eliminated from the estuary (Thomas 1983). In the areas furthest upstream, tidal swamp acreage losses have been extensive, however, a substantial amount of tidal swamp acreage is still present, particularly in the Cathlamet Bay area (Thomas 1983).

The tidal swamp habitat defined by Thomas (1983) may have been mapped as Westside riparian-wetlands by Johnson and O'Neil (2001) and IBIS (2003;Table 2-3). However, the Westside riparian-wetland habitat type typically occupies patches or linear strips within a forest matrix; other characteristics of this habitat type (Johnson and O'Neil 2001) indicate that it may differ substantially from the tidal swamp described by Thomas (1983). Nevertheless, Westside riparian-wetland appears to be the most closely related habitat type to tidal swamp. In the Columbia Estuary Subbasin, an increase of about 6,000 acres (i.e. 41% of 1850 acreage) of Westside riparian-wetlands occurred from 1850 to 1999 (Table 2-7 and Figure 2-25). Similarly in the Columbia Lower Subbasin, Westside riparian-wetland habitat acreage increased by about 3,000 acres (i.e. 24% of 1850 acreage) from 1850 to 1999 (Table 2-8 and Figure 2-26). This result was completely opposite that observed by Thomas (1983) for tidal swamp habitat. The increased acreage of Westside riparian-wetland from 1850 to 1999 is most likely a result of different resolutions between the mapping data rather than an actual increase in this wetland habitat type; the habitat change result for this habitat type would likely be much different if the resolution in the 1850 and 1999 data were similar (Thomas O'Neil, personal communication).

The substantial acreage loss of the tidal swamp and tidal marsh habitat types has important implications on juvenile salmonid survival in the estuary because evidence suggests salmonids, particularly ocean-type salmonids, depend on these habitats for food and cover requirements. Further, tidal marsh and swamp habitat acreage constituted 30% of the total 1870 acreage while these habitats comprise only 14% of the total 1983 estuarine habitat acreage.

The tidal swamp habitat defined by Thomas (1983) may have been mapped as forested wetlands by Garono et al. (2003a; Table 2-3). The recent habitat change analysis by Garono et al. (2003a) documented an increase of about 5,500 acres of forested wetland habitat from 1992 to 2000; this increase represents 49% of the 1992 acreage (Table 2-9). Most of the forested wetland habitat in 2000 was formerly scrub-shrub wetland (21%) or herbaceous wetland (9%); thus, the increase in forested wetland habitat appears to be partially explained by succession of other

wetland habitats. The increase of forested wetland habitat is completely opposite that observed by Thomas (1983) for tidal swamp habitat; this difference is likely a result of the different time period, geographic area, and method used in each study.

2.1.3.3.6 Non-Estuarine Wetlands

Thomas (1983) estimated that about 7,000 acres of non-estuarine wetlands habitat (i.e. non-estuarine swamps, marsh, and water) were created in the estuary from 1870 to 1983; most of this area was formerly tidal swamps and, to a lesser extent, tidal marsh. Non-estuarine wetlands habitat was created in all estuary areas except the Mixing Zone (Table 2-10).

Similar habitat types defined by Johnson and O'Neil (2001) (i.e. Westside riparian-wetlands, herbaceous wetlands) or by Garono et al. (2003a) (i.e. forested wetlands, herbaceous wetlands)(Table 2-3) have already been discussed.

2.1.3.3.7 Forested Uplands

Forest upland habitats in the Columbia River estuary and lower mainstem characterized by Johnson and O'Neil (2001) include Westside (mesic) lowlands conifer-hardwood forest, Westside oak and dry Douglas fir forest, and montane mixed conifer forest. In the Columbia Estuary Subbasin and the Columbia Lower Subbasin, Westside lowlands conifer-hardwood forest increased by about 17,500 and 33,000 acres, respectively, from 1850 to 1999 (Table 2-7, Table 2-8, Figure 2-25, and Figure 2-26). In the analysis of more recent habitat change, Garono et al (2003a) documented an increase of about 4,500 acres of coniferous forest upland from 1992 to 2000 (Table 2-9). About half of the coniferous forest upland habitat in 1992 remained as such in 2000; much of the remaining coniferous forest upland habitat in 2000 was a result of conversion of mixed forest upland (26%), deciduous forest upland (18%), and scrub-shrub upland (18%).

In the Columbia Estuary Subbasin and the Columbia Lower Subbasin, montane mixed conifer forest decreased by about 4,500 and 2,500 acres, respectively, from 1850 to 1999 (Table 2-7, Table 2-8, Figure 2-25, and Figure 2-26). Most of the historical montane mixed conifer forest was recently classified as Westside lowlands conifer-hardwood forest in both subbasins; this may be an artifact of the different resolution of mapping data from 1850 to 1999. For the mixed forest upland habitat type, Garono et al (2003a) observed a loss of about 6,000 acres from 1992 to 2000 (Table 2-9); most of the lost mixed forest upland habitat was explained by the conversion to deciduous forest upland (26%) and coniferous forest upland (26%).

In the Columbia Lower Subbasin, Westside oak and dry Douglas fir forest habitat decreased by about 86,000 acres from 1850 to 1999 (Table 2-8 and Figure 2-26); this represents a 93% loss of this habitat type. Most of the Westside oak and dry Douglas fir forest habitat appears to have been converted to the agriculture, pastures, and mixed environs or the urban and mixed environs habitat types (Figure 2-26). Conversely, Garono et al. (2003a) documented a substantial increase in deciduous forest upland from 1992 to 2000; the increase of over 11,000 acres of this habitat represents a 429% change over the 1992 acreage (Table 2-9). The increase in deciduous forest upland habitat acreage in 2000 was a result of conversion of scrub-shrub upland, mixed forest upland, and coniferous forest upland.

2.1.3.3.8 Developed Floodplain

Thomas (1983) estimated that about 24,000 acres of developed floodplain habitat were created in the estuary from 1870 to 1983; most of this area was formerly tidal swamps and, to a lesser extent, tidal marsh. Developed floodplain habitat was not created in the Entrance or Mixing Zone areas; developed floodplain habitat was somewhat evenly distributed among the other five estuary areas (Table 2-10).

The developed floodplain habitat of Thomas (1983) is most closely related to the agriculture, pastures, and mixed environs and the urban and mixed environs habitat types of Johnson and O'Neil (2001). In the Columbia Estuary Subbasin, 16,887 acres of the agriculture, pastures, and mixed environs habitat type and 6,344 acres of the urban and mixed environs habitat type were created between 1850 and 1999 (Table 2-7 and Figure 2-25). Thus, the combined creation of these two habitat types from 1850 to 1999 (i.e. 23,231 acres) is extremely similar to the creation of developed floodplain habitat from 1870 to 1983 documented by Thomas (1983). In the Columbia Lower Subbasin, a considerable amount of the agriculture, pastures, and mixed environs habitat type (i.e. 110,041) and the urban and mixed environs habitat type (i.e. 89,900) were created between 1850 and 1999 (Table 2-8 and Figure 2-26).

In the analysis of more recent habitat change, Garono et al. (2003a) observed a decrease of about 2,000 acres of the urban habitat type from 1992 to 2000, which represents a decrease of about 14% of the 1992 acreage. As previously mentioned, Garono et al. (2003a) felt it was unlikely that urban habitat coverage had decreased from 1992 to 2000; rather, this result may be a function of the ability of the 2000 data set to better discriminate between actual urban areas and vegetated areas within and around urban areas.

The results presented by Thomas (1983) and IBIS (2003) are consistent with the habitat mapping data summarized by Johnson et al. (2003b). In the tidal freshwater portion of the lower mainstem from rm 46-102, there was a general increase in upland habitat complemented by a substantial loss of non-tidal water/wetland, tidal flats, and tidal marsh habitat types; similarly, from rm 105-146, there was an increase of non-tidal water/wetland and upland habitat balanced with a substantial loss of tidal flats and tidal marsh habitat types (Johnson et al. 2003b). In both reaches of the tidal freshwater portion of the lower mainstem, there was no available comparison category for tidal swamp habitat (Johnson et al 2003b).

2.1.3.3.9 Natural and Filled Uplands

The 1,900 acres of historical natural and filled upland habitat identified by Thomas (1983) was comprised mostly of sand dunes throughout the Entrance, Youngs Bay, and Baker Bay areas (Table 2-10). A considerable amount of natural and filled upland habitat was created from 1870 to 1983; some of this habitat was created as a result of accretion of sand in Baker Bay and along Clatsop Spit, however, most of this created habitat resulted from the disposal of dredge spoils (Thomas 1983).

The natural and filled upland habitat defined by Thomas (1983) may have been mapped as coastal dunes and beaches habitat by Johnson and O'Neil (2001) and IBIS (2003; Table 2-3)). In the Columbia Estuary Subbasin, almost all of the historical coastal dunes and beaches habitat were lost by 1999 (Table 2-7 and Figure 2-25), which is contrary to the results of Thomas (1983). Numerous factors may explain this difference, including dissimilar habitat types and different time periods, geographic area, or methods used in each study.

The natural and filled upland habitat defined by Thomas (1983) may have been mapped as unconsolidated shore habitat by Garono et al. (2003a; Table 2-3) From 1992 to 2000, there was a loss of about 4,500 acres of unconsolidated shore habitat, which represents about 20% of the 1992 habitat acreage (Table 2-9). This result is also conflicts with the results of Thomas (1983) but is consistent with IBIS (2003).

Table 2-7. Historical (circa 1850) and current (1999) wildlife habitat types and acreage in the Columbia Estuary Subbasin (IBIS 2003).

	Acreage		
Habitat Name	**Historical (circa 1850)**	**Current (1999)**	**Change**
Westside (mesic) Lowlands Conifer-Hardwood Forest	303,217	320,712	+17,495 (6%)
Montane Mixed Conifer Forest	4,466	0	-4,466 (100%)
Agriculture, Pastures, and Mixed Environs	0	16,887	+16,887
Urban and Mixed Environs	0	6,344	+6,344
Open Water - Lakes, Rivers, and Streams	105,277	878	-104,399 (99%)
Herbaceous Wetlands	45,720	14,887	-30,833 (67%)
Westside Riparian-Wetlands	14,186	20,064	+5,878 (41%)
Coastal Dunes and Beaches	8,634	375	-8,259 (96%)
Coastal Headlands and Islets	741	510	-231 (31%)
Bays and Estuaries		101,022	+101,022
Marine Nearshore		562	+562
Total Acres:	**482,238**	**482,235**	

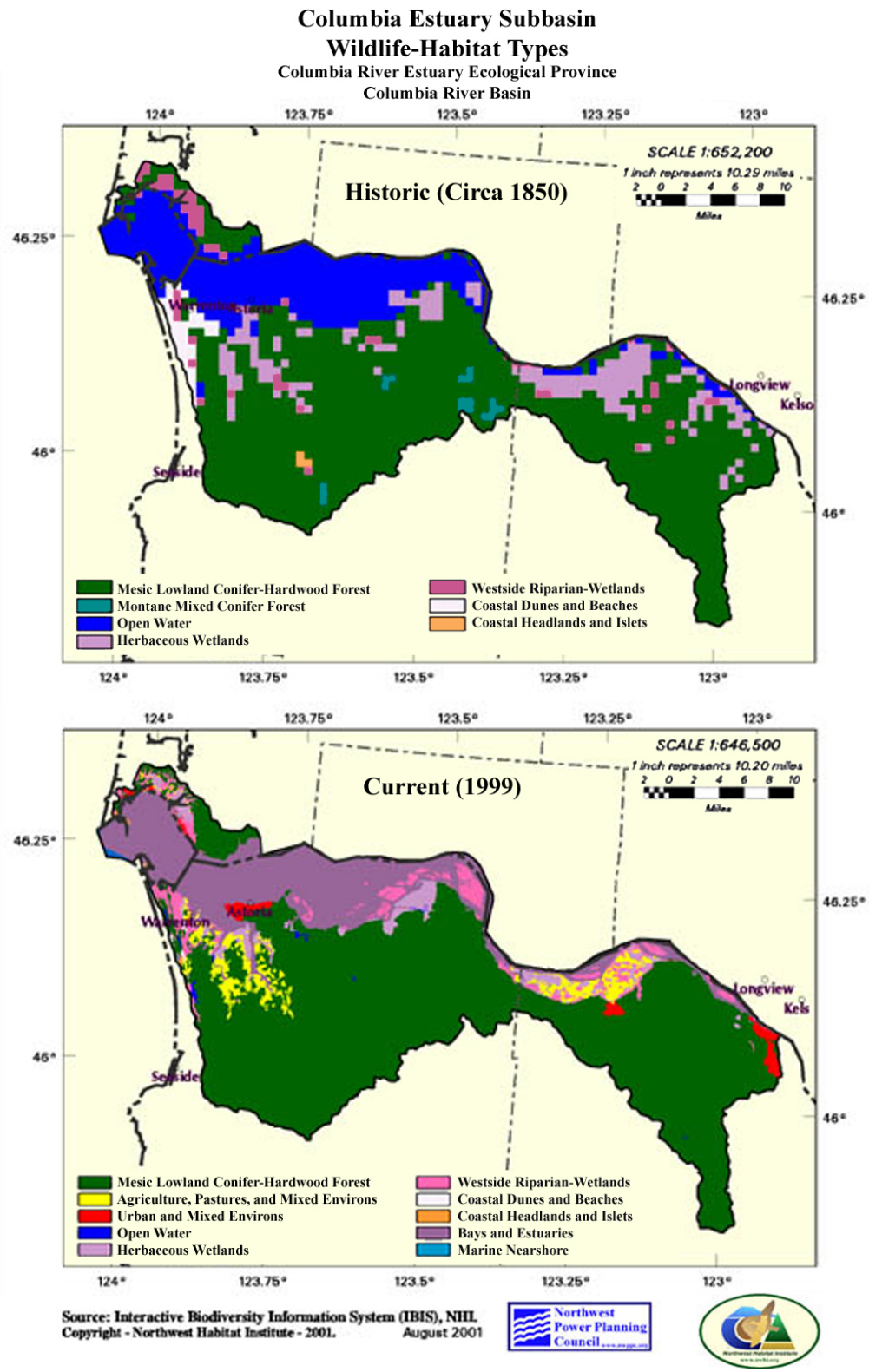


Figure 2-25. Historical (circa 1850) and current (1999) wildlife habitat types in the Columbia Estuary Subbasin (IBIS 2003).

Table 2-8. Historical (circa 1850) and current (1999) wildlife habitat types and acreage in the lower Columbia Lower Subbasin (IBIS 2003).

	Acreage		
Habitat Name	**Historical (circa 1850)**	**Current (1999)**	**Change**
Westside (mesic) Lowlands Conifer-Hardwood Forest	185,062	218,043	+32,981 (18%)
Westside Oak and Dry Douglas-fir Forest and Woodlands	92,444	6,206	-86,238 (93%)
Montane Mixed Conifer Forest	4,161	1,772	-2,389 (57%)
Alpine Grasslands and Shrublands	2,471	0	-2,471 (100%)
Westside Grasslands	2,965	0	-2,965 (100%)
Agriculture, Pastures, and Mixed Environs	0	110,041	+110,041
Urban and Mixed Environs	0	89,900	+89,900
Open Water - Lakes, Rivers, and Streams	44,350	841	-43,509 (98%)
Herbaceous Wetlands	149,521	9,413	-140,108 (94%)
Westside Riparian-Wetlands	12,982	16,086	+3,104 (24%)
Montane Coniferous Wetlands	0	1,912	+1,912
Bays and Estuaries	0	39,742	+39,742
Total Acres	**493,953**	**493,950**	

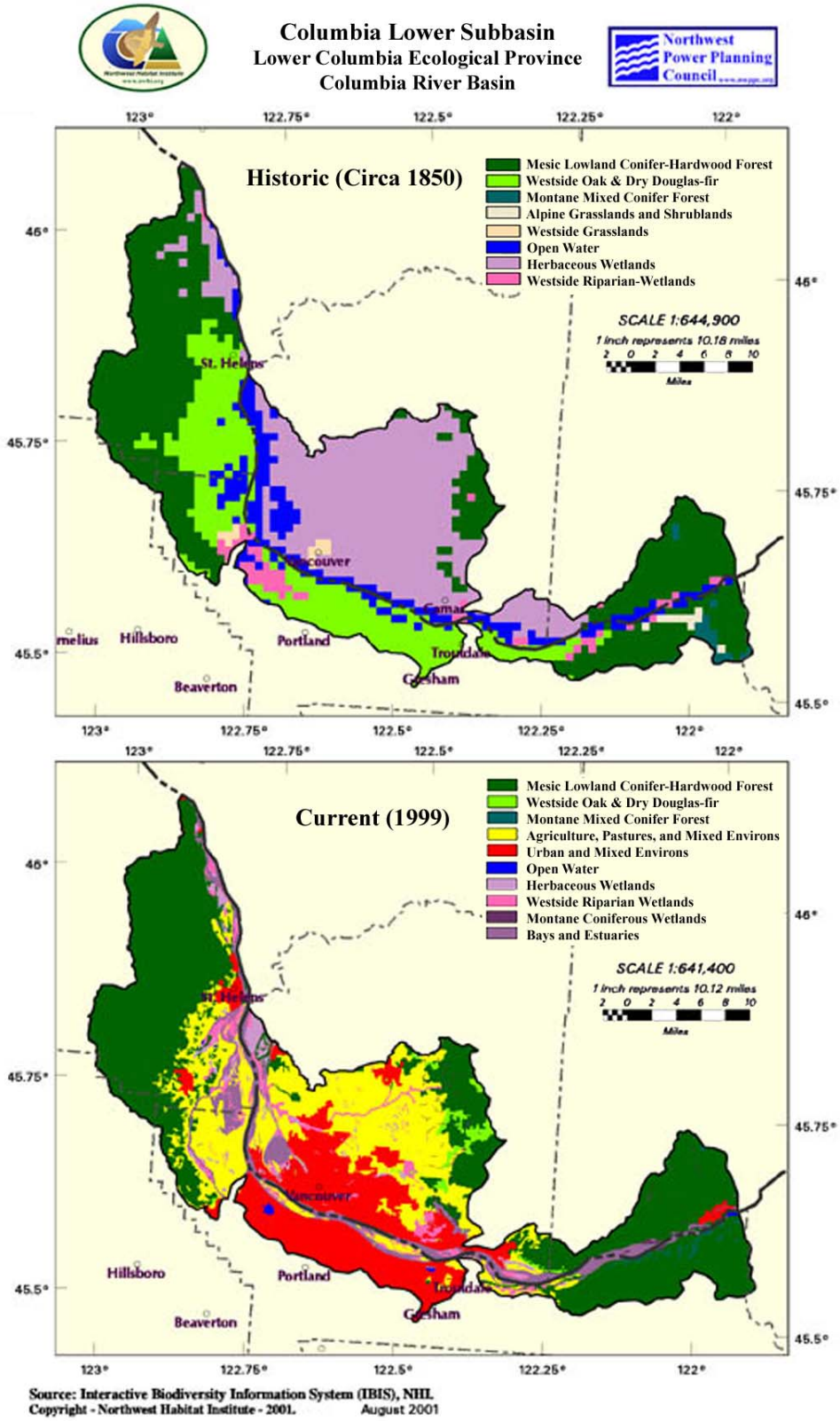


Figure 2-26. Historical (circa 1850) and current (1999) wildlife habitat types in the Columbia Lower Subbasin (IBIS 2003).

Table 2-9. Estimated change in Columbia River estuary habitat cover types from 1992 to 2000 (Garono et al. 2003a).

	1992		2000		Change	
Land Cover Class	**Area (acres)**	**% of Total**	**Area (acres)**	**% of Total**	**Area (acres)**	**% of 1992 Total**
Herbaceous Wetland	50,106.0	18.1	58,601.0	21.1	8,495.0	17
Shrub-Scrub Wetland	24,781.7	8.9	15,810.5	5.7	-8,971.1	-36
Forested Wetland	11,101.9	4.0	16,580.7	6.0	5,478.8	49
Herbaceous Upland	6,568.5	2.4	11,415.3	4.1	4,846.7	74
Shrub-Scrub Upland	21,659.7	7.8	6,993.6	2.5	-14,666.2	-68
Deciduous Forest Upland	2,627.2	1.0	13,886.8	5.0	11,259.6	429
Coniferous Forest Upland	9,354.7	3.4	13,985.6	5.0	4,631.0	50
Mixed Forest Upland	11,403.4	4.1	5,274.2	1.9	-6,129.2	-54
Unconsolidated Shore	22,709.2	8.2	18,123.4	6.5	-4,585.8	-20
Urban	14,433.7	5.2	12,482.0	4.5	-1,951.6	-14
Water	102,758.9	37.0	102,871.0	37.0	112.2	0.1
Other			1,480.2	0.5	1,480.2	-

Table 2-10. Estimated change in non-estuarine habitats by region within the Columbia River estuary from rm 0 to rm 46 (Thomas 1983).

HABITAT TYPE Estuary Region	1870 Acreage	1983 Acreage	Change
DEVELOPED FLOODPLAIN			
Entrance	0	0	0
Mixing Zone	0	0	0
Youngs Bay	0	6,670	+6,670
Baker Bay	0	3,420	+3,420
Grays Bay	0	3,270	+3,270
Cathlamet Bay	0	4,150	+4,150
Upper Estuary	0	6,440	+6,440
TOTAL	**0**	**23,950**	**+23,950**
UPLANDS – NATURAL AND FILLED			
Entrance	530	1,300	+770 (145%)
Mixing Zone	0	590	+590
Youngs Bay	350	1,070	+720 (206%)
Baker Bay	1,050	1,600	+550 (52%)
Grays Bay	0	120	+120
Cathlamet Bay	0	920	+920
Upper Estuary	0	1,990	+1,990
TOTAL	**1,930**	**7,590**	**+5,660 (293%)**
NON-ESTUARINE SWAMP			
Entrance	0	130	+130
Mixing Zone	0	0	0
Youngs Bay		1,370	+1,370
Baker Bay	0	1,260	+1,260
Grays Bay	0	200	+200
Cathlamet Bay	0	110	+110
Upper Estuary	0	250	+250
TOTAL	**0**	**3,320**	**+3,320**
NON-ESTUARINE MARSH			
Entrance	0	360	+360
Mixing Zone	0	0	0
Youngs Bay	0	930	+930
Baker Bay	0	170	+170
Grays Bay	0	40	+40
Cathlamet Bay	0	430	+430
Upper Estuary	0	1,200	+1,200
TOTAL	**0**	**3,130**	**+3,130**
NON-ESTUARINE WATER			
Entrance	50	0	-50 (100%)
Mixing Zone	0	0	0
Youngs Bay	0	160	+160

HABITAT TYPE Estuary Region	1870 Acreage	1983 Acreage	Change
Baker Bay	0	70	+70
Grays Bay	0	50	+50
Cathlamet Bay	0	270	+270
Upper Estuary	0	410	+410
TOTAL	**50**	**960**	**+910 (1,820%)**
TOTAL	**1,980**	**38,950**	**+36,970 (1,867%)**

2.1.4 *Species/Habitat Interactions*

Discussions of interactions between species and habitats are divided into multiple sections. Section 2.1.4.1 Focal Species Habitat Associations presents the general estuary and lower mainstem habitats associated with each focal species. Section 2.1.4.2 Salmonids provides a more detailed discussion of the known and suspected biological relationships between salmonids and the estuary and lower mainstem ecosystem. Sections 2.1.4.3 through 2.1.4.13 discuss the relationships between other focal species and the estuary and lower mainstem ecosystem.

2.1.4.1 Focal Species Habitat Associations

A species/habitat matrix was developed for the estuary focal species (Table 2-11); the matrix summarizes a qualitative assessment of potential species utilization within coarse estuary and mainstem habitats. Habitats were chosen for two reasons: 1) habitats were included in a current versus historical acreage comparison in the Columbia River estuary (Thomas 1983, Johnson et al. 2003b), or 2) habitats were considered important based on WDFW input. The utilization levels are based on professional interpretation of the reviewed literature and life history descriptions in the Technical Foundation; the utilization levels are an arbitrary qualitative scale that includes the following levels of habitat use: none, low, medium, high, and critical. The first four categories are self-explanatory; the critical designation indicates that the habitat type is critical to the survival of the particular life stage of the focal species. There are numerous habitat classification system available for fish and wildlife research (i.e. Rosgen stream channel typing, Cowardin wetland and deepwater habitat classification (Cowardin et al. 1979), wildlife habitat classification (Johnson and O'Neil 2001)); choice of the appropriate systems depends on the purpose of the project as described further in section 0. For this analysis, the coarse habitat types described in the current versus historical acreage comparison (i.e. Thomas 1983) provide a context to discuss potential effects of estuary habitat change over time on focal species. These estuary habitats have previously been defined in section 0.

Utilization levels of each habitat type by focal species is *not* intended to serve as the ultimate authority in determining importance of that habitat type. For example, the fish focal species do not utilize old growth/mature forests; however, the importance of this habitat type should not be ignored. More complete habitat associations specifically for wildlife species have been developed by Johnson and O'Neil (2001) and continue to be updated on the Northwest Habitat Institute's (NHI) webpage (www.nwhi.org; Table 2-12). This table presents the known wildlife focal species habitat associations within the Columbia Estuary and Columbia Lower Subbasins; thus, focal fish species are not included. The wildlife-habitat type column follows the classification of Johnson and O'Neil (2001) and is consistent with the habitats presented in Table

2-7 and Table 2-8. The association type column provides a qualitative description of the level of association between the species and the habitat. The activity type column describes the behavior that occurs within the habitat type. Finally, the confidence level indicates the level of certainty of the relationship between the species and the habitat type. NHI has also determined if a relationship exists among wildlife species and the various life stages of salmonids; those wildlife focal species that interact with salmonids are presented in Table 2-13. The relationship type column indicates the degree and repeatability of the relationship between the focal species and salmonids. The salmonid stage column describes the salmonid life stage affected by the relationship with the wildlife focal species.

Table 2-11. Likelihood of focal species utilization within various lower Columbia River mainstem and estuary habitat types.

				Riverine/Estuarine Habitat			Transition Habitat		Upland Habitat			
				Estuary Habitat Classification (Thomas 1983, Johnson et al. 2003b)					WDFW Priority Habitat Classification			
				Deep Water	Medium Depth Water	Tidal Flats	Tidal Marsh	Tidal Swamp	Riparian	Old Growth/ Mature Forest (see Note below)	Freshwater Wetland (i.e. isolated from river corridor)	Rural Natural Open Space
				Percent Habitat Change from 1870 to 1983 (Thomas 1983, Johnson et al. 2003b)								
Species	Primary Life Stage	Level of Use	Primary Season of Use	-13	-19	+10	-49	-74	-	-	-	-
Ocean-type salmonid[a]	Subyearling Juveniles	Migratory	Spring-Fall	◒	◕	◕	●	●	●	○	○	○
Stream-type salmonid[a]	Yearling Smolt	Migratory	Summer	◕	◕	◕	◕	◕	◕	○	○	○
Pacific Lamprey[b]	Ammocoetes or Macrothalmia	Migratory or Resident	Potentially Year-round	◕	◕	◔	◕	◕	◕	○	○	○
White Sturgeon[c]	Juveniles and Adults	Migratory or Resident	Year-round	●	◒	◒	◔	◔	◔	○	○	○
Northern Pikeminnow[d]	Juveniles and Adults	Migratory or Resident	Year-round	◒	◕	◒	◕	◕	◕	○	○	○
River Otter[e]	Juveniles and Adults	Resident	Year-round	◒	◒	◒	◕	◕	◕	◔	◕	◒
Caspian Tern[f]	Juveniles and Adults	Resident	Spring to Fall	◕	◕	◕	◔	◔	◔	○	○	◒
Bald Eagle/ Osprey[g]	Juveniles and Adults	Resident	Spring to Fall	◒	◒	◒	◔	◕	◕	◕	◒	◔

Yellow Warbler[h]	Juveniles and Adults	Resident	Spring to Fall	○	○	○	◔	●	●	◔	◕	◔
Red-eyed Vireo[i]	Juveniles and Adults	Resident	Spring to Fall	○	○	○	◔	●	●	◓	◕	◔
Sandhill Crane[j]	Juveniles and Adults	Resident	Winter	○	○	◓	◕	○	◕	○	◕	◕
Columbian White-tailed Deer[k]	Juveniles and Adults	Resident	Year-round	○	○	○	◓	◕	◕	◕	◓	◕

Note: Use of multiple habitat classification systems is problematic; considerable overlap occurs between habitat designations in different classifications. The habitat types used in the comparison of current and historical habitat conditions (Johnson et al. 2003b) are very general and are not intended to fully describe the vegetation components of the habitat. The WDFW Priority Habitats may be general or specific, depending on the category. For example, old growth/mature forests are described by specific tree diversity, density, and canopy layers but have no elevation specifications. Therefore, old growth forests could be a subset of tidal swamps or part of the upland region. In fact, the 74% loss of tidal swamp habitat may have consisted primarily of old growth tidal swamps and the importance of old growth habitats in the lower mainstem and estuary should not be underestimated. On the other hand, the WDFW riparian habitat category is very general and may encompass habitats categorized as tidal marsh or tidal swamp. Finally, use of the word "tidal" implies some influence of inflowing saltwater on the lower Columbia River mainstem and estuary habitats. In the Columbia River, the influence is generally realized as fluctuating water levels and not as substantial changes in salinity levels over the tidal cycle; many tidal areas in the lower Columbia River remain dominated by freshwater. In general, salinity can have an over-riding influence on estuary and mainstem habitats as it controls plant and animal species assemblages that occur in specific areas because most species have very specific salinity tolerance.

Qualitative Scale of Habitat Use:

● Critical
◕ High
◓ Medium
◔ Low
○ None

[a] Estuary habitats are utilized primarily by outmigrating juvenile salmonids, except for cutthroat trout that have been observed to occupy estuarine and tidewater habitats for the entire ocean residence period. The importance of the estuary and mainstem littoral habitats varies and is roughly equivalent to the amount of time each species utilizes the estuary and lower mainstem. Generally, salmonids that emigrate as fry or sub-yearlings (i.e. ocean-type chinook and chum salmon) use the estuary extensively for rearing, while salmonids that emigrate as yearlings spend less time in the estuary.

[b] Pacific lamprey do not feed during the transformation from ammocoetes to macrothalmia, which occurs around the time of migration from freshwater to saltwater. Although little is known about Pacific lamprey utilization of estuary or lower mainstem habitats, lampreys are not expected to spend much time in the lower mainstem or estuary.

[c] White sturgeon have been observed congregating in the Columbia River estuary during summer, presumably in relation to food availability. However, white sturgeon are likely present in the lower mainstem and estuary throughout much of the year. Estuary and lower mainstem habitat usage likely varies by age, with younger fish using nearshore or medium depth habitats and adults using deepwater habitats.

[d] Northern pikeminnow are freshwater species and are not known to use estuarine habitats. Northern pikeminnow are warm water species that inhabit the medium and deep water habitats of the Columbia River mainstem.
[e] River otter juveniles and adults are closely associated with aquatic habitats; pups are usually born in a subterranean burrow and begin to swim at about 2 months. River otters feed in water and on land; otters have been observed traveling long distances over land.
[f] Caspian terns can nest in a variety of substrates among an assortment of vegetation types; nests are commonly on sandy substrates in close proximity to abundant fish resources. Breeding Caspian terns almost exclusively eat fish; feeding occurs in near-shore and mid-channel habitats.
[g] Osprey may be found in various estuary and lower mainstem habitats. Presence is most likely in tidal swamps or riparian areas where adequate nest sites exist in proximity to aquatic habitats where fish/birds are abundant and available for consumption.
[h] Possible breeding evidence of yellow warblers has been documented in the Columbia River estuary and along the lower mainstem. If present, yellow warblers would most likely be found in tidal swamp, riparian, or freshwater wetland habitats because they are a riparian obligate species most strongly associated with wetlands that contain Douglas spirea and deciduous tree cover.
[i] Red-eyed vireos are relatively abundant in the Puget Sound and northeast Washington; there has been no confirmed breeding in the Columbia River estuary while possible breeding evidence has been documented along the mainstem near Bonneville. If present, red-eyed vireos would most likely be found in tidal swamp, riparian, or freshwater wetland habitats where woody species satisfy the canopy height and density requirements.
[j] The Columbia River estuary and lower mainstem is generally a migratory stop for sandhill cranes that breed in the Central Valley of California; up to 1,000 sandhill cranes have wintered on lower Columbia River bottomlands in recent years.
[k] Columbian White-tailed deer are generally associated with riparian and wetland habitats; their strongest habitat association is with oak and Douglas fir forest in close proximity to a stream or river.

Table 2-12. Wildlife focal species habitat associations in the Columbia Estuary and Columbia Lower Subbasins (IBIS 2003).

Focal Species	Wildlife-Habitat Type	Association Type	Activity Type	Confidence Level	Comments
Columbian White-tailed Deer	Mesic Lowlands Conifer-Hardwood Forest	Generally Associated	Feeds and Breeds	High	none
	Westside Oak and Dry Douglas-fir Forest and Woodlands	Closely Associated	Feeds and Breeds	High	Strong association with oak within 200 meters of a stream or river.
	Agriculture, Pastures, and Mixed Environs	Generally Associated	Feeds and Breeds	High	none
	Urban and Mixed Environs	Generally Associated	Feeds and Breeds	High	none
	Herbaceous Wetlands	Generally Associated	Feeds	High	none
	Westside Riparian-Wetlands	Generally Associated	Feeds and Breeds	High	none
Caspian Tern	Open Water - Lakes, Rivers, and Streams	Closely Associated	Feeds and Breeds	High	Nests on sandbars and dredge spoil islands within rivers.
	Herbaceous Wetlands	Closely Associated	Feeds	High	none
	Coastal Dunes and Beaches	Closely Associated	Other (see comments)	High	O = roosting/resting.
	Coastal Headlands and Islets	Generally Associated	Other (see comments)	High	O = roosting/resting.
	Bays and Estuaries	Closely Associated	Feeds	High	none
	Marine Nearshore	Closely Associated	Feeds	High	none
Bald Eagle	Mesic Lowlands Conifer-Hardwood Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Westside Oak and Dry Douglas-fir Forest and Woodlands	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Montane Mixed Conifer Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.

Focal Species	Wildlife-Habitat Type	Association Type	Activity Type	Confidence Level	Comments
	Agriculture, Pastures, and Mixed Environs	Generally Associated	Feeds	High	none
	Urban and Mixed Environs	Generally Associated	Feeds and Breeds	High	Could breed in this habitat where near open water habitats, and if suitable nest structures are available.
	Open Water - Lakes, Rivers, and Streams	Closely Associated	Feeds	High	none
	Herbaceous Wetlands	Generally Associated	Feeds	High	none
	Westside Riparian-Wetlands	Generally Associated	Feeds and Breeds	High	none
	Coastal Dunes and Beaches	Present	Feeds	High	none
	Coastal Headlands and Islets	Generally Associated	Feeds and Breeds	High	none
	Bays and Estuaries	Generally Associated	Feeds and Breeds	High	Requires some sort of structure to place nest on, such as old pilings, if breeding is to occur in this habitat.
	Marine Nearshore	Generally Associated	Feeds	High	none
Osprey	Mesic Lowlands Conifer-Hardwood Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Westside Oak and Dry Douglas-fir Forest and Woodlands	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Montane Mixed Conifer Forest	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats.
	Agriculture, Pastures, and Mixed Environs	Present	Reproduces	High	Could breed in this habitat where near open water habitats, and if suitable nest structures are available.
	Urban and Mixed Environs	Generally Associated	Reproduces	High	Could breed in this habitat where near open water habitats, and if suitable nest structures are available.
	Open Water - Lakes, Rivers, and Streams	Closely Associated	Feeds	High	none
	Westside Riparian-Wetlands	Generally Associated	Feeds and Breeds	High	none

Focal Species	Wildlife-Habitat Type	Association Type	Activity Type	Confidence Level	Comments
	Coastal Headlands and Islets	Generally Associated	Reproduces	Moderate	none
	Bays and Estuaries	Generally Associated	Feeds and Breeds	Moderate	Requires some sort of structure to place nest on, such as old pilings, if breeding is to occur in this habitat.
	Marine Nearshore	Generally Associated	Feeds	Moderate	none
River Otter	Urban and Mixed Environs	Present	Feeds	High	Might be found in marinas.
	Open Water - Lakes, Rivers, and Streams	Closely Associated	Feeds and Breeds	High	Dens placed in banks.
	Herbaceous Wetlands	Closely Associated	Feeds and Breeds	High	none
	Westside Riparian-Wetlands	Closely Associated	Feeds and Breeds	High	none
	Coastal Dunes and Beaches	Generally Associated	Feeds and Breeds	Moderate	Uses this habitat in the Puget Sound, Hood Canal, etc., but not likely to use outer coast beaches.
	Coastal Headlands and Islets	Present	Feeds and Breeds	High	Only where this habitat is near estuaries, coastal bogs, or along the Puget Sound and Strait of Juan de Fuca. Not likely on the outer coast.
	Bays and Estuaries	Closely Associated	Feeds and Breeds	High	none
	Marine Nearshore	Generally Associated	Feeds	High	Puget Sound, Hood Canal etc. only, not outer coast.
Sandhill Crane	Agriculture, Pastures, and Mixed Environs	Closely Associated	Feeds and Breeds	High	Also includes staging areas; must have roosting areas within the range.
	Herbaceous Wetlands	Closely Associated	Feeds and Breeds	High	none
Yellow Warbler	Westside Riparian-Wetlands	Closely Associated	Feeds and Breeds	High	none
Red-eyed Vireo	Mesic Lowlands Conifer-Hardwood Forest	Present	Feeds and Breeds	Moderate	Requires a hardwood component.
	Westside Riparian-Wetlands	Closely Associated	Feeds and Breeds	Moderate	Range of red-eyed vireo overlaps that of large black cottonwood groves.

Table 2-13. Focal species relationship to salmonids (IBIS 2003).

Common Name	Relationship Type	Salmonid Stage	Comments
Caspian Tern	Strong, consistent	Saltwater - smolts, immature adults, and adults	none
	Strong, consistent	Freshwater rearing - fry, fingerling, and parr	none
Bald Eagle	Indirect	Incubation - eggs and alevin	Feed on birds that feed on salmon.
	Indirect	Freshwater rearing - fry, fingerling, and parr	Feed on birds that feed on salmon.
	Strong, consistent	Carcasses	none
	Indirect	Saltwater - smolts, immature adults, and adults	Feed on birds that feed on salmon.
	Strong, consistent	Spawning - freshwater	none
	Indirect	Carcasses	Feed on birds that feed on salmon.
	Strong, consistent	Saltwater - smolts, immature adults, and adults	none
Osprey	Strong, consistent	Saltwater - smolts, immature adults, and adults	none
	Strong, consistent	Spawning - freshwater	none
	Strong, consistent	Freshwater rearing - fry, fingerling, and parr	none
River Otter	Strong, consistent	Freshwater rearing - fry, fingerling, and parr	none
	Strong, consistent	Spawning - freshwater	none
	Strong, consistent	Carcasses	none

2.1.4.2 Salmonids

Estuaries are important for many species, particularly anadromous salmonids. For example, anadromous salmonids that survive to reproduce migrate through the estuary at least twice during their life cycle; the estuary serves as a vital transition zone during the physiological acclimation from freshwater to saltwater (Simenstad et al. 1994b, Thorpe 1994 as cited in Bottom et al. 2001). Further, estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995); estuarine habitats serve as a productive feeding area, free of marine predators.

Many studies indicate that estuarine conditions are important in salmonid survival rates; however, to date researchers have not been able to specifically agree on what attributes of the estuary confer enhanced survival to salmon. Certain general physical and biological functions performed by estuaries, however, can be assumed to have direct impacts on salmon as they transition from their natal river basins to seawater.

2.1.4.2.1 Conceptual Models

The natural forces of ocean tides and river flows have been influenced by anthropogenic factors. The basic habitat-forming processes (i.e. physical forces of the ocean and river) create the conditions that define the estuarine and mainstem freshwater habitats. The created habitat types provide an opportunity for the primary plant production that serves as the base of complex food webs. All of these pathways combine to influence the growth, survival, and, eventually, the production of juvenile salmonids moving through the lower Columbia River (USACE 2001). These processes and pathways are generally described in the juvenile salmonid production conceptual model as illustrated below (Figure 2-27 and Table 2-14). The conceptual model was developed to describe juvenile salmonid production in the Columbia River estuary; it does not address the premise that population structure and life history diversity may be equally as important in determining salmonid survival. Further, although the conceptual model was developed with an ecosystem focus, it needs to be scrutinized to determine applicability to other tidal freshwater and estuary species. The foundational basis for a wildlife species conceptual model has been developed by Johnson and O'Neil (2001).

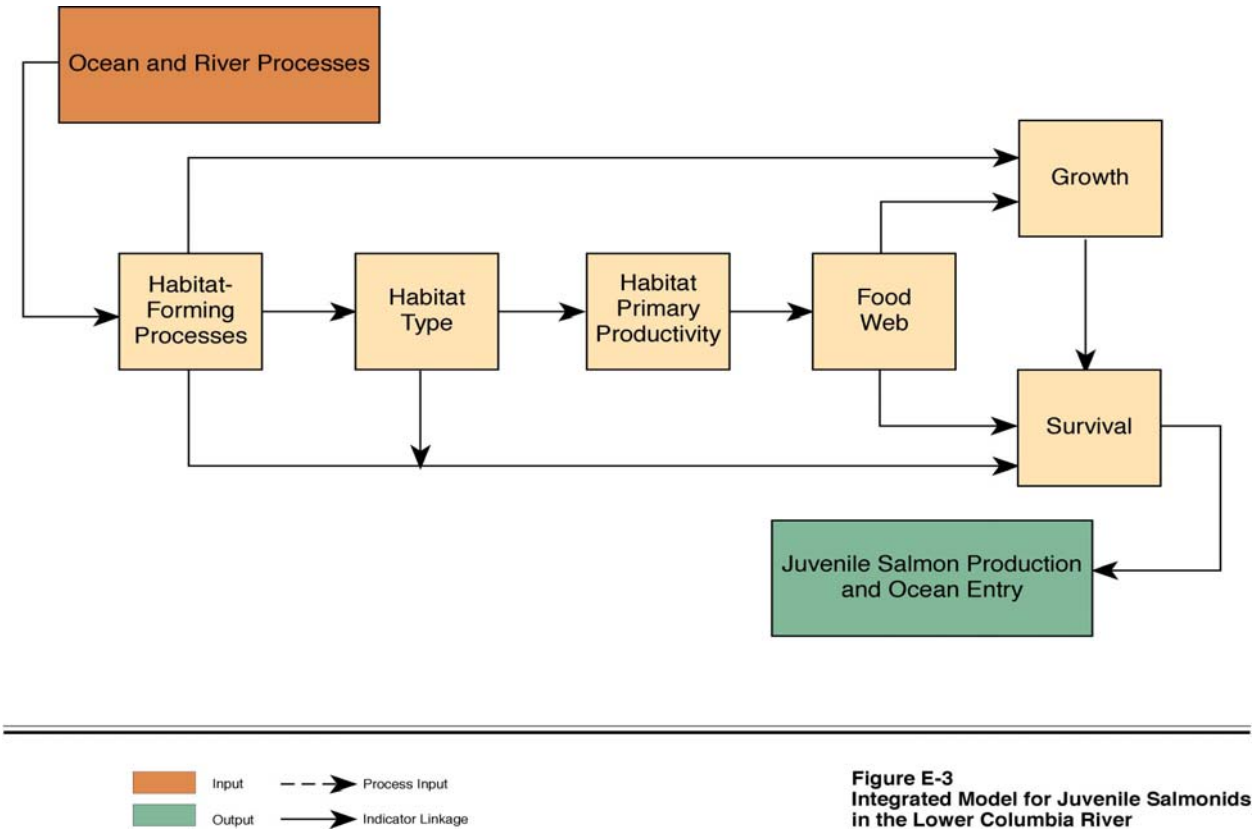


Figure 2-27. Conceptual model of the major components affecting juvenile salmonid production in the Columbia River estuary (USACE 2001).

Table 2-14. Conceptual model pathways and components for juvenile salmonid production in the Columbia River estuary (USACE 2001).

Model Pathways	Pathway Description	Model Components	Component Description
Habitat-Forming Processes	Physical processes that define the living conditions and provide the requirements fish naturally need within the river system are included in the Habitat-Forming Processes Pathway.	Suspended Sediment	Sand, silt, and clay transported in the water column
		Bedload	Sand grains rolling along the surface of the riverbed
		Woody Debris	Downed trees, logs, root wads, limbs
		Turbidity	Quality of opacity in water, influenced by suspended solids and phytoplankton
		Salinity	Saltwater introduced into freshwater areas through tidal ocean process
		Accretion/ Erosion	Deposited/carved sediments
		Bathymetry	Topographic configuration of the riverbed
Habitat Types	This pathway describes definable areas that provide the living requirements for fish in the Lower Columbia River.	Tidal Marsh and Swamp	Areas between mean lower low water (MLLW) and mean higher high water (MHHW) dominated by emergent vegetation (marsh) and low shrubs (swamp) in estuarine and riverine areas.
		Shallow Water and Flats	Areas between 6-foot bathymetric line (depth) and MLLW
		Water Column	Areas in the river where depth is greater than 6feet
Habitat Primary	This pathway describes the biological mass of plant materials that provides the fundamental nutritional base for animals in the river system.	Light	Sunlight necessary for plant growth
		Nutrients	Inorganic source materials necessary for plant growth
		Imported Phytoplankton Production	Material from single-celled plants produced upstream above the dams and carried into lower reaches of the
		Resident Phytoplankton Production	Material from single-celled plants produced in the lower reaches of the river
		Benthic Algae Production	Material from simple plant species that inhabit the river bottom
		Tidal Marsh and Swamp Production	Material from complex wetland plants (hydrophytes) present in tidal marshes and swamps

Model Pathways	Pathway Description	Model Components	Component Description
Food Web	The Food Web pathway shows the aquatic organisms and related links in a food web that supports growth and survival of salmonids.	Deposit Feeders	Benthic organisms such as annelid worms that feed on sediments, specifically organic material and detritus
		Mobile Macroinvertebrates	Large epibenthic organisms such as sand shrimp, crayfish, and crabs that reside and feed on sediments at the bottom of the river
		Insects	Organisms such as aphids and flies that feed on vegetation in freshwater wetlands, tidal marshes, and swamps
		Suspension/Deposit Feeders	Benthic and epibenthic organisms such as bivalves and some amphipods that feed on or at the interface between sediment and the water column
		Suspension Feeders	Organisms that feed from the water column itself, including zooplankton
		Tidal Marsh Macrodetritus	Dead and decaying remains of tidal marsh and tidal swamp areas that are an important food source for benthic communities
		Resident Microdetritus	Dead and decaying remains of resident phytoplankton and benthic algae, an important food source for zooplankton
		Imported Microdetritus	Dead remains of phytoplankton from upstream that serve as a food source for suspension and deposit feeders
Growth	The Growth Pathway highlights the factors involved in producing both the amount of food and access by fish to productive feeding areas.	Habitat Complexity, Connectivity, and Conveyance	Configuration of habitat mosaics that allow for movement of salmonids between those habitats
		Velocity Field	Areas of similar flow velocity within the river
		Bathymetry and Turbidity	River bottom and water clarity conditions that influence the ability of salmonids to locate their prey
		Feeding Habitat Opportunity	Physical characteristics that affect access to locations that are important for fish feeding
		Refugia	Shallow water and other low energy habitat areas used for resting and cover
		Habitat-Specific Food Availability	Ability of complex habitats to provide feeding opportunities when fish are present

Model Pathways	Pathway Description	Model Components	Component Description
Survival	The Survival Pathway is a summary of key factors controlling or affecting growth and migration.	Contaminants	Compounds that are environmentally persistent and bioaccumulative in fish and invertebrates
		Disease	Pathogens (viruses, bacteria, and parasites) that pose survival risks for salmon
		Suspended Solids	Sand, silt, clay, and organics transported within the water column
		Stranding	Trapping of young salmonids in areas with no connectivity to water column habitat
		Temperature and Salinity Extremes	Temperature or salinity conditions that are problematic to salmonid survival
		Turbidity	Water clarity as it pertains to potential for juvenile salmonids to be seen by predators
		Predation	Potential for piscivorous mammals, birds, and fish to prey on salmonids
		Entrainment	Trapping of fish or invertebrates into hopper or pipeline dredges

The general conceptual model has been separated into component parts. The first figure in the series (Figure 2-28) is the juvenile salmon growth and survival conceptual model developed by Bottom et al. (2001); this conceptual model incorporates the premise that salmonid population structure and life history diversity plays an important role in salmonid survival. The next series of diagrams (Figure 2-29, Figure 2-30, and Figure 2-31) describe a conceptual model for juvenile salmonid production in the lower Columbia River and estuary detailed in USACE (2001); the conceptual model represents a 6 month collaborative effort by the USACE, Battelle Marine Science Laboratories, Parametrix, Inc., the Port of Portland, NMFS, USFWS, Limno-Tech, Inc., University of Washington, and the Sustainable Ecosystems Institute Science Panel. This conceptual model presents some of the same concepts as the Bottom et al. (2001) model. As previously mentioned, the conceptual model presented here was developed specifically for juvenile salmon production; the model needs to be scrutinized for applicability to other focal species. In regards to wildlife focal species, Johnson and O'Neil (2001) have explored possible components that would serve as a foundation for wildlife conceptual models, although such models have not been iteratively developed.

As described in the overall conceptual model for juvenile salmon production in the estuary (Figure 2-27), the type of available habitat determines the food web, which then drives salmon growth, survival, and ultimate production from the estuary. Within the food web, the available habitat determines the amount and type of primary productivity and hence, the base of the food web (Figure 2-29). In turn, the food web base determines the amount and type of prey species available to juvenile salmonids and therefore influences growth and survival (Figure 2-29). Salmonid growth is also influenced by habitat-forming processes and the types of habitat available as these provide refuge and affect each individuals energy costs (Figure 2-30). Growth is also affected by temperature and other compounding factors such as hatchery practices that may result in density-dependent competition as a result of large releases of hatchery fish (Figure 2-28). Finally, all of the base components of the conceptual model (i.e. habitat-forming processes, habitat type, food web, and growth) in conjunction with the physiological condition and adaptive behaviors of juvenile salmonids determines the ultimate production from the estuary (Figure 2-31).

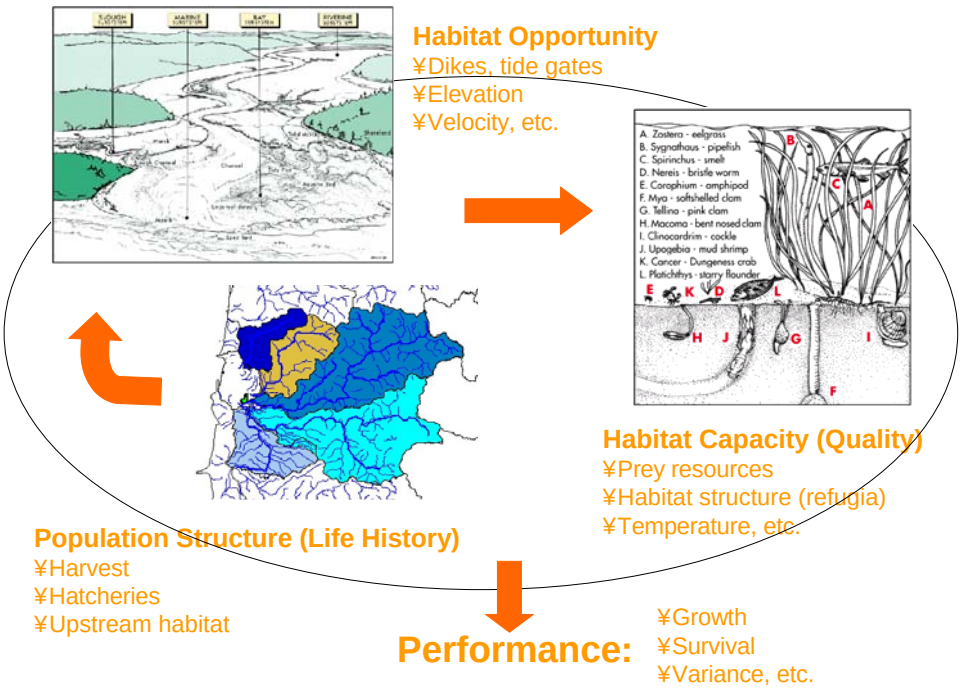


Figure 2-28. Conceptual model for juvenile salmon growth and survival in the Columbia River estuary (from Bottom et al. 2001).

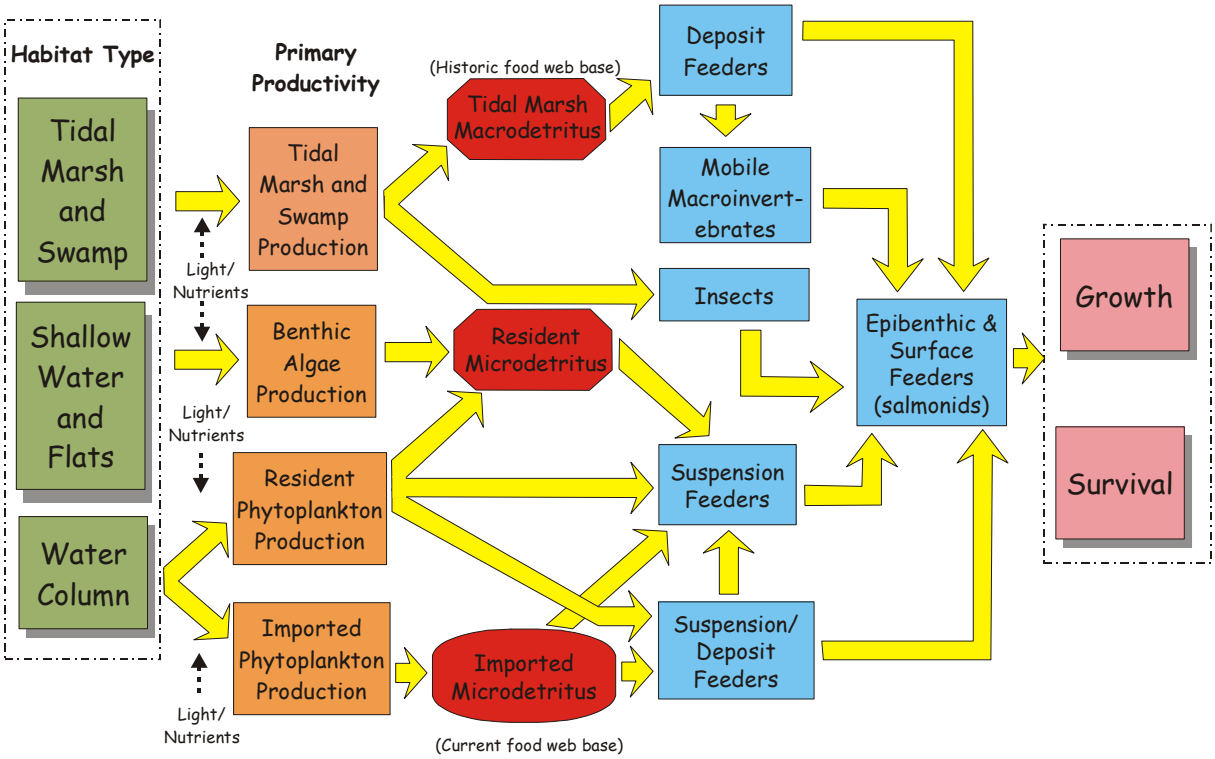


Figure 2-29. Conceptual model of the Columbia River estuary food web (adapted from USACE 2001).

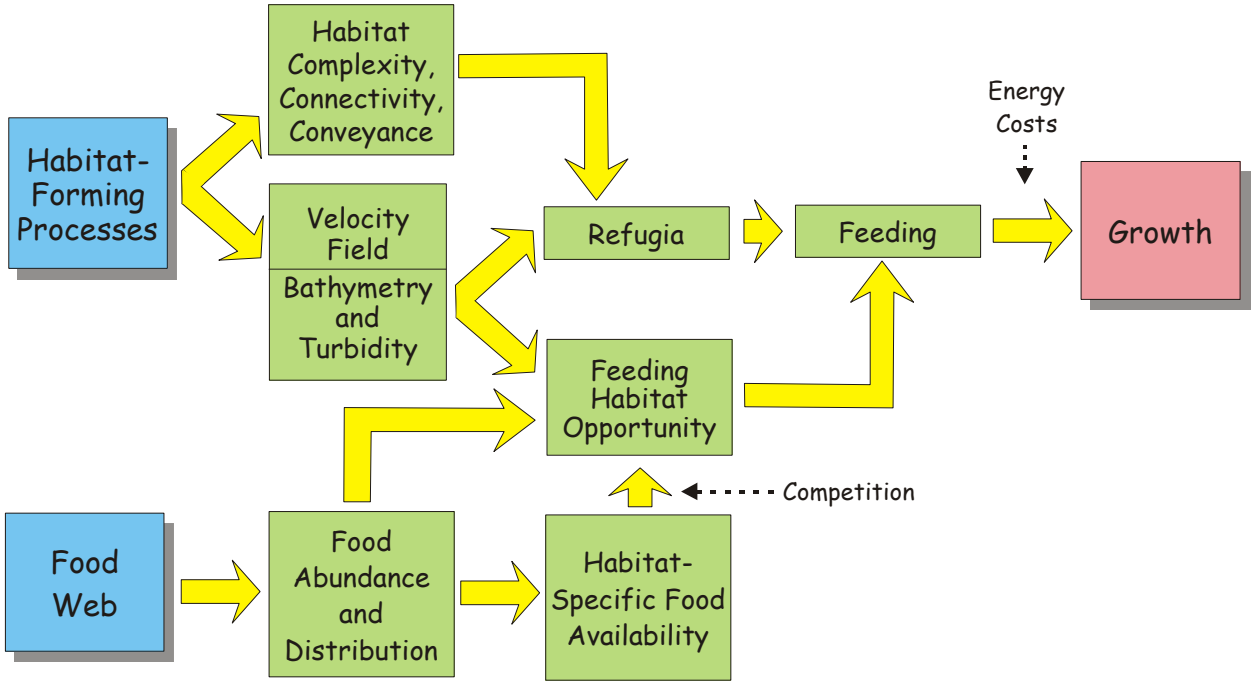


Figure 2-30. Conceptual model of juvenile salmonid growth in the Columbia River estuary (adapted from USACE 2001).

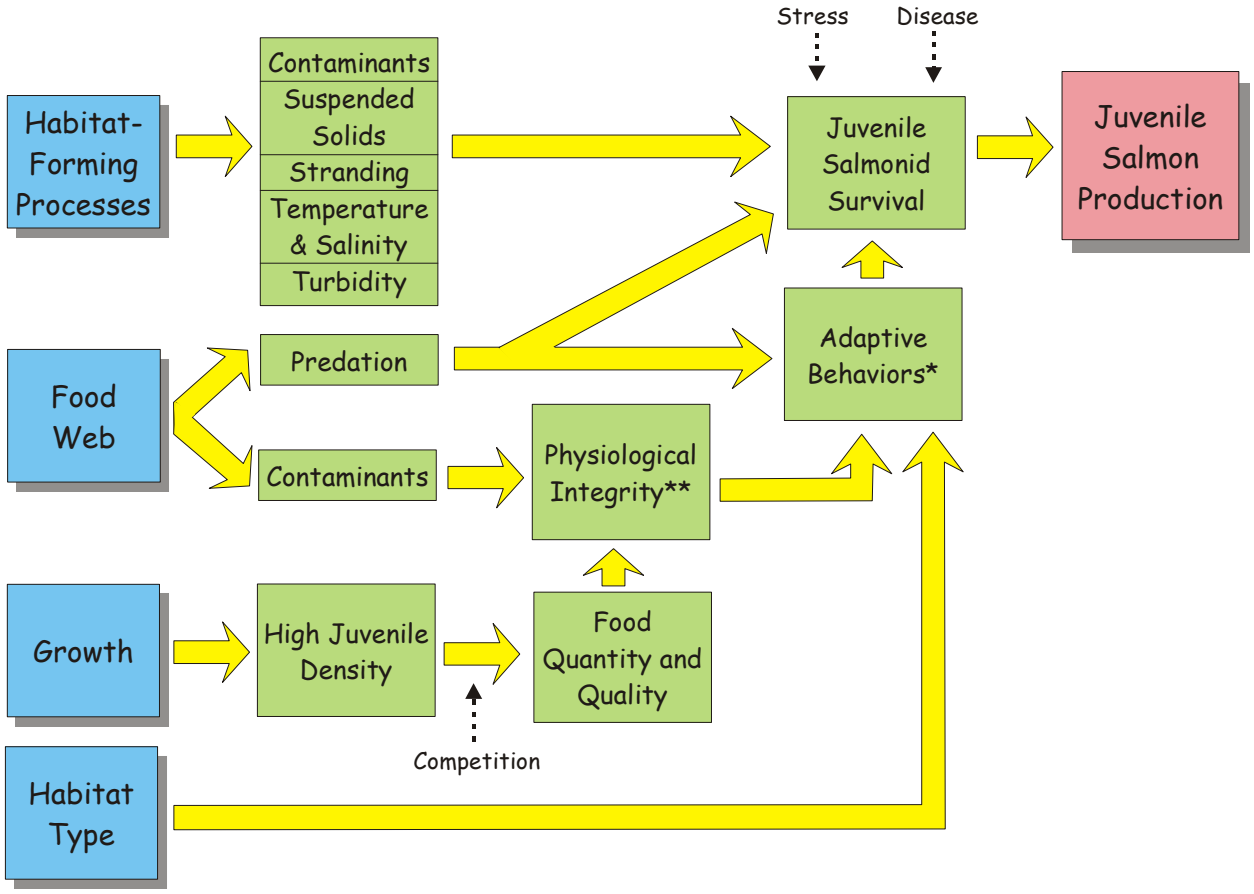


Figure 2-31. Conceptual model of juvenile salmonid production from the Columbia River estuary (adapted from USACE 2001).

2.1.4.2.2 Habitat Requirements

The freshwater habitat requirements for juvenile salmonids are well studied and understood; however, the estuarine habitat requirements of juvenile salmonids are just now coming into focus. In describing estuarine habitat requirements, juvenile salmonids are divided into two primary life-history types: ocean- and stream-type. Johnson et al. (2003b) recently presented the current understanding of the estuarine physical habitat requirements and threshold levels of juvenile salmon (**Error! Reference source not found.**). Note that the studies related to salinity, water temperature, and turbidity addressed threshold levels of exposure in which salmonids could survive. Although threshold levels may be similar among ocean- and stream-type salmonids, there is not complete agreement among researchers on the preferred ranges of these parameters for different salmonids.

Table 2-15.Physical habitat requirements and threshold levels of juvenile salmonids in relation to various habitat parameters (adapted from Weitkamp et al. 2001, as cited in Johnson et al. 2003b).

Parameter	Ocean-Type	Stream-Type
Water Depth	Surface waters	Surface to 6 m
Currents	Less than ~9 cm/second Less than 30 cm/second for current threshold modeling (1)	Found throughout a wide range of current velocities and tend to avoid low-velocity areas
Substrate	Varies (mostly sand/silt)	Varies, but tends to be associated with the water column to a greater extent than with substrate type
Salinity	Upon hatching 15-20 ppt (2) Juveniles 30 ppt seawater (3) Chinook fry of 1.5 gram could survive and grow in seawater (4)	Generally same as ocean-type
Water Temperature	Can tolerate brief periods of 15-20˚C; Lethal at approximately 22˚C (5) Sub-lethal effects can occur below lethal threshold, but vary.	Coho preferred range of 12-14˚C; Upper lethal temperature was 25˚C (6)
Turbidity	LC_{50} for coho (summer conditions) 1.2 g/l (7) LC_{50} for chum (summer conditions) 2.5 g/l (8)	Generally same as ocean-type

(1) Bottom et al. 2001, (2) Wagner et al. 1969, (3) Tiffan et al. 2000, (4) Clark and Shelbourn 1985, (5) Brett 1971, Lee and Rinne 1980, (6) Brett 1952, (7) Noggle 1978, (8) Smith 1978.

2.1.4.2.3 Habitat Utilization

Juvenile salmon may be found in the Columbia River estuary at all times of the year, as different species, life history strategies and size classes continually move into tidal waters; Wissmar and Simenstad (1998) estimated that there may be as many as 35 potential life history strategies for ocean-type chinook. Peak estuary entrance varies among and within species. Rich (1920) reported that juvenile migration span of any given chinook brood in the Columbia River basin is around 18 months – from fry that emigrate to the estuary soon after emerging in December to yearlings that do not leave until late their second spring. Myers and Horton (1982) have suggested that differentiation of life history forms may be a mechanism for partitioning limited estuarine habitats. Duration of estuarine residence varies from species to species. Coho, stream-type chinook salmon, steelhead, and anadromous cutthroat trout typically rear in fresh water for a year or more, and move rapidly through the estuary on their way seaward (<6 weeks). Chum and ocean-type chinook salmon make greater use of the estuary. Chum salmon typically live in the estuary for several weeks, and ocean type chinook that migrate to the estuary as fry can reside in estuaries for up to 2 months or more (Healey 1982).

Estuaries have important impacts on juvenile salmonid survival. Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995). Estuarine habitats provide young salmonids with a productive feeding area, free of marine predators, where smolts can undergo physiological changes necessary to acclimate to the saltwater environment. Studies conducted by Emmett and Schiewe (1997) in the early 1980s have shown that favorable estuarine conditions translate into higher salmonid survival. During this research, juvenile coho and chinook smolts were collected and released in the river, in the

estuary, in the transition zone outside the estuary, and in the ocean; efforts were replicated over multiple years. In both coho and chinook, smolts released in the estuaries consistently contributed in higher rates to commercial fisheries or returned at higher rates than smolts released outside the estuaries.

Studies show that habitat use of juvenile salmon within the estuary environment is size related. Fry less than 60 mm usually occupy shallow, protected habitats such as salt marshes, tidal creeks and intertidal flats (Levy and Northcote 1982, Myers and Horton 1982, Simenstad et al. 1982, Levings et al. 1986 as cited in Bottom et al. 2001). Fish 60-100 mm move to slightly deeper shoals and channels further from the shoreline (Healey 1982, 1991, Myers and Horton 1982, as cited in Bottom et al. 2001). Fish greater than 100 mm can be found in both deep and shallow water habitats. (Levy and Northcote 1982, Myers and Horton 1982, Simenstad et al. 1982, Bottom et al. 1984). These generalizations hold true more during the day than at night, when schooling fry or fingerlings may be seen venturing into deeper waters (Schreiner 1977, Kjelson 1982, Bax 1983, Healey 1991, Salo 1991, as cited in Bottom et al. 2001). Moreover, salmonids must continually adjust their habitat distribution in relation to twice-daily tidal fluctuations and seasonal and anthropogenic variations in river flow. Juveniles have been observed to move from low-tide refuge areas in deeper channels to salt marsh habitats at high tide and back again (Healey 1982). These patterns of movement suggest that access to suitable low-tide refuge near marsh habitat may be an important factor in production and survival of salmonid juveniles in the Columbia River estuary.

2.1.4.2.4 Habitat Availability

Using a model that incorporated predevelopment and current river flows and estuarine bathymetry, the habitat availability for juvenile salmonids in the historical and present estuary were simulated and compared. Based on the velocity criteria ($< 0.3 m\ s^{-1}$), habitat opportunity has declined in the upriver tidal freshwater mainstem and the upper estuary peripheral bays (Cathlamet and Grays) while it has not changed substantially in the lower regions of the estuary (lower estuary mainstem and lower estuary peripheral bays [Youngs and Baker]). Based on the depth criteria (0.1 to 2 m), habitat opportunity has increased in all regions compared to historical conditions, except in the upriver tidal freshwater mainstem. However, limitations in the representation of historical and modern bathymetry in the model limit confidence in the depth criteria results and prevent comparison of historical and current habitat opportunity based on the combined depth and velocity criteria. Despite model limitations, results indicate that the availability of suitable juvenile salmonid estuary habitat varies in response primarily to bathymetry, but also to river discharges and tides. Also, seasonal and inter-annual variability is important particularly in upper regions of the estuary where habitat opportunity is reduced during freshet flows (Bottom et al. 2001).

Small changes in salinity distribution may have significant effects on the ecology of fishes in the estuary, including salmonids. Salinity distribution, as affected by tidal flow and river discharge, determines the location of the ETM; salinity and the ETM are primary factors explaining seasonal species distributions and the structure of entire fish, epibenthic, and benthic invertebrate prey species assemblages throughout the Columbia River estuary (Haertel et al. 1969, Bottom and Jones 1990, Jones et al. 1990 as cited in NMFS 2000c and Simenstad et al. 1994b as cited in USACE 2001). By altering the distribution of preferred habitats within specific salinity ranges and the particular array of species that salmon encounter at different locations during their estuarine residence, small changes in salinity structure may have significant effects

on the estuarine food web and fish production in the estuary. In particular, small changes in the distribution and gradient of oligohaline salinities may change the type of habitats available when juvenile salmon make the critical physiological transition from fresh to brackish water (NMFS 2000c).

2.1.4.2.5 Habitat Connectivity

Within the estuary, rapid changes in salinity gradients, water depths, and habitat accessibility impose important energetic and ecological constraints that salmonids do not encounter in freshwater (Bottom et al. 2001). Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids (Simenstad et al. *in press* as cited in Bottom et al. 2001). As subyearlings grow, they move across a spectrum of salinities, depths, and water velocities. For species like chum and ocean type chinook salmon that rear in the estuary for extended time periods, a broad range of habitat types in the proper proximities to one another may be necessary to satisfy feeding and refuge requirements within each salinity zone. If juvenile salmonid life cycles require specific spatial and temporal sequences, then areas suitable for supporting salmonids may remain unused if their connectivity with other habitats is lost (Bottom et al. 1998). That is, the connectedness of these habitats likely determines whether juvenile salmonids are able to access the full spectrum of habitats they require.

Juxtaposition of high-energy areas with ample food availability and sufficient refuge habitat is a key habitat structure necessary for high salmonid production in the estuary. In particular, tidal marsh habitats, tidal creeks and associated complex dendritic channel networks may be especially important to subyearlings as areas of both high insect prey density, and as potential refuge from predators afforded by sinuous channels, overhanging vegetation and undercut banks (McIvor and Odum 1988). Salmonid production in estuaries is supported by detrital food chains (Healey 1979, 1982). Therefore habitats that produce and/or retain detritus, such as tidal wetlands emergent vegetation, eelgrass beds, macro algae beds and epibenthic algae beds, are particularly important (Sherwood et al. 1990). Historically, before the Columbia River was isolated from its floodplain, influx of organic matter occurred regularly during spring freshets.

The importance of proximate availability of feeding and refuge areas may hold true even for species that move more quickly through the estuary. For example, radio tagged coho in Grays Harbor estuary moved alternatively from low velocity holding habitats to strong current passive downstream movement areas (Moser et al. 1991). Consistent with these observations, Dittman et al. (1996) suggest that habitat sequences at the landscape level may be important even for species and life history types that move quickly through the estuary during the important smoltification process, as salmon gather the olfactory cues needed for successful homing and these cues may depend on the environmental gradients experienced during migrations.

2.1.4.2.6 Habitat Capacity

Diking and filling activities in the estuary have likely reduced the rearing capacity for fry and sub-yearling life stages by decreasing the tidal prism and eliminating emergent and forested wetlands and floodplain habitats adjacent to shore (Bottom et al. 2001, NMFS 2000c). Dikes throughout the lower Columbia River and estuary have disconnected the main channel from a significant portion of the wetland and floodplain habitats. Further, filling activities (i.e. for agriculture, development, or dredge material disposal) have eliminated many wetland and floodplain habitats. Because fry and subyearling smolts rely heavily on emergent and forested

wetlands and floodplain habitats for food and refugia, reduction of these habitats have reduced the capacity for these salmonid life stages.

Both large woody debris and sand/gravel substrates are important factors defining the quantity and quality of estuarine habitat for salmonids; changes in flow cycles, flow magnitude, and habitat isolation has decreased the availability of these estuarine habitat components to juvenile salmonids (Sherwood et al. 1990 as cited in Nez Perce et al. 1995, NMFS 2000c, Bottom et al. 2001, USACE 2001). *Anecdotal* observations indicate that salmonids congregate near large woody debris; feeding may be enhanced because of the deposition of organic matter and the production of small benthic prey species. Much of the habitat that served as the large woody debris source (i.e. tidal swamps/wetlands, freshwater riparian forests and forested wetlands) has been disconnected from the lower river and estuary via diking and subsequent development. Decreases in flow decreases bedload transport of sand and large woody debris movement; recruitment of these important habitat features to estuary habitats has decreased. Restoration of lost estuary wetland habitat and historical flow patterns may benefit recovery of depressed salmonid stocks (ISAB 2000, NMFS et al. 2000).

2.1.4.2.7 Migration and Spawning

Hydrologic effects of the Columbia River hydrosystem include water level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. Altered flow regimes can affect the migratory behavior of juvenile salmonids. For example, water level fluctuations associated with hydropower peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and strand juveniles during the downstream migration. Reservoir drawdowns reduce available habitat which concentrates organisms, potentially increasing predation and disease transmission (Spence et al. 1996 as cited in NMFS 2000c).

Altered flow regimes can affect the spawning success of mainstem Columbia River spawners. For example, reservoir drawdowns in the fall for flood control produces high flow for fall spawners; fish may spawn in areas that are dewatered during the winter or spring, potentially resulting in complete egg mortality (NMFS 2000c).

2.1.4.2.8 Food Web Structure

There is a general inference today that the capacity of the Columbia River estuary to produce salmonids has decreased from historical levels. Losses of emergent marsh and forested wetland habitats have been substantial, and may be a major factor affecting the capacity of the estuary to support juvenile salmon. Studies show that small subyearling ocean-type chinook salmon occupy shallow habitats and feed extensively on emergent insects. The diet composition and distribution of small juveniles far into shallow tidal channels and sloughs at high tide suggest that these fish are rearing in direct association with vegetated edges of estuarine wetlands (Simenstad et al. 2000). However, habitat alterations such as artificial river confinement and water regulation through hydrosystem operations have restricted access to some productive Columbia River estuary floodplain habitats. The current estuary food web does not support the same diversity of salmon life-history types that occurred historically (Bottom et al. 2001).

Juvenile salmonids are part of a complex food web in the lower Columbia River mainstem and estuary (Figure 2-29; USACE 2001). Plant primary productivity is the base of the food web; plant material can be incorporated into the food web via direct consumption or

through decaying material and consumption by detritivores (Jones et al. 1990 as cited in USACE 2001). Salmonids consume prey species supported by resident plant material and resident and imported plankton and detritus. The relative amount of available prey species depends on the abundance of estuary habitat types as well as the input of imported detrital material from upstream sources. The contribution of imported detritus is controlled primarily by reservoir production and flow rates from Bonneville Dam. Subyearling salmonids feed primarily on benthic prey items available in near-shore habitats while yearling salmonids feed primarily on zooplankton available in the water column; larvae and adult floating insects appear to be important prey items for most salmonids. Prey availability and consumption varies with tide stage; prey items inhabiting shallow habitats become more available during high tides while planktonic prey items appear to be equally available at different tide levels. Further, food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000).

Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995). Juvenile chinook salmon growth in estuaries is often superior to river-based growth (Rich 1920a, Reimers 1971, Schluchter and Lichatowich 1977). Ability of the Columbia River estuary to support juvenile salmonid growth and maximize survival to the time of ocean entry depends on habitat productivity and access to productive habitats (Figure 2-30 and Figure 2-28; Brodeur et al. 2000, Bottom et al. 2001). The estuarine food web was historically macrodetritus-based because of the abundance of emergent, forested, and other wetland rearing areas throughout the estuary (Figure 2-29; Bottom et al. 2001, USACE 2001, Johnson et al. 2003b); these areas have been largely been lost or disconnected from the river via dike construction and subsequent development. Emergent plant production in the estuary has decreased by 82% and benthic macroalgae production by 15% (Sherwood et al. 1990 as cited in Nez Perce et al. 1995). The loss of wetland habitats combined with the development of reservoirs throughout the Columbia River has shifted the food web to a microdetritus base, primarily in the form of imported phytoplankton production from upriver reservoirs that dies upon exposure to salinity in the estuary (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001). Imported phytoplankton are found within the water column and support a pelagic food web that is less accessible to small juvenile salmonids that inhabit the edge habitat throughout the lower Columbia River and estuary (Sherwood et al. 1990 as cited in USACE 2001, USACE 2001).

While the macrodetritus-based food web was historically distributed throughout the lower river and estuary, the modern microdetritus-based food web is focused on the spatially confined turbidity maximum region of the estuary (Bottom et al. 2001). This modified food web benefits exotic species (American shad) and lower estuary forage fish (northern anchovy, Pacific herring, longfin smelt) and is a disadvantage to anadromous salmonids (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001). Although these forage fish are found in the diet of larger juvenile salmonids in the lower estuary and nearshore ocean, the presence of these forage fish unlikely satisfies smaller ocean-type salmonid feeding requirements in the estuary (Bottom and Jones 1990 as cited in USACE 2001). Survival tradeoffs between juvenile salmon estuary feeding requirements and estuary food web support of feeding requirements in the lower estuary and nearshore ocean are unknown.

Habitat alterations such as artificial river confinement have restricted access to some productive Columbia River estuary floodplain habitats. Further, water regulation through the hydrosystem operation has decreased seasonal freshet flows. Flow volumes that create over bank flows are rare, which further restricts access to any existing riparian wetland or forest habitat. Thus, because of the alteration of the estuary food web and the restricted habitat access, productive capacity of the estuary has decreased from historical levels (Bottom et al. 2001, NMFS 2000c, USACE 2001, Johnson et al. 2003b).

The role and importance of microbial communities in the modern day estuary food web has recently been the focus of a considerable amount of research. As discussed previously in section 2.1.3.1.3, the ETM traps particulate material of river and ocean origin. The residence time of these particles within in the ETM is believed to be 2-4 weeks, compared to the 1-2 day residence time of water (Neal 1972 as cited in Crump et al. 1999) or associated free-living bacteria outside the ETM (Crump et al. 1999). The circulation and trapping processes in the ETM facilitates attachment among particles, forming rapidly settling macroaggregates. In the Columbia River estuary, bacteria associated with these particles are believed to be a primary food source within the food web (Baross et al. 1994, Crump et al. 1998 as cited in Crump et al. 1999). For example, particle-attached bacteria accounted for about 90% of the heterotrophic bacterial activity in the Columbia River estuary water column; these bacteria were 10-100 times more active than free-living bacteria outside the ETM (Crump and Baross 1996, Crump et al. 1998 as cited in Crump et al. 1999). Crump et al. (1999) noted that a large part of the particle-attached bacteria in the ETM were unrelated to river or coastal ocean bacteria, suggesting these ETM bacteria developed in the estuary. Further, these bacteria attached to ETM particles are extremely important degraders of particulate organic matter in the system and serve as the food base for detritivorous copepods (the dominant grazer; Simenstad et al. 1994a) as well as rotifers and protozoa (Crump and Baross 1996). These organisms are often important in the diet of salmonids.

The estuarine food web can be highly variable because of differential pulses of organic matter and the varied distributions of food sources across estuarine habitats (Wissmar and Simenstad 1998 as cited in USACE 2001). Because of seasonal changes in habitats and prey resources caused by changes in habitat-forming processes, salmonids encounter a seasonally varying array of habitat conditions and prey resources. Consequently, the contribution of the estuary for juvenile salmonid survival, growth, passage, and smolting varies seasonally, especially when salmonids localize their rearing and movements in a specific estuarine region or habitat (USACE 2001).

The marine fish community off the mouth of the Columbia River has changed since the 1980s and is structured by physical oceanographic characteristics (such as salinity, temperature, and chlorophyll). The distribution and abundance of the nearshore marine predator and forage fish community affects the amount of predation on juvenile salmonids; that is, high prey densities increases the probability of predation on juvenile salmonids while high forage fish density decreases the probability of predation on juvenile salmonids (NMFS 1998, NMFS et al. 1998).

2.1.4.2.9 Changes in Salmonid Life History and Estuarine Residence Time

The physical habitat requirements of juvenile salmonids are related to their life history pattern (i.e. stream-type vs. ocean-type). The primary factors that describe physical habitats are water depth, water velocity, and substrate type, while secondary physical factors are water

temperature, salinity, and turbidity (USACE 2001). Salmonids adapt to relatively wide ranges within the secondary physical factors. Anthropogenic factors may create artificial selection (Sheridan 1995 as cited in Bisbal and McConnaha 1998), add challenges for salmonids to maintain their biological diversity and ability to withstand environmental variation, and thus, can alter the biological structure of salmonid populations and reduce the variation in life history patterns (Bisbal and McConnaha 1998). Most mitigation efforts are optimized based on juvenile fish adundance, rather than life history diversity, such as the process of transporting emigrating juvenile salmonids past Columbia River dams (Bisbal and McConnaha 1998).

Rich (1920) investigated juvenile chinook life history and migration in the estuary from 1914-1916. He collected 1365 fish and discussed scale patterns of fish captured at different locations or known to be of a specific origin (such as a specific tributary or hatchery). From this scale pattern analysis, Bottom et al. (2001) classified the life history patterns described below (Table 2-16). Rich's 1916 data show that chinook fry were present in the estuary from late March through September and chinook fingerlings were present from April to December (Bottom et al. 2001). Based on a comparison of average fork lengths of different sample groups, Rich (1920) indicated that growth in the estuary was particularly rapid in June, July, and August; however, Rich (1920) cautioned that average fork length comparisons may not represent actual growth rates because sampling in successive months likely measured entirely different groups of fish.

Table 2-16. Chinook life history types from scale analysis of fish captured in the Columbia River estuary (from Bottom et al. 2001 based on Rich 1920).

Life-history Type Collected	Rearing Behavior	% of Total
Fry	Fish that moved into the estuary as fry shortly after emergence	33%
Fingerling		
Smolts and recent arrivals	Fish too recently arrived at the estuary to have evidence of estuarine rearing on their scales. Includes both smolts and fingerlings bound for estuarine rearing habitats	28%
Fluvial-rearing	Fluvial rearing as fry and as fingerling. Includes fish that reared near their natal areas, and also fish that migrated into larger rivers downstream from their natal sites to rear, but which did not rear in the estuary	6%
Estuarine-rearing	Fish that reared for a short time in their natal stream then migrated to the estuary to rear	25%
Fluvial and estuarine-rearing	Fish with evidence of either adfluvial or estuarine rearing, but with scale patterns that did not lend themselves to identifying a fish in either category with certainty.	8%

Bottom et al. (2001) used historical and contemporary fish surveys to assess changes in use of estuarine environments by juvenile salmon. They conclude that population structure and life history diversity of subyearling ocean-type chinook salmon has simplified significantly since the early part of last century. Historically, chinook salmon in the Columbia River exhibited a wide diversity of life history types, using streams, rivers, the estuary, and perhaps the Columbia River plume as potential rearing areas. For ocean-type chinook salmon, there may be as many as 35 potential life history strategies (Wissmar and Simenstad 1998 as cited in USACE 2001, Bottom et al. 2001). Bottom et al. (2001) suggest that human affects on the environment have caused chinook life history patterns to be more constrained and homogenized than historical data show. Data collected by Rich (1920) show several forms of ocean-type chinook life histories, based on scale patterns, length, and time of capture. Groups of fish migrated to the estuary as either fry or fingerlings, in the spring or fall. Individual fingerlings arrived in the estuary throughout the year. Some fish remained in the estuary for extended periods of time while others migrated seaward rapidly. Fish from a brood represented a continuum of rearing and migrant behaviors spanning an 18-month period. However, even the work of Rich (1920) may have underestimated the historical diversity of estuarine rearing behaviors because many changes in the basin had already occurred. Migration timing and size of juvenile salmonids entering the estuary are important factors affecting stock life histories, maturation, and ultimate survival (Reimers 1973, Schluchter and Lichatowich 1977, Groot and Margolis 1991 as cited in Nez Perce et al. 1995).

By contrast, today ocean-type chinook with estuarine rearing life histories are not a primary life history form observed by managers and resource users. Most modern day ocean-type chinook fit into one of three groups: subyearling migrants that rear in natal streams,

subyearling migrants that rear in larger rivers and/or the estuary, yearling migrants. Today, fish enter the estuary later (by at least two weeks) in pulses that coincide with hatchery releases. Subyearling chinook abundance in the estuary is limited; most chinook are yearlings with a homogeneous size distribution. Abundance patterns of juvenile chinook in the estuary now reflect hatchery management practices more than historical migration behavior. Although, current life history diversity may be underestimated because most research has focused on the migration and survival of hatchery yearlings and large natural subyearlings, not smaller subyearlings. Nevertheless, the uniform sizes and rapid estuary migrations of chinook salmon compared to historical observations suggests a loss of diversity and type of life history responses (Bottom et al. 2001). Hatchery practices have promoted a decrease in life history diversity; restoration efforts need to consider habitats/life histories that may be limited or non-existent today (Bottom et al. 2001).

Also, the size range of fish sampled today is smaller than the historical ranges. Size distributions indicate that historical juvenile entry continued from spring through fall, with some extended estuarine residence. The flux of chinook entering the estuary included fry that migrated to the estuary in the fall and may have overwintered in the lower reaches (Bottom et al. 2001). Smaller fish historically present in the fall are poorly represented in modern sampling studies. Today's chinook are composed of relatively few fry, and many larger subyearlings that likely do not reside in the estuary for extended periods. Bottom et al. (2001) suggest that the data indicate that ocean-type chinook with estuarine rearing life histories are now substantially reduced in proportion relative to their historical levels. The authors caution, however, that present day diversity may be underestimated by inclusion of data from modern monitoring programs that emphasize migration and survival of hatchery yearlings and subyearlings, but did not sample in many shallow-water habitats where smaller size ranges of juveniles would be more likely to be found.

2.1.4.3 Pacific Lamprey

Juvenile lamprey depend on sand and silt substrates, thus, habitat forming processes and conditions that create this habitat characteristic are likely beneficial to juvenile lamprey survival. Anthropogenic factors that introduce more sand and silt to a river's substrate (i.e. riparian zone development, logging, road building either within the subbasin or in upriver locations) may contribute to the development of habitat preferred by juvenile lamprey. Further, the altered Columbia River flow regime resulting from water regulation has decreased the flow volumes capable of transporting large volumes of sand/silt to the estuary/ocean; thus, sand and silt substrates are more likely to remain in the mainstem compared to historical conditions.

2.1.4.4 Sturgeon

Hard-bottom, high-velocity, structured habitats with adequate interstitial space are critical as spawning and incubation substrate as well as juvenile predation refuge and feeding areas for white sturgeon (Parsley et al. 1993; Perrin et al. 1999; Parsley et al. 2002; Secor et al. 2002). White sturgeon juveniles that burrow into fine sediments commonly die as a result of suffocation. Maintenance of these preferred white sturgeon habitats are important to the species continued productivity in the lower Columbia River and estuary. Anthropogenic factors that continue to introduce more sand and silt to the river's substrate (i.e. riparian zone development, logging, road building) likely decreases the availability of preferred white sturgeon habitat. Further, the decreased the flow volumes resulting from Columbia River water regulation has

decreased sand/silt transport to the estuary/ocean; thus, sand and silt substrates are more likely to remain in the mainstem, adversely affecting white sturgeon. These habitat changes have likely occurred in mainstem and distributary channel habitats.

Altered daily and seasonal river discharge and thermal regimes resulting from impoundment and dam operations also may alter migration, limit habitat availability, and affect timing, location and success of reproduction (Paragamian and Kruse 2001; Paragamian *et al.* 2001; Anders *et al.* 2002; Cooke *et al.* 2002; Jager *et al.* 2002; Secor *et al.* 2002). Parsley *et al.* (2001) simulated drawdown of a Columbia River reservoir and concluded that the quality and quantity of white sturgeon spawning habitat would increase as reservoir levels were lowered. However, these authors suggested this outcome was due to increased availability of suitable velocities for spawning (Parsley *et al.* 1993) despite a decrease in total area of the river (Parsley *et al.* 2001).

Important empirical correlations between water year; discharge characteristics during June, July and August; and recruitment measured during September in the lower Columbia River impoundments attest to the importance of flow alterations on white sturgeon recruitment (Counihan *et al.* in press). An understanding of a positive relationship between discharge (water years) and natural production of Columbia River white sturgeon has existed since the late 1980s (Beamesderfer et al. 1995). Furthermore, consistent annual recruitment in the lower Columbia River, in the Bonneville Dam tailrace, and downriver areas were associated with conditions representing good water years due to the artificial constriction of the Columbia River through Bonneville Dam; as such hydro development has artificially created what functionally amounts to white sturgeon spawning channels downstream from Bonneville Dam, resulting in reliable annual recruitment (L. Beckman USGS (retired), G. McCabe Jr. NMFS (retired), M. Parsley, USGS, Cook Washington. personal communication).

Flow alterations can also affect white sturgeon spawning and embryo hatching success, to the extent that flow they alter downstream thermographs. In the lower Columbia River, annual white sturgeon spawning appears to be triggered consistently when water temperature reaches 50°F (10°C) (M. Parsley, US Geological Survey, G. McCabe, NMFS (retired), personal communication). Spawning in the four impoundments farthest downstream occurs exclusively in tailrace areas immediately downstream from hydropower dams when water temperatures reach 54°F (12°C) (Parsley *et al.* 1993). Because water temperatures generally reach spawning temperatures first in downstream areas of the Columbia Basin, annual spawning is usually initiated downstream from Bonneville Dam when water temperatures reach 50°F (10°C), followed by spawning activity in each adjacent upstream tailrace when lower impoundment water temperatures reach and exceed 54°F (12°C). Most spawning occurs in the four farthest downriver Columbia River impounded areas at 57°F (14°C) (Parsley *et al.* 1993; Anders and Beckman 1995) with an optimum range generally cited as 54-57°F (12-14°C) for those areas.

Sturgeon are particularly abundant in deep-water habitats of the Columbia River subject to channel maintenance and dredging activities. Suction dredging in deep areas (66-85 ft [20-26 m]) in the lower Columbia River is known to seriously injure and kill juvenile white sturgeon (Buell 1992) but the magnitude of the population impact is unclear. Channel deepening also may affect sturgeon directly via entrainment or indirectly via habitat or food interactions, but the net effect is unclear and speculation continues.

Very little is known regarding the effects of food source abundance for white sturgeon in marine and estuarine environments, but, based on empirical growth studies of white sturgeon in

the four Columbia River impoundments farthest downstream and in the lower Columbia River, annual juvenile growth rates in the impounded areas generally surpassed those in the lower Columbia River until approximately age 7 or 8. Following this age, mean annual growth rate in the lower Columbia River, possibly including the estuary, generally exceeded rates in the impoundments (M. Parsley, USGS, personal communication). This increase in relative growth rate for juvenile white sturgeon downstream from Bonneville Dam was thought to result from access to food items unavailable in the impoundments (e.g. Eulachon) (DeVore et al. 1995; M. Parsley, J. Devore, personal communication).

2.1.4.5 Northern Pikeminnow

Northern pikeminnow abundance in the mainstem Columbia River below the Snake River confluence is greatest in the lower mainstem from the estuary to The Dalles Dam (Beamesderfer et al. 1996). Although Northern pikeminnow have relatively broad spawning and rearing requirements, they seem to prefer low velocity water with clean rocky substrate. Anthropogenic factors that contribute to sedimentation and the altered flow regime of the Columbia River likely have decreased the availability of these preferred pikeminnow habitats. However, Northern pikeminnow have successfully adapted to the changing habitat conditions in the lower Columbia River mainstem as evidenced by their current abundance; it is anticipated that Northern pikeminnow will continue to thrive under the current trend of habitat alterations.

2.1.4.6 Eulachon

Hydropower development on the Columbia River has decreased the available spawning habitat for eulachon. Prior to the completion of Bonneville Dam, eulachon were reported as far upstream as Hood River, Oregon (Smith and Saalfeld 1955). Similar developments on tributary rivers, like the Cowlitz, also may have decreased spawning habitat.

Eulachon freshwater spawning habitat can be affected by in-channel conditions. Eulachon are broadcast spawners with highly adhesive eggs that attach to coarse sandy substrates. Dredging has the potential to impact adult and juvenile eulachon (Larson and Moehl 1990). In a 2001 study, researchers found that the sand wave movements in near-shore areas of dredging operations in the lower Columbia River made the substrate too unstable for the incubation of eulachon eggs. Recommendations of the study suggested that channel-deepening operations be scheduled to avoid eulachon spawning areas during peak spawning times (Romano et al. 2002). The same recommendations have been echoed in the Washington and Oregon Eulachon Management Plan concerning dredging activities in tributaries to the Columbia River.

2.1.4.7 River Otter

In the estuary, river otters are concentrated in shallow water tidal sloughs and creeks associated with willow-dogwood and Sitka spruce habitats located primarily in the Cathlamet Bay area and along the Oregon riverbank (Howerton et al. 1984); otters likely inhabit similar areas throughout the tidal freshwater area of the lower Columbia. Dikes throughout the estuary have disconnected substantial amounts of side channel and floodplain habitats from the mainstem. However, the Cathlamet Bay area remains as one of the most intact and productive tidal marsh and swamp habitat throughout the entire estuary. Because river otters are capable of traveling over land, it is not understood how the loss of habitat connectivity of side channel and floodplain habitat has affected species' behaviors such as foraging, resting, mating, and rearing.

2.1.4.8 Columbian White-tailed Deer

Columbian White-tailed deer are most closely associated with Westside oak/dry Douglas fir forest within 200m of a stream or river; however, they can be found breeding or feeding in any number of habitats (lowland forest, grasslands, riparian wetlands, agriculture/pastures/mixed environments, urban/mixed environments; Johnson and O'Neil 2001). Agriculture and urban development throughout the lower Columbia River and estuary decreased the acreage of some of these habitats while increasing the acreage of others; thus, the net effect on Columbian White-tailed deer is difficult to quantify but appears to have negatively affected population abundance. Establishment of the Columbian White-tailed Deer National Wildlife Refuge and other recovery efforts have focused on providing deer with appropriate contiguous habitat.

2.1.4.9 Caspian Tern

Caspian terns were not historically present in the Columbia River estuary. Management actions (i.e. periodic deposition of dredge spoils forming flat, sandy, unvegetated, mid-channel habitats) have created preferred habitat, encouraging colonization by Caspian terns. The altered Columbia River flow regime as a result of water regulation will likely produce variable effects on the presence of preferred Caspian tern habitat. For example, reduced peak flows are less likely to erode or inundate newly created dredge spoils islands; thus, sand substrates may remain stationary for long periods of time, but, without periodic inundation, vegetational succession begins and Caspian terns do not adapt well to the presence of vegetation in the breeding area. Further, decreased peak river flows and decreased wave action as a result of jetty construction have generally increased the amount of accretion throughout the estuary, which has increased the presence of the preferred newly formed, flat, sandy habitats of Caspian terns.

2.1.4.10 Bald Eagle

In western Washington, nest trees are most often old-growth Douglas-fir (Pseudotsuga menziesii) and Sitka spruce (Picea sitchensis) near the coast (Grubb 1976 as cited in Stinson et al. 2001), with a higher component of mature grand fir (Abies grandis) and black cottonwood (Populus balsamifera) around Puget Sound (Watson and Pierce 1998 as cited in Stinson et al. 2001). Assuming the presence of an adequate food supply, the single most critical habitat factor associated with bald eagle nest locations and success is the presence of large trees (Watson and Pierce 1998 as cited in Stinson et al. 2001). Thus, loss or alteration of nesting habitat as a result of natural events (e.g., fire, windstorms, etc.) or human-caused alterations (e.g., timber harvest, development) that results in permanent loss of nest trees or potential nesting habitat or prevents trees from attaining the size capable of supporting a nest, has the potential to reduce the number of nesting territories in Washington. Further, roost sites and perch sites also are often associated with large trees, so availability of this mature forest habitat determines potential bald eagle territories.

Declines in salmonid abundance has likely negatively affected bald eagles. Because the time of spawning for most Columbia River salmon runs is from August to January, declines in salmon runs have probably primarily affected the distribution and abundance of post-breeding and wintering bald eagles. Supplementation of salmon runs through hatchery fish generally does not replace the carcasses that historically provided food for bald eagles. Likewise, abundance of many seabirds and waterfowl have declined in recent years; loss of this prey base has also likely negatively affected eagles (Stinson et al. 2001).

Contaminant-free prey is necessary to maintain the reproductive health and survival of bald eagles. Organochlorine compounds and derivatives are still present in the Columbia River estuary and lower mainstem as result of industrialization within the subbasins. Often, contaminants are re-released in the ecosystem during river dredging. Bald eagles in the Columbia River estuary have exhibited chronic low nest productivity, apparently because of a variety of contaminants, including DDE, PCB's, and dioxins (Anthony et al. 1993 as cited in Stinson et al. 2001). Residual DDT and PCBs continue to accumulate and concentrate as individuals consume contaminated prey. Some eagles may contain elevated levels of DDE in their tissues that prevents successful reproduction, or their territory may contain contaminated prey that continues to affect the resident eagles (Jenkins and Risebrough 1995 as cited in Stinson et al. 2001).

2.1.4.11 Osprey

Breeding osprey are concentrated in forested riparian areas, generally nesting atop trees or rock pinnacles. Osprey have adapted with human development and have been observed nesting on artificial structures such as channel markers or utility/light poles; recent data (late 1990s) suggests that the osprey population along the lower Columbia River mainstem may be increasing. Although habitat alterations do not appear to be having significant detrimental effects on osprey along the lower Columbia River, Columbia River osprey eggs contained the highest concentration of DDE (derivative of formerly banned pesticide DDT) reported in North America in the late 1980s and 1990s (Henny et al. 2003); DDE adversely affects eggshell thickness and decreases breeding success.

2.1.4.12 Sandhill Crane

The lower Columbia River mainstem and estuary is not a historical breeding or overwintering area for sandhill cranes. Agricultural development throughout the lower Columbia River floodplain has likely attracted overwintering sandhill cranes; for the last seven or eight years, an average of a few hundred, but up to 1,000 cranes have overwintered in the lower Columbia River floodplain. Reclamation of agricultural land for habitat restoration projects may discourage overwintering by sandhill cranes, although future development of herbaceous wetlands may provide adequate winter habitat for sandhill cranes currently using the region.

2.1.4.13 Yellow Warbler and Red-eyed Vireo

The yellow warbler and red-eyed vireo are both riparian obligate species; warblers prefer shrub-dominated habitats and vireos prefer dense, closed canopy forests. Habitat alterations along the lower Columbia River corridor have likely been more damaging to the possible presence of red-eyed vireos as opposed to yellow warblers. Dense riparian forests along the lower Columbia River are likely less abundant than shrub-dominated wetland habitat. Neither species is likely greatly affected by the disconnectedness of floodplain habitat from the mainstem.

2.1.5 *Ecological Relationships*

Ecological relationships describe species-species relationships and species-environment relationships; paramount to these relationships are the effects to the specific life stage of focal species, if known. Two general categories of interspecies relationships exist: native-native interactions (Section 2.1.5.1) and native-exotic interactions (Section 2.1.5.2). Each of these

categories are addressed separately below; each section addresses predation and competition aspects of species interactions. Additionally, the discussion of exotic species addresses full scale ecosystem alterations.

2.1.5.1 Native Species Interactions

2.1.5.1.1 Predation

Significant numbers of salmon are lost to fish, bird, and marine mammal predators during migration through the mainstem Columbia River. Predation likely has always been a significant source of mortality but has been exacerbated by habitat changes. Piscivorous birds congregate near dams and in the estuary around man-made islands and consume large numbers of outmigrating juvenile salmon and steelhead (Roby et al. 1998). Caspian terns, cormorants, and gull species are the major avian predators (NMFS 2000a). While some predation occurs at dam tailraces and juvenile bypass outfalls, by far the greatest numbers of juveniles are consumed as they migrate through the Columbia River estuary. Native fishes, particularly northern pikeminnow, prey on juvenile salmonids. Marine mammals prey on adult salmon, but the significance is unclear.

Caspian terns are native to the region but were not historically present in the lower Columbia River mainstem and estuary; they have recently made extensive use of dredge spoil habitat and are a major predator of juvenile salmonids in the estuary. The terns are a migratory species whose nesting season coincides with salmonid outmigration timing. Since 1900, the tern population has shifted from small colonies nesting in interior California and southern Oregon to large colonies nesting on dredge spoil islands in the Columbia River and elsewhere (NMFS 2000c). Many of these Columbia River dredge spoils islands were created as a result of dredging the navigational channel after the eruption of Mt. St. Helens in 1980; however, Rice Island was initially constructed from dredge spoils around 1962 (Geoffrey Dorsey, USACE, personal communication). Caspian terns did not nest the estuary until 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds (and others) moved to Rice Island in 1987 and the colony expanded to 10,000 pairs. Diet analysis has shown that juvenile salmonids make up 75% of food consumed by Caspian terns on Rice Island. Roby et al. (1998) estimated Rice Island terns consumed between 6.6 and 24.7 salmonid smolts in the estuary in 1997, and that avian predators consumed 10-30% of the total estuarine salmonid smolt population in that year. However, there are no data to compare historical and modern predation rates or predator populations; thus, effects of these unique predator populations in relation to historical losses of juvenile salmon to predation cannot be adequately quantified (Bottom et al. 2001). Also, recent management actions have been successful in discouraging Caspian tern breeding on Rice Island while encouraging breeding on East Sand Island, which may decrease predation on juvenile salmonids. Further, current predation studies are limited because of the unknown effects hatchery rearing and release programs have had on salmon migration behavior and predator consumption. Nevertheless, evidence suggests that current predator populations could be a substantial limiting factor on juvenile salmon survival (Bottom et al. 2001).

Pikeminnow have been estimated to consume millions of juveniles per year in the lower Columbia, as outlined in the following table.

Table 2-17. Projected abundance of northern pikeminnow, salmonid consumption rates, and estimated losses of juvenile salmonids to predation (NMFS 2000b).

Location	Length (km)	Predator Number	Consumption Rate (smolts/predator day)	Estimated Losses (millions/year)
Estuary to Bonneville Dam	224	734,000	0.09	9.7
Bonneville Reservoir	74	208,000	0.03	1.0

Pikeminnow numbers likely have increased as favorable slack-water habitats have been created by impoundment and flow regulation. In unaltered systems, pikeminnow predation is limited by smolt migratory behavior; the smolts are suspended in the water column away from the bottom and shoreline habitats preferred by pikeminnow. However, dam passage has disrupted juvenile migratory behavior and provided low velocity refuges below dams where pikeminnow gather and feed on smolts. The diet of the large numbers of pikeminnow observed in the forebay and tailrace of Bonneville Dam is composed almost entirely of smolts. Pikeminnow also concentrate at dam bypass outfalls and hatchery release sites to prey on injured or disoriented fish, and pikeminnow eat many healthy smolts as well. Predation rates on salmonids are often much lower in areas away from the dams, although large numbers of predators in those areas can still impose significant mortality.

In 1990, responding to observed predation problems, a pikeminnow management program was instituted that pays rewards to anglers for pikeminnows over a prescribed size. Through 2001, over 1.7 million pikeminnow had been harvested, primarily in a sport reward fishery. Modeling results project that potential predation on juvenile salmonids by northern pikeminnow has decreased 25% since fishery implementation (NMFS 2000a). By paying only for pikeminnow over a certain size, the program takes advantage of their population characteristics—they are relatively long-lived and only the large individuals are fish predators. Relatively low exploitation rates of only 10-20% per year compound over time to substantially reduce pikeminnow survival to large predaceous sizes.

Seals and sea lions (particularly harbor seals [*Phoca vitulina*], Steller sea lion [*Eumetopias jubatus*], and California sea lion [*Zalophus californianus*]) are common in and immediately upstream of the Columbia River estuary and are regularly observed up to Bonneville Dam. Seals and sea lions are regularly reported to prey on adult salmon and steelhead, although diet studies indicate that other fish comprise the majority of their food. Large numbers of pinnipeds might translate into significant salmon mortality despite this occasional use. However, it is difficult to interpret the significance of this mortality factor for salmon, considering that large pinniped populations have always been present in the Columbia River. However, current marine mammal predation may be proportionally more significant, since all sources of mortality on depressed stocks become more important. Their numbers were reduced by hunting (including bounty hunters) and harassment from the late 1800s until the Federal Marine Mammal Protection Act (FMMPA) was adopted in 1972. Their numbers have significantly increased since the adoption of FMMPA. Fishers historically viewed seals and sea lions as competitors and the old Columbia River Fisherman Protection Associations funded a control program. These mammals can be troublesome to sport and commercial fishers by taking hooked or net-caught fish before they can be landed.

2.1.5.1.2 Competition

The productivity of the Columbia River estuary likely has decreased over time as a result of habitat degradation, which initially would appear to increase the likelihood for competition among salmonids in the estuary especially during times of high juvenile abundance. However, historical natural abundance of juvenile salmonids in the lower mainstem and estuary was far greater than the current abundance, even considering large hatchery releases of juvenile salmonids. Thus, it is possible that decreases in estuary habitat productivity are of the same magnitude as decreases in salmon abundance, suggesting that salmonid density dependent mechanisms in the estuary are no more likely today than they were historically.

Because ocean-type chinook salmon spend more time in the estuary, they may be sensitive to changes in the productivity of the estuary environment than stream-type chinook salmon. Estuaries may be "overgrazed" when large numbers of ocean-type juveniles enter the estuary en masse (Reimers 1973, Healey 1991). Food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000). Reimer (1971) suggested a density dependant mechanism affects growth rate and hypothesized that fall chinook growth in the Sixes River was poor from June to August because of the large population in the estuary at this time and that the increased growth rate in September to November resulted from reduction in population size and a better utilization of the whole estuary.

The potential exists for large-scale hatchery releases of fry and fingerling ocean-type chinook salmon to overwhelm the production capacity of estuaries (Lichatowich and McIntyre 1987). However, Witty et al. (1995) could not find any papers or studies that evaluated specific competition factors between hatchery and wild fish in the Columbia River estuary. Simenstad and Wissmar (1983) cautioned that the estuary condition may limit rearing production of juvenile chinook, and many other studies have demonstrated the importance of the estuary to early marine survival and population fitness. However, rivers such as the Columbia, with well-developed estuaries, are able to sustain larger ocean-type populations than those without (Levy and Northcote 1982).

The intensity and magnitude of competition in estuaries depends in part on the duration of residence of hatchery and natural juvenile salmonids. One would expect summer/fall chinook from the mid-Columbia region to use the estuary for a period that probably depends upon their size when they arrive (Chapman et al. 1994). Chapman et al. (1994) conclude that the survival of juveniles transported to below Bonneville Dam at a size too small to ensure high survival at sea may depend upon growth in the estuary for successful ocean entry. Meanwhile, some workers (Reimers 1973; Neilson et al. 1985) have suggested that the amount of time spent in estuaries may relate to competition for food. Chapman et al. (1994) suggested that, if large numbers of hatchery fish are present in the Columbia River estuary, growth and survival of wild subyearling chinook could be reduced. However, Levings et al. (1986) reported that the presence of hatchery chinook salmon did not affect residency times and growth rates of wild juveniles in a British Columbia estuary and that hatchery fish used the estuary for about half the length of time that wild fry were present (40-50 days).

Natural populations of salmon and steelhead migrate from natal streams over an extended period (Neeley et al. 1993; Neeley et al. 1994); they also enter the estuary over an extended period (Raymond 1979). Hatchery fish are generally—but not always—released over a shorter

period resulting in a mass emigration into natural environments. In recent years, managed releases of water, commonly called water budgets, have been used to aid mass and fast migration of hatchery and wild smolts through the migration corridor. Decisions regarding the mode of travel in the migration corridor (i.e., in river migration or collection/transportation) are made by managers to expedite movement of smolts to the estuary. Water budget management combined with large releases of hatchery fish result in large numbers of juvenile salmon and steelhead in the estuary during spring months when the estuary productivity is low. Fish that arrive in the estuary later in the season may benefit from increased food supplies. Chapman et al. (1994) note that subyearling chinook released later in the summer returned at significantly higher rates than subyearlings released early in the summer.

There is substantial overlap in estuarine habitat usage among chum and chinook salmon fry (Levy and Northcote 1982), suggesting significant potential for competition between these two salmonids. However, possible interactions between chum and chinook seems to be minimized by differences in migration timing and estuary residence periods; chum fry typically precede chinook in the estuary and spend a relatively short amount of time in the estuary compared to chinook (Levy and Northcote 1982).

2.1.5.2 Non-Indigenous Species Interactions

Introductions of aquatic non-indigenous species has become the focus of increasing concern and research; their increasing predominance in species assemblages indicate major changes in aquatic ecosystems (OTS 1993, Cohen and Carlton 1995, Smith 2001 as cited in Waldeck et al. 2003). Globally, there is an increasing rate of aquatic non-indigenous species introductions; this increase has been attributed to the increased speed and range of world trade, which facilitates the volume, variety, and survival of intentionally or unintentionally transported species. All aquatic non-indigenous species introductions in the lower Columbia River represent permanent alterations of the biological integrity of the ecosystem for numerous reasons: impacts of introduced species are unpredictable, introduced species alter food web dynamics, and introduced species are a conduit for diseases and parasites (Waldeck et al. 2003). Further, it has been hypothesized that changes in the Columbia River estuary and lower mainstem ecosystem as a result of hydrosystem development and water regulation have affected the successful establishment of aquatic non-indigenous species (Cordell et al. 1992 as cited in Draheim et al. 2002, Weitkamp 1994). The lower Columbia River ecosystem may still be adjusting to these major flow alterations; this adjustment period may benefit aquatic non-indigenous species (Weitkamp 1994).

Draheim et al. (2002) performed a literature review of aquatic non-indigenous species introductions in the Columbia River estuary and lower mainstem to Bonneville Dam; the authors also presented a 2001-2003 sampling plan for aquatic non-indigenous species. A final report on these sampling efforts was not available at the time of publication of this report, however, an interim report has been produced (Waldeck et al. 2003). A complete list of aquatic non-indigenous and cryptogenic (i.e. obscure or unknown origin) species to date was compiled in Draheim et al. 2002; the non-indigenous list includes plants (16), mammal (1), amphibians (1), fish (37), Annelida (2), Amphipoda (3), Cirripedia (1), Copepoda (3), Cumacea (1), Decapoda (4), Isopoda (1), Bivalvia (2), and Gastropoda (1), and the cryptogenic list includes Annelida (29), Amphipoda (3), Copepoda (1), Isopoda (1), Nemertea (1), and plants (2). However, limited information is available regarding the ecological interactions of many of these species; thus, only a select few are discussed in the sections below. In general, non-native fish species are

dominated by species that have been intentionally introduced, whereas, most invertebrates are the result of unintentional introductions (Draheim et al. 2002). Further, fish introductions in the lower Columbia River increased in a linear fashion in the 1900s while non-indigenous invertebrate introductions seem to be increasing exponentially (Waldeck et al. 2003).

2.1.5.2.1 Predation

Walleye (*Stizostedium vitreum*) are voracious predators of fishes, including juvenile salmonids. On a fish-per-fish basis, walleye are every bit as damaging as pikeminnow, but walleye are considerably less abundant. Originally introduced into the upper Columbia basin, walleye, since the 1970s, have gradually spread downstream throughout the lower mainstem. Significant numbers of walleye have become established in Bonneville Reservoir and between Bonneville Dam and the estuary. Walleye population sizes are quite variable and driven by periodic large year classes that occur during warm low flow springs. Walleye are subject to a small directed sport fishery but were not included in the sport reward fishery because projected exploitation effects on salmonids were low. Unlike pikeminnow, most walleye predation occurs in smaller individuals not readily caught by anglers and unaffected by the compounding effects of annual exploitation.

Other introduced fishes—including smallmouth bass (*Micropterus dolomeiui*) and channel catfish (*Ictalurus punctatus*)—also have been found to consume significant numbers of juvenile salmonids. However, these species are more significant problems in upstream areas than in the lower river where their abundance is low.

2.1.5.2.2 Competition

American shad (*Alosa sapidissima*) have grown to substantial populations since introduction into the Columbia River system in 1885 (Welander 1940, Lampman 1946); in recent years, 2-4 million adults have been counted annually at Bonneville Dam. Although the construction of dams in shad-producing streams has been blamed in part for the decimation of East Coast stocks of American shad (Walburg and Nichols 1967 as cited in Weitkamp 1994), Weitkamp (1994) suggested that dams in the Columbia River system may partially be responsible for the shad's rapid population growth. American shad can successfully navigate some dams (Miller and Sims 1983 as cited in Weitkamp 1994); the completion of The Dalles Dam in 1956 (and subsequent inundation of Celilo Falls) extensively expanded the range of American shad into the upper Columbia and Snake Rivers (Stober et al. 1979 as cited in Weitkamp 1994). Further, the transition of the estuarine food web from a macrodetritus to microdetritus base (i.e. increased importation of plankton from upstream reservoirs) has benefited zooplanktivores, including American shad (Sherwood et al. 1990).

Because of the abundance of American shad in the Columbia River, system studies have been launched to investigate species interactions between shad, salmonids, and other fish species such as northern pikeminnow, smallmouth bass, and walleye (Petersen et al. In press). A pattern is slowly emerging that suggests the existence of American shad is changing trophic relationships with the Columbia River. Because of their abundance, consumption rates and patterns of American shad may have modified the estuarine food web. One study found that in the Columbia River estuary and lower mainstem (up to RKm 62) shad diet overlapped with subyearling salmonid diets, which may indicate competition for food. Juvenile shad and subyearling salmonids also utilize similar heavily-vegetated backwater habitats (McCabe et al. 1983). Another study examined the abundance of shad as prey on the faster growth rates of

northern pikeminnow, which in turn are significant predators of juvenile salmonids (Petersen et al. In press).

In the Columbia River estuary, American shad were described as year-round residents (Bottom et al. 1984). Subyearling shad were captured in all areas of the estuary, primarily from August to December (Bottom et al. 1984). Yearling shad were captured throughout the year in all areas of the estuary with all gear types (Bottom et al. 1984), indicating widespread temporal and spatial distribution. Two-year old American shad were also captured throughout the year in all areas of the estuary, but they were more common in the freshwater and estuarine regions (Bottom et al. 1984). In the January, yearling American shad were distributed throughout the freshwater and estuarine areas of the estuary in water column and channel bottom habitats while 2-year olds were also present in freshwater and estuarine areas, primarily in water column habitats (Bottom et al. 1984). In the spring (April to June), a large pelagic assemblage was identified that included subyearling and yearling American shad, subyearling and yearling salmonids, and Pacific herring (Bottom et al. 1984); thus, there is overlap in habitat usage by American shad and juvenile salmonids during the season of high juvenile salmonid abundance. In August, yearling and 2-year old American shad were associated with water column habitats in the marine, estuarine, and freshwater areas of the estuary (Bottom et al. 1984). Diet analysis indicated that subyearling American shad most frequently preyed upon calanoid, cyclopoid, and harpacticoid copepods and *Daphnia spp*. (Bottom et al. 1984). Meanwhile, yearling and 2-year old American shad most frequently consumed calanoid copepods, *Corophium salmonis*, and harpacticoid copepods; to a lesser extent, cyclopoid copepods and *Corbicula manilensis* were also consumed (Bottom et al. 1984). In the spring, yearling American shad consumed primarily calanoid copepods, although up to 25% of their diet consisted of *Corophium salmonis*; *Corophium salmonis* was the primary prey item (up to 75%) of subyearling and yearling salmonids present in the estuary during the same season (Bottom et al. 1984). In the summer, *Daphnia spp.* are a major prey item of subyearling and yearling American shad; *Daphnia spp*. are also the primary prey item of subyearling chinook salmon during the summer, comprising over 75% of the diet (Bottom et al. 1984).

Commercial harvest has been considered as a means to reduce the abundance of American shad in the Columbia River, however, harvest has been restricted because the shad spawning run coincides with the timing of depressed runs of summer and spring chinook, sockeye, and summer steelhead (WDFW and ODFW 2002).

The banded killifish (*Fundulus diaphanous*) was likely introduced illegally into the Columbia River basin (Farr and Ward 1993 as cited in Weitkamp 1994) sometime around 1970 (Weitkamp 1994). Although not abundant initially, densities of 375 fish per hectare have been observed at Miller Sands in summer and fall (Hinton et al. 1990 as cited in Weitkamp 1994). In its native range, the banded killifish is a midwater and surface feeder, preying primarily on cladocerans and ostracods, although, it consumes mollusks and flatworms to a lesser extent (Smith 1985 as cited in Weitkamp 1994). Although there may be some diet overlap among banded killifish, salmonids, and other fish in the estuary and lower mainstem, its impacts on native fish and the estuarine ecosystem are largely unknown (Weitkamp 1994). Changes to the estuary ecosystem resulting from development and operation of the hydropower system may have contributed to increased survival and range extension of banded killifish (Weitkamp 1994). Weitkamp (1994) suggested that the banded killifish's limited distribution in shallow water habitats and its small size may limit the potential ecological impact in the estuary; however, continued growth of the population would warrant further investigation.

2.1.5.2.3 Ecosystem Alteration

Significant changes in estuary faunal communities have occurred through species introductions, but, for the most part, the effects of these species introductions have not been assessed. Several nonnative invertebrate species have expanded their populations dramatically since introduction, particularly the Asian bivalve, *Corbicula fluminea.* First discovered in the Columbia River estuary in 1938 (Ingram 1948), it was likely unintentionally introduced from ship ballast (Weitkamp 1994). This bivalve has expanded from the estuary far into the lower mainstem reservoirs and tributaries (Bottom et al. 2001). Densities exceeding 10,000 m^2 have been recorded in Cathlamet Bay, however, densities of 100-3,000 m^2 are more typical in the estuary (Emmett et al. 1986, Hinton et al. 1990 as cited in Weitkamp 1994); density elsewhere in the basin is not known. *C. fluminea* has been shown to outcompete native bivalves and are very tolerant of variable environmental conditions (i.e. can withstand considerable ranges and fluctuations in temperature, dissolved oxygen, flow velocity, water level, and contaminant concentrations) (Sinclair 1971, Gardner et al. 1976). Lauritsen (1986) suggests that large numbers of *C. fluminea* can have an affect on phytoplankton biomass and nutrient cycling. Because of their abundance, consumption rates and patterns of *C. fluminea* may have modified the estuarine food web. However, the influences of *C. fluminea* in the Columbia River estuary ecosystem and on native bivalves are poorly understood. Unpublished data from the California Department of Fish and Game showed that while these nonindigenous species were never prominent in the diets of juvenile salmonids, they seasonally made up the principle stomach contents of other pelagic fishes, such as American shad, herring, stickleback and smelt species (Bottom et al. 2001).

The calanoid copepod *Pseudodiaptomus inopinus* was recently introduced (around 1990) in the Columbia River estuary, likely from cargo ship ballast water originating from the Indo-Pacific region (Weitkamp 1994). The moderated peak flows and warmer water temperatures resulting from hydrosystem operation and other anthropogenic activities has facilitated success of this copepod in the estuary (Cordell et al. 1992 as cited in Weitkamp 1994). Cordell et al. (1992 as cited in Weitkamp 1994) identified *P. inopinus* as the third most abundant zooplanktor in the estuary; densities of 17,000 m^2 were recorded. *P. inopinus*, as well as other zooplanktors, is associated with the ETM, although ETM sampling has shown that *P. inopinus* is associated with different physical attributes of the ETM than the two most abundant zooplanktors in the estuary, *Eurytemora affinis* and *Scottolana canadensis* (Cordell et al. 1992 as cited in Weitkamp 1994). This spatial segregation suggests a reduced potential for competition between these native and exotic zooplankton (Cordell et al. 1992 as cited in Weitkamp 1994); however, the abundance of *P. inopinus* suggests that it may have substantial impact on the estuary ecosystem (Weitkamp 1994).

Ecosystem effects of non-indigenous aquatic plants are a concern for many resource managers. Of particular interest in the Columbia River estuary and lower mainstem are four plants considered noxious weeds: purple loosestrife (*Lythrum salicaria*), Eurasian water milfoil (*Myriophyllum spicatum*), parrot feather (*Myriophyllum aquaticum*), and Brazilian elodea (*Egeria densa*). Because much of the information regarding these aquatic nuisance plants was derived from the Washington Department of Ecology webpage, the following paragraphs identify known distribution within Washington. These, and other non-indigenous macrophytes, may also be a significant concern on the Oregon side of the lower mainstem and estuary, however, specific information regarding the status and distribution within Oregon was not found. Additionally, Wahkiakum County, Washington, recently published a management plan that

discusses in detail the issue of aquatic vegetation management as well as known distribution of select non-indigenous aquatic plants in the Columbia River estuary (AquaTechnex 2003).

Purple loosestrife, native to Eurasia, was originally introduced to the eastern seaboard of North America in the early 1800s from European ship ballast and as a valued medicinal herb; expansion westward coincided with increased transportation systems and various commercial uses, such as horticulture and forage cultivation for beekeepers. In Washington, purple loosestrife was first collected in 1929 from Lake Washington; it has since spread to most areas of the state. Purple loosestrife generally occurs in shallow, fresh and brackish water, and may grow in wetlands, ponds/lakes, stream banks, and ditches. Purple loosestrife is a successful colonizer of any wet, disturbed site; it quickly adapts to environmental changes and can expand its range rapidly. The primary ecological effect of purple loosestrife is that it disrupts wetland ecosystems by displacing native plants and eventually displacing the animals that rely on the native flora for food, nesting, or cover. Purple loosestrife spreads aggressively and is very difficult to control; combinations of cutting and herbicide application have produced mixed results, depending on the season and duration of treatment. Biological control agents through the use of leaf-eating beetles or root-mining weevils show considerable promise for controlling purple loosestrife (WDOE 2003).

Eurasian water milfoil, native to Europe, Asia, and northern Africa, may have first been introduced to North America in the late 1800s at Chesapeake Bay; expansion of the plant throughout much of North America is thought to largely be a result of boating activity from one waterbody to the next. In Washington, the first known record of Eurasian water milfoil was a 1965 herbarium specimen from Lake Meridian in King County. Eurasian water milfoil is extremely adaptable and thrives in a variety of environmental conditions, such as still or flowing water, salinity up to 15 parts per thousand, water depth up to 10 meters, pH from 5.4-11, and survival under ice; it appears to grow best on fine-textured, inorganic substrates. Eurasian water milfoil negatively affects aquatic ecosystems in a number of ways. First, the dense canopies produced by Eurasian water milfoil shade out native vegetation, creating monospecific stands that provide poor habitat for fish and wildlife. Second, plant sloughing, leaf turnover, and decomposition at the end of the growing season increases phosphorus and nitrogen loading to the water column, affecting water quality. Third, dense canopies of Eurasian water milfoil affect water quality by increasing pH, increasing water temperature, and decreasing oxygen under the dense mats. Eurasian water milfoil also has many societal impacts; it often disrupts recreational activities such as fishing, boating, or water skiing. Further, Eurasian water milfoil can negatively impact power generation or irrigation withdrawals by clogging dam trash racks or water intake pipes. Numerous methods have been effectively used to control Eurasian water milfoil; success of each method depends on a number of factors, including duration of application and appropriateness of the method to the local environment. For example, covering sediments with an opaque fabric works well in localized areas but is not appropriate for large scale control programs. Water level drawdown has proven effective at dessicating plants in cold or dry climates, but this method is not effective in wet climates, such as western Oregon and Washington. Numerous herbicides have effectively controlled Eurasian water milfoil, provided the duration and concentration of application is sufficient. Finally, biological controls, particularly a native North American weevil, have been successfully used to control Eurasian water milfoil (WDOE 2003).

Parrot feather, native to the Amazon River in South America, has naturalized worldwide, particularly in warmer climates; its worldwide introduction has resulted primarily because of

widespread use as an indoor/outdoor aquaria or aquatic garden plant. In the United States, parrot feather is present throughout the southern states and along both coastlines. In Washington, presence of parrot feather was first reported in 1944; parrot feather appears to be present in coastal lakes and streams, as well as the Southwest Washington portion of the Columbia River. Parrot feather is prevalent throughout the Longview/Kelso area drainage system, as well as many drainage ditches in Wahkiakum County. Able to colonize slow moving or still water, parrot feather is commonly found in freshwater lakes, ponds, streams, or canals. Parrot feather is well adapted to high nutrient environments and grows best when rooted in shallow water, although it is known to occur as a floating plant in nutrient-rich lakes. Although parrot feather provides cover for some aquatic organisms, generally it negatively alters the physical and chemical characteristics of its environment. Dense parrot feather stands alter aquatic ecosystems by shading the water column algae that previously served as the base of the aquatic food web. Further, parrot feather provides choice mosquito larvae habitat, which has created substantial problems in areas of high parrot feather occurence. Parrot feather is difficult to control; combinations of herbicides and mechanical controls (i.e. cutting or water drawdown) have produced mixed results. Further, because of its high tannin content, most grazers find parrot feather unpalatable. At present, biological control agents are not available, although research on multiple beetles and weevils show promise for parrot feather control. Additionally, fungal control options are currently under development (WDOE 2003).

Brazilian elodea, native to South America, is now distributed virtually worldwide, particularly because of its popularity as an aquarium plant. First reported in the United States in 1893 on Long Island, New York, Brazilian elodea has spread rapidly in fresh inland water throughout the U.S.; it was first reported in Washington in the early 1970s at Long Lake, Kitsap County. Brazilian elodea is distributed throughout many lakes, sloughs, and drainage ditches of western Washington, however, it has not been reported growing in eastern Washington lakes. Brazilian elodea may be rooted in water depths up to 20 feet or can be found drifting; it is adapted to both still and flowing water and thus can be found in lakes, ponds, ditches, and slow moving streams. Brazilian elodea forms dense monospecific stands that likely provide little benefit to native fish and wildlife; the dense stands restrict water movement and trap sediments, which affects water quality. Numerous methods have been effectively used to control Brazilian elodea; success of each method depends on a number of factors, much like that of Eurasian water milfoil. Thus, covering sediments with an opaque fabric works well in localized areas but not large scale control programs. Also, water level drawdown is not effective in wet climates, such as western Oregon and Washington. Numerous herbicides have effectively controlled Brazilian elodea. Additionally, a fungus that damaged Brazilian elodea in laboratory tests shows promise as a biological control. Finally, grass carp find Brazilian elodea particularly palatable and have been successfully employed as a management tool; however, use of grass carp has been limited because they are generally considered unsuitable for waterbodies where inlets and outlets cannot be screened (WDOE 2003).

Invasions of exotic cordgrasses (*Spartina alterniflora*, *S. anglica*, *S. densiflora*, and *S. patens*) have caused ecosystem changes in estuaries worldwide; each of these species are known to occur along the West coast of North America (Ayres et al. 2003). These species thrive in areas of accreting sediments, where they out-compete native vegetation (Daehler and Strong 1996). Although not known to be an immediate concern in the Columbia River estuary, *S. alterniflora* and *S. anglica* have caused significant changes in Willapa Bay, WA (Ayres et al. 2003). Cordgrasses disperse by floating seed and clonal fragments (Huiskes et al. 1995); such dispersal

has been observed in Washington where *S. alterniflora* has spread from Willapa Bay to Grays Harbor 30 km to the north (Ayres et al. 2003). Thus, significant potential exists for dispersal of these exotic cordgrasses to the Columbia River estuary.

Although not currently known to occur anywhere in the Columbia River basin, zebra mussels (*Dreissena polymorpha*) are a concern of Federal and State agencies throughout the Pacific Northwest (BPA 2002). Zebra mussels are an extremely prolific, freshwater mollusk native to the Caspian Sea (USGS 2002). In North America, they were first discovered in the Great Lakes in 1988 and have since spread to all the Great Lakes, as well as the major river systems in the Midwest (Hebert et al. 1991 as cited in USGS 2002). Introduction to the Great Lakes was likely a result of ballast water discharge; dispersal to river systems outside the Great Lakes may be a result of zebra mussels attaching to boats that are trailed from infested waters to other locations (USGS 2002). Under cool, humid conditions, zebra mussels can stay alive for several days out of water (USGS 2002), thus are capable of being transported long distances. During routine inspections at agricultural inspection stations, zebra mussels have been found attached to the hull or in the motor compartment of trailered boats crossing into California (USGS 2002). Many biological impacts of zebra mussels in North America are not yet known, primarily because many effects may still be developing (USGS 2002). However, zebra mussels have the potential to outcompete and eliminate native mussels (Nalepa 1994 and Schloesser and Nalepa 1994, as cited in USGS 2002), consume sizeable amounts of algae and increase water clarity, and alter macrophyte plant communities as a result of changes in water clarity (Skubinna et al. 1995 as cited in USGS 2002). In the Great Lakes, zebra mussels initially appear to be having little effect on fish populations, although it may be soon to determine because of their recent introduction (USGS 2002). Zebra mussels are well known for their ability and affinity to colonize and foul water supply pipes to many different types of industrial facilities; this colonization reduces effective pipe diameter and flow through these water pipes (USGS 2002). Although many methods have been used to control zebra mussels, each has varying levels of success under specific applications (USGS 2002).

2.1.6 *Knowledge Gaps*

There is an abundance of knowledge gaps in our current understanding of the physical processes of the estuary and lower mainstem and how these processes relate to the biological requirements of focal species. Faced with the challenge of recovering ESA-listed populations, recovery efforts need to progress in the face of uncertainty, recognizing our current limitations. Section 2.1.6.1 Uncertainty reminds us that there are many things we do not know regarding focal species relationships to the estuary and lower mainstem ecosystem. Section 2.1.6.2 Physical Process Models briefly describes the ongoing research efforts to increase our understanding of estuarine physical processes. Section 2.1.6.3 Current Research Needs identifies the future direction necessary to increase our understanding of the biological requirements of salmonids in relation to the estuary and lower mainstem ecosystem.

2.1.6.1 Uncertainty

Habitat requirements of non-salmonid fishes and wildlife focal species as they relate to Columbia River estuary habitat conditions and the processes that form and maintain those habitats are largely understudied. A considerable amount of information is available in the Pacific Northwest regarding habitat classification, habitat conservation, and wildlife-habitat relationships (Brown 1985, Ruggiero et al. 1991, WDNR 1996, WDNR 1998, Johnson and

O'Neil 2001), however, none of these efforts have focused specifically on the interaction of wildlife focal species and the Columbia River estuary and lower mainstem. Gaumer et al. (1985) and Buchanon et al. (2001) generally discussed the dynamics of estuary habitats and relationship of different wildlife species to this habitat; again, the relationship of wildlife focal species and the Columbia River estuary were not specifically addressed.

Throughout this qualitative analysis, there are multiple inferences regarding the expected or likely relationship between salmonids and the habitat conditions or habitat-forming processes in the Columbia River estuary or lower mainstem. Much of what we know about the effects of changing habitat conditions on salmonid habitat requirements in the estuary is based on limited estuary-specific research or is speculative based on salmon and habitat relationships in non-tidal freshwater.

The issue of uncertainty is a significant challenge; as a result, US Army Corps of Engineers organized a workshop in March 2003 to review past and ongoing research in the Columbia River estuary, identify data gaps and key future research needs, and prioritize the identified research needs related to Columbia River salmonids (R2 2003). Although this workshop focused on salmonids, it is quite likely that many of these research needs apply to all focal species included in this assessment.

The key biological relationships in which we need a clearer understanding include:

- Specific relationships between salmonid life history strategies and habitat requirements, especially for ESA-listed species.
- Juvenile salmon usage and ecology in the tidal freshwater portion of the Columbia River estuary (i.e. Puget Island [rm 46] to Bonneville Dam [rm 146]).
- Specific linkages between biological and physical processes in various estuary habitat types.
- Inventory of current size, quality, and accessibility of habitat preferred by juvenile salmonids.
- Survival rates and growth indices for various salmonid life history types and the relationship to estuary habitats.
- Food web structure and linkages to estuary habitat types.
- Habitat forming processes required to maintain habitat types utilized by salmon.
- Relationship of structural and functional ecosystem components, including the natural variability associated with each.

2.1.6.2 Physical Process Models

Considerable effort has focused on developing predictive capabilities to describe the physical processes in the Columbia River estuary and lower mainstem. Considerable knowledge has been gained through this effort, however, connection of physical process models to biological requirements of salmonids and other focal species remain largely based on professional assumptions. The programs described below are not strictly physical process models, as identified in each program's description available on the internet. Note that the LCFRB was not involved in the development of the physical process models outlined here; these models are merely presented as an introduction to our current level of understanding of physical processes within the Columbia River estuary and lower mainstem and to highlight our current inability to connect physical process models with biological processes.

2.1.6.2.1 CORIE

The CORIE program is administered through the Oregon Graduate Institute, School of Science and Engineering, which is part of the Oregon Health and Science University. The following exerpts describing the CORIE program were taken directly from the CORIE website (http://www.ccalmr.ogi.edu/CORIE/):

> *CORIE is a pilot environmental observation and forecasting system (EOFS) for the Columbia River. It integrates a real-time sensor network, a data management system and advanced numerical models. Through this integration, we seek to characterize and predict complex circulation and mixing processes in a system encompassing the lower river, the estuary and the near-ocean. The acquired knowledge is transformed into data products designed to provide objective insights on the spatial and temporal variability of the Lower Columbia River.*
>
> *As a scientific tool, CORIE is designed to advance the emerging field of environmental information systems, and the understanding of river-dominated estuaries and plumes.*
>
> *The scientific objectivity and breadth of products of CORIE also gives the region's natural resource management and regulation community powerful new planning and analysis tools to improve policies and decisions.*
>
> *Early applications of CORIE have, in particular, addressed issues combining salmon habitat and passage, hydropower management, navigation improvements and habitat restoration. These applications show that there is a role for objective science to engender consensus across agencies with conflicting mandates. They also suggest that coordinating resources of multiple users of a waterway in the development of a shared scientific infrastructure, readily adaptable to evolving needs, might be a practical way to develop affordable management tools.*
>
> *Rapidly advancing performance and declining costs of electronic and computer technology will soon make EOFS economically feasible. The experience of systems like CORIE will encourage and provide paradigms for the development of national and international networks of EOFS, to the benefit of science and society.*
>
> *The CORIE modeling system integrates models and field controls. Focus is on the simulation of 3D circulation, in a region centered in the estuary and plume, but extending from Bonneville Dam to the Eastern North Pacific.*
>
> *CORIE simulations include (a) short term forecasts, (b) actual past conditions (referred to as hindcasts), (c) characteristic climatology conditions, and (d) scenario conditions. River, atmospheric, and ocean forcings are complied, in some cases in quasi-real time, from a variety of sources.*

2.1.6.2.2 Columbia River Estuary Turbidity Maxima Research Project

The Columbia River Estuary Turbidity Maxima (CRETM) is a US National Science Foundation (NSF) Land-Margin Ecosystem Research (LMER) Project; the project is an ecosystem-scale, interdisciplinary investigation of the role of estuarine turbidity maxima (ETM) in shaping the food web of the Columbia River estuary. The following exerpt describing the CRETM program was taken directly from the CRETM website

(http://depts.washington.edu/cretmweb/CRETM.html):

Our fundamental research goal is to understand how circulation phenomena in the estuary, called estuarine turbidity maxima (ETM), trap particles and promote biogeochemical, microbial and ecological processes that sustain a dominant pathway in the estuary's food web. To study this relationship between the physics of ETM and these various processes requires a resolutely interdisciplinary approach, and a complex, highly-orchestrated suite of field and laboratory measurements and experiments. The CRETM-LMER team involves scientists from six distinct disciplines-geophysics, sedimentology, geochemistry, microbiology, primary production biology, and zooplankton and food web ecology-to characterize ETM process. But, we depend upon hydrodynamic and ecosystem process modelers to help us synthesize our understanding about how the ETM and associated estuarine processes act as a "living" system that is fundamental to the way the estuary behaves.

2.1.6.3 Current Research Needs

A research, monitoring, and evaluation (RME) plan for the Columbia River estuary and plume was recently developed (Johnson et al. 2003a) for the purpose of fulfilling certain requirements of Reasonable and Prudent Alternatives 160, 161, and 163 of the 2000 Biological Opinion on the Operation of the Federal Columbia River Power System (NMFS 2000c). The three primary goals of this RME plan are: 1) Status Monitoring – quantify status/trends in listed salmonid usage/survival in the Columbia River estuary and plume, 2) Action Effectiveness – quantify effects of habitat restoration efforts on listed salmonids in the Columbia River estuary and plume, and 3) Uncertainties – resolve uncertainties regarding salmonid recovery efforts in the Columbia River estuary and plume (Johnson et al. 2003a). To the extent possible, future development of an RME plan for the lower Columbia River and estuary by the LCFRB should attempt to be consistent with and not duplicate the work of Johnson et al. (2003a).

During the recent lower Columbia River and estuary research needs workshop (R2 2003), research needs were categorized by priority and expected time needed for completion. Note that the LCFRB was not involved in the development of the research needs presented here, but we are simply presenting the findings of the collaborative workshop. Although this workshop focused on salmonids, it is quite likely that many of these research needs apply to all focal species included in this assessment. Four categories of research were identified: high priority/immediate, high priority/10-year window, high priority/long term, and medium priority. The following research topics were taken directly from the workshop proceedings report (R2 2003):

High priority research needs that could be addressed now include:

- *Move from a collection of available conceptual frameworks to an integrative implementation framework, where we combine what we have learned in the various conceptual frameworks to identify the most important areas for restoration actions, and what are the most likely avenues for success.*

- *Implement selected restoration projects as experiments, so that we can learn as we go.*

- *Implement pre- and post-restoration project monitoring programs, to increase the learning.*

- *"Mining" of existing, underutilized data to minimize the risk of collecting redundant or unnecessary data, and to compare with current and projected conditions.*

- *Make more use of ongoing PIT tagging and other tagging and marking studies and data to determine origin and estuarine habitat use patterns of different stocks.*

- *Collect additional shallow water bathymetry data for refining the hydrodynamic modeling, and identifying/evaluating potential opportunities for specific restoration projects.*

- *Determine operational and hydrologic constraints for the FCRPS, so that we have a better understanding of feasibility and effectiveness of modifying operations.*

- *Identify and implement off-site mitigation projects in CRE tributaries.*

- *Establish a data and information sharing network so that all researchers have ready and up-to-date access.*

- *Increased genetic research to identify genotypic variations in habitat use.*

High priority research needs that appear to be feasible within the present 10-year window of opportunity, but may not be implemented immediately or lead directly to projects in the near term include:

- *Understanding salmonid estuarine ecology, including food web dynamics.*

- *Understanding sediment transport and deposition processes in the estuary.*

- *Understanding juvenile and adult migration patterns.*

- *Identifying restoration approaches for wetlands and developing means for predicting their future state after project implementation.*

The following items were identified as high priority, but are considered long-term efforts (i.e. will likely take the longest to complete before a tangible product is developed):

- *Improve our understanding of the linkages between physical and biological processes to the point that we can predict changes in survival and production in response to selected restoration measures.*

- *Improve our understanding of the effect of toxic contaminants on salmonid fitness and survival in the CRE and ocean.*

- *Improve our understanding of the effect of invasive species on restoration projects and salmon and of the feasibility to eradicate or control them.*

- *Improve our understanding of the role between micro- and macro-detrital inputs, transport, and end-points.*

- *Improve our understanding of the biological meaning and significance of the Estuarine Turbidity Maximum relative to restoration actions.*

- *Identify end-points where FCRPS BO RPA action items are individually and collectively considered to be satisfied, so that the regulatory impetus is withdrawn.*

The following research needs were identified as medium priority (i.e. they may provide additional insights, but we currently have a reasonable idea of the most important features based on preceding work):

- *Increasing our understanding of how historical changes in the estuary morphology and hydrology have affected habitat availability and processes.*

2.1.7 *Hypothesis Statements*

The ultimate goal of this subbasin assessment is to assemble the technical information necessary to develop biological objectives for the Columbia Estuary and Lower Columbia Subbasins. The subbasin assessment concludes with the develop a working hypothesis that establishes the basis for the future management plan. The NPPC defines the working hypothesis as follows:

> *The working hypothesis is a collection of component hypotheses – a set of key assumptions that are based on assessment data and analysis. The overall working hypothesis describes a scientific understanding of the subbasin and contains the key assumptions relating to species-habitat relationships and/or the effectiveness of strategies to modify the elements of the environment. A working hypothesis summarizes a scientifically based understanding of the subbasin at the time the management plan is developed and begins to bridge the gap between the science and strategies. By developing a working hypothesis, you will have an explicit scientific rationale to considering alternative biological objectives and strategies. It will be used to evaluate and derive biological objectives and strategies in relation to the subbasin vision. Finally, the working hypothesis provides the elements necessary for scientific review of the subbasin plan by the Council and the Independent Scientific Advisory Board.*

The NPPC suggests that the working hypothesis is best developed around a scientific model such as Ecosystem Diagnosis and Treatment (EDT; NPPC 2001); however, EDT, or other similar models have not been parameterized for the estuary or lower mainstem. Therefore, in this assessment, hypotheses were developed based on scientific evidence and professional judgement. The hypothesis statements collectively represent our current understanding of the primary issues in the estuary and lower mainstem. Because the hypotheses are supposed to serve as the foundation of the management plan and directly link to biological objectives, in some cases the hypothesis statements needed to make a quantum leap to bridge the gap between our current level of understanding and the desired conditions in the subbasins.

As part of the implementation process of the subbasin plan, the working hypothesis will be tested and refined through research, monitoring, and evaluation. It is vital that subbasin planners reach an agreement on the working hypothesis, or set of alternative hypotheses, in order to develop the management plan. The following series of component hypothesis statements are intended to collectively serve as the NPPC 'working hypothesis' for the Columbia Estuary and Lower Columbia Subbasins based on the currently available scientific information. Note that the hypothesis statements do not take the classic form of a scientific hypothesis (i.e. if…then); they are formulated to address the NPPC hypothesis definition.

Hypothesis Statement 1 – Complex and dynamic interactions between physical river and oceanographic processes, as modulated by climate and human activities, affect the general features of fish and wildlife habitat in the Columbia River estuary and lower mainstem.

Habitat formation in the lower Columbia River mainstem and estuary is controlled by opposing hydrologic forces: ocean processes (tides) and river processes (discharge). These

processes may be disturbed by storms, extreme hydrologic events, or catastrophic events such as earthquakes or volcano eruptions. Tides introduce marine-derived sediments to the estuary while river discharge carries freshwater sediments via bedload and suspended sediment. This supply of sediments influences the bathymetry of the estuary through the processes of erosion and accretion. Suspended sediment, along with the production of organic matter, determine the degree of water turbidity. The opposing processes of estuary outflow (river discharge) and inflow (tides) determine the salinity gradient and the type and location of available nutrients. River discharge also directly affects the level of woody debris recruitment to the estuary. Finally, the main components of the habitat formation process (bathymetry, water turbidity, salinity, nutrients, and woody debris) determine the location and type of habitats that form and persist throughout the estuary and lower mainstem.

As described in section 2.1.6.2, numerous on-going research projects are focused on describing the physical processes within the Columbia River estuary. For example, the CORIE program is an environmental observation and forecasting system for the Columbia River that seeks to characterize and predict complex circulation and mixing processes in the ecosystem encompassing the lower river, the estuary, and the near-ocean. Another project (CRETM) has focused its research efforts on understanding how circulation processes in the Columbia River estuary trap particles and promote biogeochemical, microbial, and ecological processes that comprise a dominant pathway in the estuarine food web.

Tide cycles (magnitude and periodicity) are natural processes that are partially influenced by storms and wind action but are largely beyond the dominion of human actions. However, the effects of tide cycles and tidal action have been altered by human intervention. For example, construction of the north and south jetties at the mouth of the Columbia River has decreased wave action in the lower river and has altered the hydrologic regime at the river/ocean interface; the result has been varying patterns of erosion and accretion compared to historical conditions.

River discharge is affected by precipitation, temperature, and water regulation/withdrawals. Sherwood et al. (1990) [as cited in Bottom et al. 2001] estimated that the 40% decrease in maximum spring freshet flow compared to historical conditions is because of water regulation (75%), irrigation withdrawal (20%), and climate change (5%). Changes in river discharge has decreased the freshwater-derived sediment supply and woody debris as well as altered the salinity gradient and nutrient distribution throughout the estuary (Sherwood et al. 1990 as cited in Williams et al. 2000, Bottom et al. 2001, USACE 2001). Artificial channel confinement has altered river discharge and hydrology, as well as disconnected the river from much of its floodplain, thereby eliminating much of the woody debris supply. Additionally, channel manipulations for transportation or development have also had substantial influence on river discharge and hydrologic processes in the river.

Evaluation of anthropogenic factors is complicated by climate effects. Variations in Columbia River discharge as a result of climate effects occur in time scales from years to centuries (Chatters and Hoover 1986, 1992 as cited in Bottom et al. 2001). The Columbia Basin's climate response to climatic cycles is governed by the basin's latitudinal position; climate in the region displays a strong response to both the PDO and ENSO cycles (Mantua et al. 1997 as cited in Bottom et al. 2001). The El Niño weather pattern produces warm ocean temperatures and warm, dry conditions throughout the Pacific Northwest. The La Niña weather pattern is typified by cool ocean temperatures and cool/wet weather patterns on land. Climate directly affects river flow and observed changes to flow are often substantial. Further, El Niño

patterns result in poor ocean productivity in the Pacific Northwest and California, as was observed in the mid 1990s. The effects of poor estuary and mainstem habitats are exaggerated during periods of low ocean productivity.

Current climate projections predict gradual warming of the region, potentially with higher precipitation, particularly in winter (Hamlet and Lettenmaier 1999). The predicted future climate conditions will possibly reduce the likelihood of spring freshets caused by heavy spring rain on late snowpack because warmer temperatures will not allow the accumulation of snow late into the spring. This freshet style (rain on snow) has historically produced the most substantial increases in river discharge (Bottom et al. 2001). However, despite our ability to measure changes in climate, Bottom et al. (2001) discussed the difficulty in separating climate versus anthropogenic effects on river discharge and the habitat-forming processes it governs.

Hypothesis Statement 2 – Human activities have altered how the natural processes interact, changing habitat conditions for fish and wildlife in the Columbia River estuary and lower mainstem.

Anthropogenic factors have substantially influenced the current habitat conditions in the lower Columbia River mainstem and estuary. The primary anthropogenic factors that have determined estuary and lower mainstem habitat conditions include hydrosystem construction and operation (i.e. water regulation), channel confinement (primarily diking), channel manipulation (primarily dredging), and floodplain development and water withdrawal for urbanization and agriculture. Generally, these anthropogenic factors have influenced estuary and lower mainstem habitat conditions by altering hydrologic conditions, sediment transport mechanisms, and/or salinity and nutrient circulation processes. Often, there are no simple connections between a single factor and a single response, as many of the factors and responses are interrelated.

Flow effects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuarine habitats and have resulted in changes to estuarine circulation, deposition of sediments, and biological processes (ISAB 2000, Bottom et al. 2001, USACE 2001, Johnson et al. 2003b). Flow regulation in the Columbia River basin has been a major contributor to the changes that have occurred in the estuary from historical conditions. The predevelopment flow cycle of the Columbia River has been modified by hydropower water regulation and irrigation withdrawal (Thomas 1983, Sherwood et al. 1990 as cited in Nez Perce et al. 1995, Weitkamp 1994, NMFS 2000c, Williams et al. 2000, Bottom et al. 2001, USACE 2001).

Flow regulation in the Columbia has decreased spring freshet magnitude and increased flows over the rest of the year as a result of winter drawdown of reservoirs and filling of the reservoirs during the spring runoff season. The historical flow records at The Dalles, Oregon, Bonneville Dam, and Beaver, Oregon, demonstrate that spring freshet flows have been reduced by about 50% and winter flows have increased about 30% (Figure 2-13, Figure 2-14, and Figure 2-15, respectively). Most of the spring freshet flow reduction is attributed to flow reduction, about 20% is a result of irrigation withdrawals, and only a small portion (5%) is connected to climatic change (Bottom et al. 2001).

Reduction of maximum flow levels, dredged material deposition, and diking measures have all but eliminated overbank flows in the Columbia River (Bottom et al. 2001), resulting in reduced large woody debris recruitment and riverine sediment transport to the estuary. Overbank flows were historically a vital source of new habitats. Moreover, historical springtime overbank

flows greatly increased habitat opportunity into areas that at other times are forested swamps or other seasonal wetlands. Historical bankfull flow levels were common prior to 1975 but are rare today; current bankfull flows have only been exceeded four times since 1948 (Figure 2-16). Further, the season when overbank flow is most likely to occur today has shifted from spring to winter, as western subbasin winter floods (not interior subbasin spring freshets) are now the major source of peak flows (Bottom et al. 2001, Jay and Naik 2002).

Thomas (1983) suggested that channel confinement (i.e. diking) is particularly detrimental to estuary habitat capacity because it entirely removes habitat from the estuarine system, while other anthropogenic factors change estuary habitats from one type to another. The lower mainstem and estuary habitat in the Columbia River has, for the most part, been reduced to a single channel where floodplains have been reduced in size, off-channel habitat has been lost or disconnected from the main channel, and the amount of large woody debris has been reduced (NMFS 2000c). Dikes prevent over-bank flow and affect the connectivity of the river and floodplain (Tetra Tech 1996); thus, the diked floodplain is higher than the historical floodplain and inundation of floodplain habitats only occurs during times of extremely high river discharge (Kukulka and Jay 2003). It is estimated that the historical estuary had 75 percent more tidal swamps than the current estuary because tidal and flood waters could reach floodplain areas that are now diked or otherwise disconnected from the main channel (USACE 2001, Johnson et al. 2003b).

Development and maintenance of the shipping channel has greatly affected the morphology of the estuary. The extensive use of jetties and pile dikes to maintain the shipping channel has impacted natural flow patterns and large volumes of sediments are dredged annually. Dredged materials are disposed of in-water (in the ocean or in the flow adjacent to the shipping channel), along shorelines, or on upland sites. Dredge disposal in upland or deepwater sites reduces the amount of sediment available for habitat formation in the estuary as well as sediments that supply shoreline areas in the Columbia River littoral cell. Annual maintenance dredging since 1976 has averaged 3.5 million cubic yards per year in the estuary. By concentrating flow in one deeper main channel, the development of the navigation channel has reduced flow to side channels and peripheral bays.

Sediments in the estuary may be marine or freshwater derived; sediments are transported via sediment suspended in the water column or bed load movement. Riverine sediments available for transport has decreased as a result of dam construction: reservoirs restrict bedload movement and trap upstream supply of sediments. Sand sediments are vital to natural habitat formation and maintenance in the estuary; dredging and disposal of sand and gravel have been one of the major causes of estuarine habitat loss over the last century (Bottom et al. 2001). Conversely, the USACE (2002) suggests that sediment deposition conditions exist in the estuary, particularly shoaling in the navigation channel and deposition/accumulation of sand in low energy areas in the estuary and along the coast. Shoaling in the navigation channel is a redistribution of bed sediments, rather than an accumulation of sediments, because it does not change the volume of bed material within a given reach (USACE 2002).

Sediment transport is non-linearly related to flow; thus, it is difficult to accurately apportion causes of sediment transport reductions into climate change, water withdrawal, or flow regulation (Jay and Naik 2002). However, the largest single factor in reduced sediment transport appears to be the reduction of spring freshet flow as a result of water regulation and irrigation withdrawal. Recent analyses indicate a two-thirds reduction in sediment-transport capacity of the

Columbia River relative to the pre-dam period (Sherwood et al. 1990, Gelfenbaum et al. 1999). Therefore, flow reductions affect estuary habitat formation and maintenance by reducing sediment transport (Bottom et al. 2001, USACE 2001). The reduction in sand and gravel transport has been higher (>70% reduction compared to predevelopment flow) than for silt and clay transport (Bottom et al. 2001), which has important implications for habitat formation and food web dynamics.

Construction of the north and south jetties significantly increased sediment accretion in marine littoral areas near the mouth of the Columbia River. Ocean currents that formerly transported Columbia River sediments along the marine littoral areas were disrupted as a result of jetty construction. Accretion, particularly in areas adjacent to the river mouth (i.e. Long Beach, Clatsop Spit), increased significantly in the late 1800s and early 1900s. Sediment accumulation rates have slowed since 1950, potentially as a result of reduced sediment supply from adjacent deltas or the Columbia River (Kaminsky et al. 1999). Because of the decreased sediment supply from the Columbia River and ebb-tidal deltas, recent modeling results indicate that the shorelines immediately north of the historical sediment source areas at the entrance to the Columbia River are susceptible to erosion in the future (Kaminsky et al. 2000).

River discharge, tidal processes, and channel depth determine the salinity gradient and the type and location of available nutrients. Altered estuary bathymetry and flow have affected the extent and pattern of salinity intrusions into the Columbia River; stratification has increased and mixing has decreased (Sherwood et al. 1990 as cited in Williams et al. 2000). The dependence of salinity intrusion on channel depth is strong; the controlling channel depth has doubled over the last 120 years. Bathymetric changes have likely caused the greatest changes in salinity intrusion and stratification, but reduced spring freshet flows have also substantially altered salinity intrusion length (Bottom et al. 2001). The combination of tidal energy and river discharge determine the location, size, shape, and salinity gradients of the Columbia River ETM; the organic matter accumulation and cycling associated with the ETM is especially important in the current imported microdetritus-based food web.

Industrial development in the lower Columbia River has resulted in pollutants accumulating in the estuary habitats; in general, contaminants affect survival by increasing stress, predisposing fish to disease, and interrupting physiological processes. Accumulation of contaminants in the lower mainstem and estuary have been exacerbated by tributary water quality problems (NMFS 2000c) and reduced peak and sustained flood flows in the lower river (Sherwood et al. 1990 as cited in Nez Perce et al. 1996). In the lower 150 miles of the mainstem Columbia River, many contaminants have been detected above guidance or regulatory levels for fish tissue, sediment, and water (Nez Perce et al. 1995, Tetra Tech 1996). However, two of the more widely known contaminants, DDT and PCBs, were much more prevalent in the lower Columbia River in the 1960s and early 1970s than they are today; their concentrations have continued to decline since 1972, when the use of DDT was banned (USACE 2001).

The degree to which habitat forming processes and anthropogenic factors determine the present day abundance of different habitat types depends on the habitat type and the processes by which they are formed. Further, total change in habitat acreage represents the sum of habitat loss and habitat formation throughout the estuary. Thus, the significance of loss of certain habitat types has been partially masked by the formation of these habitats elsewhere. Further, the geographic movement of estuary habitats is not clear from the quantification of total acreage change. For example, the total acreage of a certain habitat type within a particular estuary area

may not have changed considerably from historical to current conditions, however, the location of this habitat type within the estuary area may be completely different.

Thomas (1983) documented substantial changes to estuary habitats from historical to current condtions as summarized below. Estuary-wide tidal marsh and tidal swamp acreage has decreased 43% and 77%, respectively, from 1870 to 1983 (Table 2-5), primarily as a result of dikes and levees that have disconnected the main channel from these floodplain habitats and also from water regulation that has decreased historical peak flows that previously provided water to these habitats. Losses of tidal marsh habitat has been most extensive in Youngs Bay, where a loss of over 6,000 acres was observed (Table 2-5). Extensive tidal swamp habitat losses have been observed in all estuary areas that this habitat was historically present (Table 2-5). Losses of medium and deep water habitat acreage have been less severe (25% and 7%, respectively; Table 2-5). Acreage of medium depth water habitat was lost in all areas of the estuary except the upper estuary, where a slight increase in acreage was observed; acreage loss was highest in the entrance, Cathlamet Bay, and Baker Bay areas of the estuary (Table 2-5). Similarly, deep water habitat acreage was lost in most areas of the estuary; losses were highest in the Baker Bay and upper estuary areas (Table 2-5). Meanwhile, approximately 1,700 acres of deep water habitat were added to the entrance area of the estuary (Table 2-5). The only estuary habitat type that realized a net increase in acreage from 1870 to 1983 was shallows/flats habitat (10%; Table 2-5). This increase in acreage was primarily a result of water regulation that has decreased historical peak flows that often eroded tidal flat habitats and also from decreased wave action and erosion after construction of the jetties at the mouth of the river. A substantial loss of shallows/flats habitat was observed in entrance area of the estuary; much of this habitat was converted to medium or deep water habitat. In total, 36,970 acres (23.7%) of the estuarine habitat acreage has been lost from 1870 to 1983. During this period, lost estuarine habitats were converted to the following non-estuarine habitats: developed floodplain (23,950 acres), natural and filled uplands (5,660 acres), non-estuarine swamp (3,320 acres), non-estuarine marsh (3,130 acres), and non-estuarine water (910 acres; Table 2-10).

Hypothesis Statement 3 – Although rates of obvious physical habitat change in the Columbia River estuary and lower mainstem have slowed in recent years, current physical and biological processes are likely still changing such that current habitat conditions represent a degraded state.

It is likely that the trends in wetland habitat loss have slowed in recent years; partially because much of the available habitat has already been removed and partially because current day development is highly scrutinized for potential effects on ESA-listed species and their habitats. Further, some restoration efforts are specifically focused on restoring or preserving tidal wetlands and other key salmon habitats, thus, the potential exists for reversing the habitat loss trend for this habitat type. Conversely, current water regulation practices continue to encourage the habitat-forming processes responsible for the 10% increase in tidal flat habitat.

Garono et al. (2003a) described the Columbia River estuary as “a shifting mosaic of land cover types”. Although Garono et al. (2003a) observed considerable movement from one habitat cover class to another from 1992 to 2000, specific wetland habitats were generally categorized as other wetland habitats while specific upland habitat classes remained within the general upland class (i.e. wetlands remained wetlands and uplands remained uplands, although dominant vegetation or other distinguishing characteristic may have changed). Further, Garono et al. (2003a) indicated that some of the observed habitat changes from 1992 to 2000 were likely a

result of differences in mapping accuracy or were consistent with successional transition. Thus, most habitat changes in recent years can be characterized as an alteration of one wetland habitat type to another as opposed to the complete loss of wetland habitats that were observed historically.

The habitat alterations that have occurred since pre-development times have degraded the quality and quantity of habitat in the estuary and lower mainstem. Because this historical trend in habitat loss appears to have slowed recently, the estuary and lower mainstem habitat conditions are in a degraded state of equilibrium. This emphasizes the urgency of the current need to implement habitat restoration actions to reverse the trend of habitat loss.

Hypothesis Statement 4 – Our current understanding of the interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem is not robust and does not offer sufficient resolution to allow managers to make informed decisions to benefit recovery and sustainability of natural resources.

Habitat requirements of non-salmonid fishes and wildlife focal species as they specifically relate to Columbia River estuary and lower mainstem habitat conditions and the processes that form and maintain those habitats are largely understudied. For example, Buchanon et al. (2001) generally discussed the dynamics of estuary habitats and relationship of different wildlife species to this habitat, however, this work was not specific to the Columbia River estuary.

Our current understanding of causal relationships between salmonids and the habitat conditions or habitat-forming processes in the Columbia River estuary or lower mainstem are only slightly clearer than that of wildlife or non-salmonid fishes. Much of what we know about the effects of changing habitat conditions on salmonid habitat requirements in the estuary is based on limited estuary-specific research or is speculative based on known salmon and habitat relationships in non-tidal freshwater. For example, researchers have developed considerable predictive capabilities to describe the physical processes in the Columbia River estuary and lower mainstem through projects such as CORIE or CRETM (section 2.1.6.2), however, connection of physical process models to biological requirements of salmonids and other focal species remain largely based on professional assumptions.

To address the issue of uncertainty, a scientific workshop was convened in March 2003 to review past and ongoing research in the Columbia River estuary, identify data gaps and key future research needs, and prioritize the identified research needs related to Columbia River salmonids (R2 2003). Although this workshop focused on salmonids, it is quite likely that many of these research needs apply to all focal species included in this assessment. Specific research needs that have repeatedly been identified include the need for: linkages of physical process models with biological processes, clearer understanding of sediment transport, hydrology, and bathymetry, connectivity of estuary habitats, connectivity of research efforts, and collaboration among researchers.

In summary, continued research is vital to the progress and success of restoration and recovery efforts in the Columbia River estuary and lower mainstem. Research and monitoring can provide a clearer understanding of the relationships between biological and physical processes in the estuary and lower mainstem; it also serves as a tool for evaluating and

recalibrating implemented restoration and recovery actions. However, there is a limit to our ability to understand certain complex biological interactions as discussed below.

Hypothesis Statement 5 – Exotic species are capitalizing on the Columbia River estuary and lower mainstem habitats and they have impacted ecosystem processes and relationships.

The increasing predominance of exotic species in species assemblages indicates major changes in aquatic ecosystems (OTS 1993, Cohen and Carlton 1995, Smith 2001 as cited in Waldeck et al. 2003). Globally, there is an increasing rate of aquatic non-indigenous species introductions; this increase has been attributed to the increased speed and range of world trade, which facilitates the volume, variety, and survival of intentionally or unintentionally transported species. This observation appears to hold true in the Columbia River where fish introductions in the lower Columbia River increased in a linear fashion in the 1900s while non-indigenous invertebrate introductions seem to be increasing exponentially (Waldeck et al. 2003). The nature of exotic species introductions in the lower Columbia River are changing from the historical intentional introduction of game or food fish species to the unintentional introduction of species that have unknown or negative impacts on the ecosystem (Draheim et al. 2002). Future prevention of exotic species introductions is vital to maintaining the current balance of ecological relationships in the Columbia River estuary and lower mainstem.

The current biotic community in the Columbia River estuary and lower mainstem is fundamentally different today than it was historically because of the introduction of exotic species. All exotic species introductions in the lower Columbia River represent permanent alterations of the biological integrity of the ecosystem for numerous reasons: impacts of introduced species are unpredictable, introduced species alter food web dynamics, and introduced species are a conduit for diseases and parasites (Waldeck et al. 2003). Although the list of known exotic species in the lower Columbia River is currently greater than 70 (Draheim et al. 2002), limited information is available regarding the ecological interactions of many of these species.

Altered habitats in the Columbia River estuary and lower mainstem ecosystem as a result of hydrosystem development and water regulation have facilitated the successful establishment of aquatic non-indigenous species (Cordell et al. 1992 as cited in Draheim et al. 2002, Weitkamp 1994). The lower Columbia River ecosystem may still be adjusting to these major flow alterations and this adjustment period may benefit aquatic non-indigenous species (Weitkamp 1994).

There are many opposing philosophies regarding the control and/or eradication of exotic species based on differing political or social values. For example, some believe that introduced game fish should be removed from the Columbia River to restore the historical fish species assemblage, while others believe that introduced game fish should be protected and enhanced to ensure future social and economic benefits from recreational fisheries. Regardless of differing social values, there is often little that can be done to eradicate exotic species once a population has been established. The greatest success for removing exotic species occurs if the species is detected shortly after introduction and a population has not yet become established. Otherwise, the most we can generally expect from exotic species control efforts is to maintain the current community structure, attempt to limit the current abundance levels of exotic species, and diligently establish controls to prevent future exotic species introductions.

Hypothesis Statement 6 – Of all native fish and wildlife species utilizing the Columbia River estuary and lower mainstem habitat, salmonids appear the most distressed.

Despite substantial changes to the Columbia River estuary and lower mainstem ecosystem, many species have stable or increasing abundance trends. Some of these species may be considered a conservation concern as outlined in the body of this chapter. Regardless of their current abundance trend, implementation of an ecosystem-based approach to recovery of ESA-listed species indicates that an evaluation of effects of each recovery action on these species is warranted. The status and abundance trends of these species in the Columbia River estuary and lower mainstem is summarized below:

- The lower Columbian White sturgeon population is among the largest and most productive in the world. The deep water habitats in which sturgeon are commonly associated remain available throughout the lower mainstem and estuary. Hydrosystem development and operation has artificially created what functionally amounts to white sturgeon spawning channels downstream from Bonneville Dam, resulting in reliable annual recruitment (L. Beckman USGS (retired), G. McCabe Jr. NMFS (retired), M. Parsley, USGS, Cook Washington. personal communication). Further, sturgeon have demonstrated substantial variability in feeding locations; white sturgeon have potentially benefited from changes to the estuarine food web.
- NOAA Fisheries completed a status review for green sturgeon in 2003 and determined that listing under the Endangered Species Act was not warranted. Green sturgeon spend most of their life in near-shore marine and estuarine waters from Mexico to southeast Alaska (Houston 1988; Moyle et al. 1995). While green sturgeon do not spawn in the Columbia Basin, significant populations of subadults and adults are present in the estuary during summer and early fall. Green sturgeon are occasionally observed as far upriver as Bonneville Dam. These fish may be seeking warmer summer river waters in the northern part of their range.
- The northern pikeminnow population has flourished with habitat changes in the mainstem Columbia River and its tributaries. The highest density of northern pikeminnow in the mainstem Columbia River below the Snake River confluence is found in the lower mainstem from The Dalles to the estuary. A pikeminnow management program has been implemented in the Columbia and Snake rivers in an attempt to reduce predation mortality of juvenile salmonids by reducing numbers of the large, old pikeminnow that account for most of the losses. A bounty fishery program for recreational anglers is aimed at balancing pikeminnow numbers rather than eliminating the species and has also stimulated development of a popular fishery.
- Eulachon numbers and run patterns can be quite variable; low runs during the 1990's were a source of considerable concern by fishery agencies. Current patterns show a substantial increase in run size compared to the 1990's. The low returns in the 1990's are suspected to be primarily a result of low ocean productivity. Eulachon support a popular sport and commercial dip net fishery in the tributaries, as well as a commercial gillnet fishery in the Columbia. They are used for food and are also favored as sturgeon bait. Nevertheless, hydropower development on the Columbia River has decreased the available spawning habitat for eulachon. Prior to the completion of Bonneville Dam, eulachon were reported as far upstream as Hood River, Oregon (Smith and Saalfeld 1955). Additionally, dredging has

the potential to impact adult and juvenile eulachon (Larson and Moehl 1990); dredging operations in the lower Columbia River have made local substrate too unstable for the incubation of eulachon eggs. Thus, future dredging operations should be scheduled to avoid eulachon spawning areas during peak spawning times (Romano et al. 2002).

- Field observations and trapper data indicate the river otter population abundance in the lower Columbia River mainstem and estuary was relatively low in the early 1980s (Howerton et al. 1984); low abundance may be the normal equilibrium level for river otters in this region. River otters are concentrated in shallow water tidal sloughs and creeks associated with willow-dogwood and Sitka spruce habitats located primarily in the Cathlamet Bay area. Although dikes throughout the estuary have disconnected substantial amounts of side channel and floodplain habitats from the mainstem, the Cathlamet Bay area remains as one of the most intact and productive tidal marsh and swamp habitat throughout the entire estuary. Further, because river otters are capable of traveling over land, it is not understood how the loss of habitat connectivity of side channel and floodplain habitat has affected species' behaviors such as foraging, resting, mating, and rearing. Contaminants in river otter tissue may have adverse physiological effects, however, data suggests that the effects may be temporary (Tetra Tech 1996).
- Habitat conversion, losses, and isolation coupled with the low productivity of the population are the currently the most important threats to Columbian White-tailed deer population viability. Nevertheless, the Columbian White-tailed deer population appears stable at low numbers and shows initial indicators of increasing abundance and productivity. In 1999, the USFWS proposed to delist the Columbian White-tailed deer throughout the entire range, however, public concern over delisting motivated USFWS to withdraw the delisting proposal. Columbian White-tailed deer are present in low-lying mainland areas and islands in the Columbia River upper estuary and along the river corridor. They are most closely associated with Westside oak/dry Douglas fir forest within 200m of a stream or river; acreage of this habitat type has decreased substantially from historical to current conditions. Restoration of contiguous preferred habitat is vital to population recovery.
- The Caspian tern breeding population in the estuary has increased significantly from historical to current conditions as a result of the formation of mid-channel islands, primarily from dredge spoil disposal. The largest breeding colony of Caspian terns in North America is currently located in the Columbia River estuary, a location where terns historically did not breed. Terns are a conservation concern because very few breeding colonies exist; thus, terns are susceptible to catastrophic events, disease, or other factors that may affect terns during the breeding season.
- The Washington and Oregon bald eagle populations were included for federal listing as endangered under the Endangered Species Act in 1978. In 1994, the USFWS proposed to reclassify the bald eagle from endangered to threatened throughout its range; this reclassification was finalized in 1995. In 1999, the USFWS proposed to delist the bald eagle throughout its range, however, this delisting has not been finalized. Bald eagle population in the Columbia River estuary and lower mainstem have suffered from low reproductive success because of contaminants in the ecosystem that have caused eggshell thinning. Despite this, the population has been slowly increasing, presumably as a result of adult recruitment from adjacent populations. Bald eagles are strongly associated with large trees during nesting, perching, and roosting; thus, the loss of mature forest habitats in the

Columbia River estuary and lower mainstem has likely decreased the acreage of potential eagle territories.

- The osprey population along the lower Columbia River mainstem has increased slightly in recent years. Although forest habitats used for nesting have likely decreased, osprey have adapted to nesting on man-made structures. Contaminant levels in osprey tissue are high enough to result in decreased egg thickness, however, the increasing population in recent years suggests that young production is not a limiting factor.
- The lower Columbia River mainstem and estuary is not a historical breeding or overwintering area for sandhill cranes. Sandhill cranes currently do not breed in the area, but agricultural development throughout the lower Columbia River floodplain has attracted overwintering sandhill cranes. All cranes observed wintering at Ridgefield NWR and Sauvie Island Wildlife Area, Oregon, in late November 2001 and February 2002 were Canadian sandhills, and based on observations of marked birds, wintering cranes regularly move back and forth between these areas (Ivey et al. in prep.). Though not known to be a historical wintering area, an average of few hundred, but up to 1,000 cranes have wintered in the area during the last seven or eight years (J. Engler, personal communication). Reclamation of agricultural land for habitat restoration projects may discourage overwintering by sandhill cranes, although future development of herbaceous wetlands may provide adequate winter habitat for sandhill cranes currently using the region.
- Within Washington, yellow warblers are apparently secure and are not of conservation concern; likewise, the red-eyed vireo is common, more widespread in northeastern and southeastern Washington, and not a conservation concern. The yellow warbler and red-eyed vireo are both riparian obligate species; warblers prefer shrub-dominated habitats and vireos prefer dense, closed canopy forests. Habitat alterations along the lower Columbia River corridor have likely been more damaging to the possible presence of red-eyed vireos as opposed to yellow warblers because dense riparian forests along the lower Columbia River are likely less abundant than shrub-dominated wetland habitat. However, there are no data to compared historical and current breeding populations in the Columbia River estuary and lower mainstem.
- The only non-salmonid focal species population currently experiencing a decreasing trend is that of Pacific lamprey. However, Pacific lamprey life history suggests that survival and production through the estuary has principally been unaffected by changing habitat conditions. For example, juvenile lamprey feeding during the outmigration is thought to be limited. The sand and silt substrates important to juvenile survival remain available. The estuary may provide juvenile lamprey with cues that facilitate successful adult return migrations, as has been observed in salmonids. Adults are expected to use the estuary and mainstem primarily as a migration corridor. The Columbia River estuary and lower mainstem altered habitat conditions is not expected to be the primary factor in declining Pacific lamprey populations.

Hypothesis Statement 7 – The Columbia River estuary and lower mainstem ecosystem is critical to expression of salmon life history diversity and spatial structure which support population resilience and production.

Estuaries have important impacts on juvenile salmonid survival. Estuaries provide juvenile salmonids an opportunity to achieve the critical growth necessary to survive in the

ocean (Neilson and Geen 1986, Wissmar and Simenstad 1988 as cited in Nez Perce et al. 1995, Aitkin 1998 as cited in USACE 2001). Juvenile chinook salmon growth in estuaries is often superior to river-based growth (Rich 1920a, Reimers 1971, Schluchter and Lichatowich 1977). Estuarine habitats provide young salmonids with a productive feeding area, free of marine predators, where smolts can undergo physiological changes necessary to acclimate to the saltwater environment.

Juxtaposition of high-energy areas with ample food availability and sufficient refuge habitat is a key habitat structure necessary for high salmonid production in the estuary. In particular, tidal marsh habitats, tidal creeks and associated complex dendritic channel networks may be especially important to subyearlings as areas of both high insect prey density, and as potential refuge from predators afforded by sinuous channels, overhanging vegetation and undercut banks (McIvor and Odum 1988). Furthermore, areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids (Simenstad et al. *in press* as cited in Bottom et al. 2001). For example, as subyearlings grow, they move across a spectrum of salinities, depths, and water velocities. For species like chum and ocean type chinook salmon that rear in the estuary for extended time periods, a broad range of habitat types in the proper proximities to one another may be necessary to satisfy feeding and refuge requirements within each salinity zone. Additionally, the connectedness of these habitats likely determines whether juvenile salmonids are able to access the full spectrum of habitats they require (Bottom et al. 1998).

Juvenile salmonids must continually adjust their habitat distribution in relation to twice-daily tidal fluctuations as well as seasonal and anthropogenic variations in river flow. Juveniles have been observed to move from low-tide refuge areas in deeper channels to salt marsh habitats at high tide and back again (Healey 1982). These patterns of movement reinforce the belief that access to suitable low-tide refuge near marsh habitat is an important factor in production and survival of salmonid juveniles in the Columbia River estuary.

The importance of proximate availability of feeding and refuge areas may hold true even for species that move more quickly through the estuary. For example, radio tagged coho in Grays Harbor estuary moved alternatively from low velocity holding habitats to strong current passive downstream movement areas (Moser et al. 1991). Consistent with these observations, Dittman et al. (1996) suggest that habitat sequences at the landscape level may be important even for species and life history types that move quickly through the estuary during the important smoltification process, as salmon gather the olfactory cues needed for successful homing and these cues may depend on the environmental gradients experienced during migrations.

Hypothesis Statement 8 – Changes in Columbia River estuary and lower mainstem habitat have decreased the productivity of the ecosystem for salmonids and contributed to their imperiled status.

Natural and anthropogenic factors have negatively altered the habitat-forming processes, available habitat types, and the estuarine food web, resulting in decreased salmonid survival and production. Studies conducted by Emmett and Schiewe (1997) in the early 1980s have shown that favorable estuarine conditions translate into higher salmonid survival. The most significant habitat effects have resulted from modified river flow, channel manipulations, and contaminant effects. River flow, although influenced by many factors, will be discussed in detail in the next hypothesis statement addressing hydropower system effects; the other habitat effects will be addressed below.

Salmonid production in estuaries is supported by detrital food chains (Healey 1979, 1982). Therefore habitats that produce and/or retain detritus, such as tidal wetlands emergent vegetation, eelgrass beds, macro algae beds and epibenthic algae beds, are particularly important (Sherwood et al. 1990). Diking and filling activities in the estuary have likely reduced the rearing capacity for juvenile salmonids by decreasing the tidal prism and eliminating emergent and forested wetlands and floodplain habitats adjacent to shore (Bottom et al. 2001, NMFS 2000c). Dikes throughout the lower Columbia River and estuary have disconnected the main channel from a significant portion of the wetland and floodplain habitats. Further, filling activities (i.e. for agriculture, development, or dredge material disposal) have eliminated many wetland and floodplain habitats. Thus, diking and filling activities have eliminated the emergent and forested wetlands and floodplain habitats that many juvenile salmonids rely on for food and refugia, as well as eliminating the primary recruitment source of large woody debris that served as the base of the historical food chain. The current estuary food web is microdetritus based, primarily in the form of imported phytoplankton production from upriver reservoirs that dies upon exposure to salinity in the estuary (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001). The historical macrodetritus-based food web was distributed throughout the lower river and estuary, but the modern microdetritus-based food web is focused on the spatially confined ETM region of the estuary (Bottom et al. 2001). This current food web is primarily available to pelagic feeders and is a disadvantage to epibenthic feeders, such as salmonids (Bottom and Jones 1990 as cited in Nez Perce et al. 1995, Bottom et al. 2001, USACE 2001).

Habitat alterations in the lower Columbia River mainstem and estuary have increased the abundance of predators of juvenile salmonids (see Hypothesis Statement 11,2.1.7). Evidence suggests that predation related mortality of juvenile salmonids during outmigration is substantial, thereby limiting survival and abundance of salmonids.

Juvenile salmon collected by NOAA Fisheries at East Sand Island near the mouth of the Columbia River contained relatively high concentrations of DDTs and PCBs. Studies of sub-lethal exposure of juvenile salmon to contaminants in urban estuaries suggest that these contaminants could affect the survival, growth, and fitness of salmon (Casillas et al. 1996). Water quality issues could reduce productivity for species that make extensive use of estuarine habitats for rearing, such as ocean-type salmonids like fall chinook and chum salmon. Further, proposed future dredging operations in the lower Columbia River and estuary may locally force contaminants into the water column or expose contaminanted sediments, which may have detrimental effects if juvenile salmonids were present.

Additionally, the decreased habitat diversity and modified food web has decreased the ability of the lower Columbia River mainstem and estuary to support the historical diversity of salmonid life history types. Historically, chinook salmon in the Columbia River exhibited a wide diversity of life history types, using streams, rivers, the estuary, and perhaps the Columbia River plume as potential rearing areas. Bottom et al. (2001) identified several forms of ocean-type chinook life histories, based on the scale pattern, length, and time of capture data collected by Rich (1920). Wissmar and Simenstad (1998) and Bottom et al. (2001) suggest there may be as many as 35 potential ocean-type chinook salmon life history strategies. Bottom et al. (2001) suggested that human affects on the environment have caused chinook life history patterns to be more constrained and homogenized than historical data show. Most modern day ocean-type chinook fit into one of three groups: subyearling migrants that rear in natal streams, subyearling migrants that rear in larger rivers and/or the estuary, yearling migrants. Today, ocean-type

chinook with estuarine rearing life histories are not a primary life history form observed by managers and resource users; most chinook are yearlings with a homogeneous size distribution. Abundance patterns of juvenile chinook in the estuary now reflect hatchery management practices more than historical migration behavior. Further, food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000).

Hypothesis Statement 9 – Construction and operation of the Columbia River hydropower system has contributed to changes in Columbia River estuary and lower mainstem habitat conditions that have reduced salmonid population resilience and inhibited recovery.

Contruction and operation of the hydropower system has had profound effects on Columbia River estuary and lower mainstem habitats. The primary effects of the hydropower system include decreased mean annual river flow, reversal of the historical hydrograph, reduction of the amount and type of sediments available for transport, and alteration of the type of nutrients and organic material available for transport.

Hydrologic effects of the Columbia River hydrosystem include water level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. Altered flow regimes can affect the migratory behavior of juvenile and adult salmonids. For example, water level fluctuations associated with hydropower peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and strand juveniles during the downstream migration. Reservoir drawdowns reduce available habitat which concentrates organisms, potentially increasing predation and disease transmission (Spence et al. 1996 as cited in NMFS 2000c).

Water regulation, as part of hydropower system operations, has drastically reduced historical spring freshet flows and altered juvenile salmon outmigration behavior. Often, historical lower Columbia River spring freshet flows were approximately four times the winter low flow levels. Today, spring freshet flows are only about twice the winter low flow level, which is now generally higher as a result of reservoir drawdown in winter. Spring freshets are very important to the outmigration of juvenile salmonids; freshet flows stimulate salmon downstream migration and provide a mechanism for rapid migrations. Also, spring freshets (especially overbank flows) provide habitat, increase turbidity thereby limiting predation, and maintain favorable water temperatures during spring and early summer. Further, organic matter supplied by the river during the freshet season is a major factor maintaining the detritus-based food web. Today, the contribution of imported detritus is controlled primarily by reservoir production and flow rates from Bonneville Dam.

Because of changes to flow and sediment transport and the various habitat alterations that have occurred in the estuary, the availability of shallow (10cm-2m depth), low velocity (<30 cm/s) habitats appears to decrease at a steeper rate with increasing flow compared to historical conditions. These conditions have decreased the shallow water refugia for juvenile salmonids and likely contribute to decreased survival during high flow conditions (NMFS 2000c).

Altered flow regimes can also affect the spawning success of mainstem Columbia River spawners. For example, reservoir drawdowns in the fall for flood control produces high flow for

fall spawners; fish may spawn in areas that are dewatered during the winter or spring, potentially resulting in complete egg mortality (NMFS 2000c).

Historically, floodwaters of the Columbia River inundated the margins and floodplains along the estuary, allowing juvenile salmon access to a wide expanse of low-velocity marshland and tidal channel habitats (Bottom et al. 2001). Flooding occurred frequently and was important to habitat diversity and complexity. Historical flooding also allowed more flow to off channel habitats (i.e. side channels and bays) and deposited more large woody debris into the ecosystem. Historically, seasonal flooding increased the potential for salmonid feeding and resting areas in the estuary during the spring/summer freshet season by creating significant tidal marsh vegetation and wetland areas throughout the floodplain (Bottom et al. 2001). These conditions rarely exist today as a result of hydropower system water regulation.

Columbia River mainstem reservoirs trap sediments and nutrients, as well as reduce sediment bedload movement, thereby reducing sediment and nutrient supply to the lower Columbia River. The volume and type of sediment transported by the mainstem Columbia River has profound impacts on the estuary food web and species interactions within the estuary. For example, organic matter associated with the fine sediment supply maintains the majority of estuarine secondary productivity in the food web (Simenstad et al. 1990, 1995 as cited in Bottom et al. 2001). Also, turbidity (as determined by suspended sediments) affects estuary habitat formation, regulates primary production via affects on light penetration, and decreases predation on juvenile salmonids via decreased predator efficiency. Further, the type of sediment transported has profound effects on habitat formation. The reduction in sand and gravel transport has been higher (>70% reduction compared to predevelopment flow) than for silt and clay transport (Bottom et al. 2001). Sand and gravel substrates are important components of preferred salmonid habitat in the estuary.

Hypothesis Statement 10 – Predation has always been a significant source of juvenile salmonid mortality in the lower Columbia River mainstem and estuary but habitat changes resulting from human activities have substantially altered predator concentration and distribution, particularly Caspian terns and northern pikeminnow.

Significant numbers of salmon are lost to fish, bird, and marine mammal predators during migration through the mainstem Columbia River. Predation has always been a substantial source of mortality but is expected to have increased significantly in recent years because of increased abundance of predator populations that have responded to habitat changes resulting from human activities. For example, piscivorous birds congregate near dams and in the estuary around man-made islands and consume large numbers of outmigrating juvenile salmon and steelhead (Roby et al. 1998). Caspian terns, cormorants, and gull species are the major avian predators (NMFS 2000a). While some avian predation occurs at dam tailraces and juvenile bypass outfalls, by far the greatest numbers of juveniles are consumed as they migrate through the Columbia River estuary.

Caspian terns are native to the region but were not historically present in the lower Columbia River mainstem and estuary; they have recently made extensive use of dredge spoil habitat and are a major predator of juvenile salmonids in the estuary. The terns are a migratory species whose nesting season coincides with salmonid outmigration timing. Since 1900, the tern population has shifted from small colonies nesting in interior California and southern Oregon to large colonies nesting on dredge spoil islands in the Columbia River and elsewhere (NMFS

2000c). Caspian terns did not nest the estuary until 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds (and others) moved to Rice Island (constructed from dredge spoils) in 1987 and the colony expanded to 10,000 pairs. Diet analysis has shown that juvenile salmonids make up 75% of food consumed by Caspian terns on Rice Island. However, there are no data to compare historical and modern predation rates or predator populations; thus, effects of this unique predator population in relation to historical losses of juvenile salmon to predation cannot be adequately quantified (Bottom et al. 2001). Further, recent management actions have been relatively successful in discouraging Caspian tern breeding on Rice Island while encouraging breeding on East Sand Island, which may decrease predation on juvenile salmonids. Also, current predation studies are limited because of the unknown effects hatchery rearing and release programs have had on salmon migration behavior and predator consumption. Nevertheless, evidence suggests that current predator populations could be a substantial limiting factor on juvenile salmon survival (Bottom et al. 2001).

Native fishes, particularly northern pikeminnow, prey on juvenile salmonids during outmigration. Pikeminnow numbers likely have increased as favorable slack-water habitats have been created by hydropower system water impoundment and flow regulation. In unaltered systems, pikeminnow predation is limited by smolt migratory behavior; the smolts are suspended in the water column away from the bottom and shoreline habitats preferred by pikeminnow. However, dam passage has disrupted juvenile migratory behavior and provided low velocity refuges below dams where pikeminnow gather and feed on smolts. The diet of the large numbers of pikeminnow observed in the forebay and tailrace of Bonneville Dam is composed almost entirely of smolts. Pikeminnow also concentrate at dam bypass outfalls and hatchery release sites to prey on injured or disoriented fish, and pikeminnow eat many healthy smolts as well. Northern pikeminnow have been estimated to consume millions of juvenile salmon per year in the lower Columbia River; an estimated 9.7 million juvenile salmonids are consumed annually from Bonneville Dam to the estuary (NMFS 2000b). Predation rates on salmonids are often much lower in areas away from the dams, although large numbers of predators in those areas can still impose significant mortality.

Hypothesis Statement 11 – Density dependent factors affect salmonid productivity in the Columbia River estuary and lower mainstem However, the relationship of the quantiy and quality of habitat in relation to the expression of life history strategies of salmonids requires further clarification

The productivity of the Columbia River estuary likely has decreased over time as a result of habitat degradation, which initially would appear to increase the likelihood for competition among salmonids in the estuary especially during times of high juvenile abundance. In situations of decreased habitat availability, reducing access to habitat at critical stages may be a limiting factor in production and recovery of depressed salmonid populations (Fresh et al. 2003). There is likely a threshold level of abundance at which density dependence operates, and by reducing habitat, this threshold has been artificially reduced. However, historical natural abundance of juvenile salmonids in the lower mainstem and estuary was far greater than the current abundance, even considering the large hatchery releases of juvenile salmonids that occur today. Thus, at our current level of understanding, the presence of and the importance of density dependent mechanisms in the estuary are not clear. Because of the uncertainty about the impact of density dependence on the recovery of endangered stocks, actions which may further productivity in the system should be avoided.

Recent research in the Skagit River, WA, suggests that density dependent mechanisms are operating in the estuarine portion of that system (Greene et al. *in press* as cited in Fresh et al. 2003). For example, research has identified a density dependent limit to the number of juveniles in the estuary relative to the abundance of juvenile salmonids in the entire system. Greene et al. (*in press* as cited in Fresh et al. 2003) further demonstrated that variability in nearshore Puget Sound conditions (i.e. extension of the Skagit Bay estuary) accounted for significant variability in adult returns of Skagit Bay chinook salmon; moreover, incorporating density dependence helped to clarify the relationship between nearshore conditions and adult returns. Although research in the Skagit River estuary points toward density dependent mechanisms, applicability to the Columbia River estuary is unknown; Fresh et al. (2003) indicated that this information was forthcoming for the Columbia River estuary.

Estuaries may be "overgrazed" when large numbers of ocean-type juveniles enter the estuary en masse (Reimers 1973, Healey 1991). Food availability may be negatively affected by the temporal and spatial overlap of juvenile salmonids from different locations; competition for prey may develop when large releases of hatchery salmonids enter the estuary (Bisbal and McConnaha 1998), although this issue remains unresolved (Lichatowich 1993 as cited in Williams et al. 2000). Reimer (1971) suggested a density dependant mechanism affects growth rate and hypothesized that fall chinook growth in the Sixes River was poor from June to August because of the large population in the estuary at this time and that the increased growth rate in September to November resulted from reduction in population size and a better utilization of the whole estuary.

The potential exists for large-scale hatchery releases of fry and fingerling ocean-type chinook salmon to overwhelm the production capacity of estuaries (Lichatowich and McIntyre 1987). However, Witty et al. (1995) could not find any papers or studies that evaluated specific competition factors between hatchery and wild fish in the Columbia River estuary. Rivers such as the Columbia, with well-developed estuaries, are able to sustain larger ocean-type populations than those without (Levy and Northcote 1982).

Natural populations of salmon and steelhead migrate from natal streams over an extended period (Neeley et al. 1993; Neeley et al. 1994); they also enter the estuary over an extended period (Raymond 1979). Hatchery fish are generally—but not always—released over a shorter period resulting in a mass emigration into natural environments. Managed releases of water combined with large releases of hatchery fish result in large numbers of juvenile salmon and steelhead in the estuary during spring months when the estuary productivity is low. Some workers (Reimers 1973; Neilson et al. 1985) have suggested that the amount of time spent in estuaries may relate to competition for food. Fish that arrive in the estuary later in the season may benefit from increased food supplies. Chapman et al. (1994) note that subyearling chinook released later in the summer returned at significantly higher rates than subyearlings released early in the summer; but an alternate mechanism that may account for this difference includes different rates of piscivory due to both the size of the later hatchery releases and the presence of fewer predators (Tod Jones, pers. comm.).

In summary, the existence of density dependent mechanisms among salmonids in the Columbia River estuary and lower mainstem are equivocal. Although capacity of the estuary to support juvenile salmonids has decreased from historical conditions (see section 2.1.4.2.8), abundance of salmonids has also decreased substantially. To date, we have limited ability to quantify the lower mainstem and estuary capacity and, therefore, have limited knowledge of how

many salmonids can be present in the estuary/mainstem at any given time (i.e. different seasons, flow conditions, nutrient levels, macroinvertebrate abundance, etc.) before significant competition for resources results. It is clear that the capacity of the estuary/mainstem ecosystem has decreased relative to historical conditions, however, it is not clear whether this decreased habitat capacity has resulted in density dependent mechanisms that limit salmonid production at current salmonid abundance levels.

Hypothesis Statement 12 – Habitat restoration efforts are capable of significantly improving conditions for fish and wildlife species in the Columbia River estuary and lower mainstem.

Habitat actions proposed in the NMFS Biological Opinion on the Operation of the Federal Columbia River Power System (BiOp; NMFS 2000c) are intended to accelerate efforts to improve survival in priority areas while laying the foundation for long-term habitat strategies. The overarching objectives of the habitat strategy are: protect existing high quality habitat, restore degraded habitats and connect them to functioning habitats, and prevent further degradation of habitat and water quality. Specifically, Reasonable and Prudent Alternative (RPA) Actions 158 through 163 of the BiOp detail specific actions related to estuarine habitat while RPA Actions 156 and 157 address habitat issues within the lower mainstem (NMFS 2000c). An "Action Plan" has recently been published that outlines a plan for implementing the above RPA actions related to estuary and mainstem habitat restoration, as well as RPA actions that address planning, modeling, and research, monitoring, and evaluation needs described in the BiOp (BPA and USACE 2003).

Restoration of tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River has been identified as an important component of current and future salmon restoration efforts. Reasonable and Prudent Alternative Action 160 in the NMFS Biological Opinion on the Operation of the Federal Columbia River Power System (NMFS 2000c) called for an estuary restoration program with the goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, with the intention of rebuilding productivity for ESA-listed salmonid populations in the lower 46 miles of the Columbia River. There is considerable uncertainty whether the 10,000 acres is the precise amount needed to produce desired increases in salmonid productivity or if the 10-year schedule is an appropriate time scale for recovery efforts. Thus, NMFS (2000c) identified the importance of continued monitoring and evaluation of the estuary restoration program and the 10,000-acre goal to ensure that habitats being restored are important for salmon survival and recovery. NMFS (2000c) also suggested examples of acceptable habitat improvement efforts, including but not limited to: acquiring diked lands, breaching levees, improving plant communities, reestablishing flow patterns, or enhancing connections between lakes, sloughs, side channels, and the main channel.

Dike removal could provide a sizable increase in shallow water habitat, even without restoration of historical flow regimes (Kukulka and Jay 2003). Dike removal alone provided more of an increase in shallow water habitat than flow restoration without dike removal. Restoration of natural flows increases the duration of shallow water habitat inundation in high-flow years, but individually does not restore the large size of the area historically inundated.

Management actions that seek to alter anthropogenic factors and restore natural habitat-forming processes need to be evaluated based on their impact on biological diversity and not simply on production of juvenile salmonids (Bisbal and McConnaha 1998). For example,

changes in hydrosystem water management should attempt to provide benefits for the full range of historical salmonid life history patterns and not just the primary life history patterns currently observed. Restoration efforts need to move from the practice of management for average biological conditions to management for the full spectrum of possible biological variation (Williams et al. 1996 as cited in Bisbal and McConnaha 1998).

2.1.8 *Literature Cited*

Aitkin, J.K. 1998. The importance of estuarine habitats to anadromous salmonids of the Pacific Northwest: a literature review. US Fish and Wildife Service, Lacey, WA. 25p.

Allen, M.J. and G.B. Smith.1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. NOAA. Tech.Rep.NMFS 66: 151p.

Altman 2001 *(note that this reference was unconfirmed at time of press)*

Anders, P. J., D. L. Richards, M. S. Powell. 2002. The First Endangered White Sturgeon Population (Acipenser transmontanus): Repercussions in an Altered Large River-floodplain Ecosystem. Pages 67-82 In: W. VanWinkle, P. Anders, D. Dixon, and D. Secor, eds. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Symposium 28.

Anders, P. J., and L. G. Beckman. 1995. Comparison of white sturgeon egg mortality and juvenile deformity among four areas of the Columbia River. Report H *In:* Status and Habitat Requirements of the White Sturgeon Populations in the Columbia River Downstream from McNary Dam. Project No. 86-50. Final Report of Research to the Bonneville Power Administration, US Dept. of Energy, Portland, Oregon. Volume 2.

Anthony, R.G., M.G. Garrett, and C.A. Schuler. 1993. Environmental contaminants in bald eagles in the Columbia River Estuary. Journal of Wildlife Management 57:10-19.

Anthony, R. G., R. L. Knight, G. T. Allen, B. R. McClelland, and J. I. Hodges. 1982. Habitat use by nesting and roosting bald eagles in the Pacific Northwest. Trans. N. American Wildlife and Natural Resource Conference 47:332-342.

AquaTechnex. October 2003. Wahkiakum County integrated aquatic vegetation management plan. Centralia, WA.

Arkoosh, M.R., E. Casillas, E. Clemons, A.N. Kagley, R. Olson, P. Reno, and J.E. Stein. 1998a. Effect of pollution on fish diseases: potential impacts on salmonid populations. Journal of Aquatic Animal Health 10:182-190.

Arkoosh, M.R., E. Casillas, P. Huffman, E. Clemons, J. Evered, J.E. Stein, and U. Varanasi. 1998b. Increased susceptibility of juvenile chinook salmon from a contaminated estuary to Vibrioanguillarum. Transactions of the American Fisheries Society 127:360-374.

Armbruster, M. J. 1987. Habitat suitability index models: greater sandhill crane. USDI-Fish and Wildife Service Biological Rep. 82 (10.140). 26 pp.

Ayres, D.R., D.L. Smith, K. Zaremba, S. Klohr, and D.R. Strong. 2003. Spread of exotic cordgrasses and hybrids (*Spartina sp*.) in the tidal marshes of San Francisco Bay, CA, USA. Biological Invasions.

Bakkala, R.G. 1970. Synopsis of biological data on the chum salmon, *Oncorhynchus keta* (Walbaum) 1792. FAO Fish. Symposium 41; U.S. Fish and Wildife Service Circular 315. 89 pp.

Barnes, C.A., C. Duxbury, and B.A. Morse. 1972. Circulation and selected properties of the Columbia River plume at sea. Pages 41-80 in A.T. Pruter and D.L. Alverson, editors. The Columbia River estuary and adjacent ocean waters. University of Washington Press, Seattle.

Baross, J. A., B. Crump, and C. A. Simenstad. 1994. Elevated 'microbial loop' activities in the Columbia River estuary turbidity maximum. Pp. 459-464 *In* K. Dyer and R. Orth (*eds*.), Changing Particle Fluxes in Estuaries: Implications from Science to Management, ECSA22ERF Symposium, Olsen & Olsen Press, Friedensborg.

Barraclough, W.E. 1964.Contribution to the marine life history of the eulachon *Thaleichthys pacificus*. Journal of the Fisheries Research Board of Canada 21(5):1333-1337.

Barrows, W. B. 1912. Michigan bird life. Michigan Agricultural College, Lansing, Michigan. 822 pp.

Bax, N.J. 1983. The early marine migration of juvenile chum salmon (Oncorhynchus keta) through Hood Canal – its variability and consequences. Ph.D. Dissertation, Univ. of Washington, Seattle, 196 p.

Beall, E.P. 1972. The use of predator-prey tests to assess the quality of chum salmon *Oncorhynchus keta* fry. Master's thesis. University of Washington, Seattle. 105 p.

Beamesderfer, R.C. 1992. Reproduction and early life history of northern squawfish, *Ptychocheilus oregonensis*, in Idaho's St. Joe River. Environmental Biology of Fishes 35:231-241.

Beamesderfer, R.C.P. 2000. Managing fish predators and competitors: deciding when intervention is effective and appropriate. Fisheries 25(6):18-23.

Beamesderfer, R.C.P., T. A. Rien, and A. A. Nigro. 1995. Differences in the dynamics and potential production of impounded and unimpounded white sturgeon populations in the lower Columbia River. Transactions of the American Fisheries Society 124:857-872.

Beamesderfer, R.C.P., D.L. Ward, and A.A. Nigro. 1996. Evaluation of the biological basis for a predator control program on northern pikeminnow (*Ptychocheilus oregonensis*) in the Columbia and Snake rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908.

Beamish, R.J. 1980. Adult biology of the river lamprey (*Lampetra agresi*) and the Pacific lamprey (*Lampetra tridentate*) from the Pacific Coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 37:1906-1923.

Bemis, W.E., and B. Kynard. 1997. Sturgeon rivers: an introduction to Acipenseriform biogeography and life history. Environmental Biology of Fishes 48:167-183.

Bent, A. C. 1926. Life histories of North American marsh birds. US National Museum Bulletin 135, Washington, DC 490 pp.

Bent 1965

Bisbal, G.A. and W.E. McConnaha. 1998. Consideration of ocean conditions in the management of salmon. Canadian Journal of Fisheries and Aquatic Sciences 55:2178-2186.

Bonneville Power Administration (BPA). June 11, 2002. Feds enlist boaters to battle the zebra mussel. News Release of the BPA Crime Witness Program, Portland, Oregon.

Bonneville Power Administration (BPA) and U.S. Army Corps of Engineers (USACE), Portland District. September 30, 2003. *Final Draft* Action plan to implement the Federal Columbia River power system biological opinion in the Columbia River estuary. Prepared for NOAA Fisheries.

Bostick, W.E. 1955. Duwamish River seining studies. Pages 5-6 *in* Puget Sound stream studies, Washington Department of Fisheries, Olympia. (Available Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501-1091).

Bottom, D. and K. Jones. 1990. Species composition, distribution, and invertebrate prey assemblages in the Columbia River estuary. Pages 243-270 in M.V. Angel and R.L. Smith eds., Columbia River: estuarine system. Progress in Oceanography 25(1-4).

Bottom, D.L., C.A. Simenstad, A.M. Baptista, D.A. Jay, J. Burke, K.K. Jones, E. Casillas, and M.H. Schiewe. 2001. Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon. NMFS, Seattle.

Bottom, D.L., J.A. Lichatowich, and C.A. Frissell. 1998. Variability of Pacific Northwest marine ecosystems and relation to salmon production. *In* G.R. McMurray and R.J. Bailey, (*editors*), Change in Pacific Northwest coastal ecosystems regional study workshop, August 13-14, 1996, Troutdale, Oregon. NOAA Coastal Ocean Program Decision Analysis Series No. 11, Silver Spring, Maryland, 342 p.

Bottom, D.L., K.K. Jones, and M.J. Herring. 1984. Fishes of the Columbia River estuary. Final Report on the Fish Work Unit of the Columbia River Estuary Data Development Program, prepared by Oregon Department of Fish and Wildlife, Research and Development Section, Corvallis, OR.

Bowman, T. D., P. F. Schempf, and J. A. Bernatowicz. 1995. Bald Eagle survival and population dynamics in Alaska after the Exxon Valdez oil spill. J. Wildlife Management 59(2):317-324.

Brannon, E., S. Brewer, A. Setter, M. Miller, F. Utter, and W. Hershberger. 1985. Columbia River white sturgeon early life history and genetics study. Final report (Project Number 83-316) to Bonneville Power Administration. Portland, Oregon.

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus *Oncorhynchus*. Journal of the Fisheries Research Board of Canada 9:265-323.

Brett, J.R. 1971. Energetic responses of salmon to temperature: a study of some thermal relations in the physiology and freshwater ecology of sockeye salmon (*Oncorhynchus nerka*). American Zoology 11(1):99-113.

Brodeur, R.D. 1992. Factors related to variability on feeding intensity of juvenile coho salmon and chinook salmon. Transaction of the American Fisheries Society 121:104-114.

Brodeur, R.D., G.W. Boehlert, E. Casillas, M.B. Eldridge, J.H. Helle, W.T. Petersen, W.R. Heard, S.T. Lindley, and M.H. Schiewe. 2000. A coordinated research plan for estuarine and ocean research on Pacific salmon. Fisheries 25:7-16.

Brown, E.R. 1985. Management of wildlife and fish habitats in forests of Western Oregon and Washington. US Department of Agriculture, Forest Service, Pacific Northwest Region in cooperation with US Department of the Interior, Bureau of Land Management.

Brown, R. C. 1942. The sandhill crane. Wyoming Wildlife 7:8, 21, 22, 23.

Buchanan, D.V., R.M. Hooten, and J.R. Moring. 1981. Northern pikeminnow (*Ptychocheilus oregonensis*) predation on juvenile salmonids in sections of the Willamette River basin, Oregon. Can. J. Fish. Aquat. Sci. 38:360-364.

Buchanan, J.B., D.H. Johnson, E.L. Greda, G.A. Green, T.R. Wahl, and S.J. Jeffries. 2001. Wildlife of coastal and marine habitats *In* D.H. Johnson and T.A. O'Neil (*eds*.) Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis.

Buehler, D. A., 2000. Bald Eagle (*Haliaeetus leucocephalus*). Birds of North America No. 506. The Birds of North America, Inc., Philadelphia, PA. 40 pp.

Buijsman, M. 2000. Shoreline change modeling – in relation to the sediment budget. *In* Southwest Washington Coastal Erosion Workshop Report, 1999, G. Gelfenbaum and G.M. Kaminsky, *eds*. United States Geological Survey, Open File Report 00-439, prepared in cooperation with the Washington State Department of Ecology.

Bureau of Indian Affairs (BIA). 1993. Yakama Indian Reservation Forest Management Plan 1993-2002. U.S. Bureau of Indian Affairs, Branch of Forestry, Toppenish, WA.

Callahan, B., E. Miles, and D. Fluharty. 1999. Policy implications of climate forecasts for water resources management in the Pacific Northwest. Policy Sciences 32:269.

Carter, H.R., A.L. Sowls, M.S. Rodway, U.W. Wilson, R.W. Lowe, G.J. McChesney, F. Gress, and D.W. Anderson. 1995. Population size, trends, and conservation problems of the double-crested cormorants on the Pacific Coast of North America. Colonial Waterbirds 18 (Special Publication 1): 189-215.

Caspian Tern Working Group 1999

Casillas, E., B.B. McCain, M. Arkoosh, and J.E. Stein. 1996. Estuarine pollution and juvenile salmon health: potential impact on survival. Pages 169-178 *in* Estuarine and Ocean Survival of northeastern Pacific Salmon. NOAA Technical Memorandum NMFS-NWFSC-29.

Chapman, D.W., A. Giorgi, T. Hillman, D. Deppert, M. Erho, S. Hays, C. Peven, B. Suzumoto, and R. Klinge. 1994. Status of summer/fall chinook salmon in the mid-Columbia region. Report for Chelan, Douglas and Grant County PUDs. 412 pp.+ app. (Available from Don Chapman Consultants, 3653 Rickenbacker, Ste. 200, Boise, ID 83705).

Chatters, J.C. and K.A. Hoover. 1986. Changing late Holocene flooding frequencies on the Columbia River, Washington. Quaternary Res. 26:309-320.

Chatters, J.C. and K.A. Hoover. 1992. Response of the Columbia River fluvial system to Holocene climate change. Quaternary Res. 37:42-59.

Chatters, J. C., V. L. Butler, M. J. Scott, D. M. Anderson, and D. A. Neitzel. 1995. A paleoscience approach to estimating the effects of climatic warming on salmonid fisheries of the Columbia River Basin. Can. Spec. Publ. Fish. Aquat. Sci.121:489-496.

Christy, J.A. and J.A. Putera. 1992. Lower Columbia River natural area inventory. Prepared for the Nature Conservancy, Washington Field Office, Seattle, WA. Oregon Natural Heritage Program, Portland, OR. 75p.

Claire, C.W. 2003. Pacific lamprey larvae life history and habitat utilization in Red River subbasin, South Fork Clearwater River drainage, Idaho. Draft Master's Thesis, University of Idaho, 74p.

Clark, C. and J.E. Shelbourn. 1985. Growth and development of seawater adaptability by juvenile fall chinook salmon (*Oncorhynchus tshawytscha*) in relation to temperature. Aquaculture 45:21-31.

Cohen, A.N. and J.T. Carlton. 1995. Nonindigenous aquatic species in a United States estuary: a case study of the biological invasions of the San Francisco Bay and Delta. U.S. Fish and Wildife Service. 246p.

Collis, K., S. Adamany, D. D. Roby, D. P. Craig, and D. E. Lyons. 1999. Avian predation on juvenile salmonids in the lower Columbia River. 1998 annual report to Bonneville Power Administration and US Army Corps of Engineers, Portland, Oregon.

Collis, K., D. D. Roby, D. E. Lyons, R. M. Suryan, M. Antolos, S. K. Anderson, A. M. Myers, and M. Hawbecker. 2001. Caspian tern research on the lower Columbia River: draft 2001 summary. Unpublished DRAFT season summary for the Bonneville Power Administration and the Interagency Caspian Tern Working Group.

Cone, J., and S. Ridlington. 1996. The northwest salmon crisis: a documentary history. Oregon State University Press, Corvallis, OR.

Conte, F. S., S. I. Doroshov, P. B. Lutes, and M. E. Strange. 1988. Hatchery manual for the white sturgeon (*Acipenser transmontanus*) with application to other North American Acipenseridae. Publications Division, Agriculture and Natural Resources, University of California, Oakland. Publication 3322.

Cooke, D. W., S. D. Leach, and J. J. Isely. 2002. Behavior and lack of upstream passage of shortnose sturgeon at a hydroelectric facility/navigation lock complex. Pages 101-110 In: W. VanWinkle, P. Anders, D. Dixon, and D. Secor, eds. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Press, Bethesda, Maryland,USA.

Cordell, J.R., C.A. Morgan, and C.A. Simenstad. 1992. Occurrence of the Asian calanoid copepod *Pseudodiaptomus inopinus* in the zooplankton of the Columbia River estuary. Journal of Crustacean Biology 12(2):260-269.

Counihan, T. C., J. D. DeVore, and M. J. Parsley. In Review. The effect of discharge and water temperature on the year-class strength of Columbia River white sturgeon. Submitted to Transactions of the American Fisheries Society.

Cowardin, L.M, V. Carter, and E.T. Roe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildife Service, Office of Biological Services, FWS/OBS-79/31, Washington, D.C.

Craddock, D.R., T.H. Blahm, and W.D. Parente. 1976. Occurrence and utilization of zooplankton by juvenile chinook salmon in the lower Columbia River. Transactions of the American Fisheries Society 105:72-76.

Crump, B.C., C.A. Simenstad, and J.A. Baross. 1998. Particle-attached bacteria dominate the Columbia River estuary. Aquat. Microb. Ecol. 14:7-18.

Crump, B.C., E.V. Armbrust, and J.A. Baross. 1999. Phylogenetic analysis of particle-attached and free-living bacterial communities in the Columbia River, its estuary, and the adjacent coastal ocean. Applied and Environmental Microbiology 65(7): 3192-3204.

Crump, B.C., and J. A. Baross. 1996. Particle-attached bacteria and heterotrophic plankton associated with the Columbia River estuarine turbidity maxima. Mar. Ecol. Prog. Ser.138: 265-273.

Cudaback, C.N. and D.A. Jay. 1996. Buoyant plume formation at the mouth of the Columbia River – an example of internal hydraulic control? Buoyancy effects on coastal and estuarine dynamics. Coastal and Estuarine Studies 53:139-154.

Cuthbert, F. J., and L. R. Wires. 1999. Caspian tern (*Sterna caspia*). In A. Poole and F. Gill [Eds.], The birds of North America, No. 403. The Birds of North America, Inc., Philadelphia, PA.

Daehler, C.C. and D.R. Strong. 1996. Status, prediction and prevention of introduced cordgrasses *Spartina spp*. invasions in Pacific estuaries, USA. Biological Conservation 78:51-58.

Dawley, E.M., R.D. Ledgerwood, and A.L. Jensen. 1985. Beach and purse seine sampling of juvenile salmonids in the Columbia River estuary and ocean plume, 1977-1983. Volume I: Procedures, sampling effort, and catch data. Volume II: Data on marked fish recoveries. National Marine Fisheries Service, Coastal Zone and Estuarine Studies Division, Seattle, WA.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kirn, A.E. Rankin, G.E. Monan, and F.J. Ossiander. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. Unpublished Report by National Marine Fisheries Service, Seattle, Washington. 256 pp.

Dawson, W.L. and J.H. Bowles. 1909. The Birds of Washington. Occidental Publishing Co., Seattle.

Detlaff, T. A., A. S. Ginsburg, and O. J. Schmalhausen. 1993. Sturgeon fishes: developmental biology and aquaculture. Springer-Verlag, Berlin 300 pp.

DeVore and Grimes 1993

DeVore, J. D., B. W. James, C. A. Tracy, and D. A. Hale. 1995. Dynamics and potential production of white sturgeon in the Columbia River downstream from Bonneville Dam. Transactions of the American Fisheries Society 124:845-856.

DeVore, J., B. James, and R. Beamesderfer. 1999. Lower Columbia River white sturgeon current stock status and management implications. Washington Department of Fish and Wildlife Report Number 99-08, Olympia, WA.

Dittman, A.H., T.P. Quinn, and G.A. Nevitt. 1996. Timing of imprinting to natural and artificial odors by coho salmon (*Oncorhynchus kisutch*) Can. J. Fish. Aquat. Sci. 53: 434-442.

Draheim, R., M. Sytsma, J. Chapman, and J. Cordell. June 2002. Lower Columbia River aquatic nonindigenous species survey, 2001-2003, Phase 1: Literature review and sampling plan. Annual Progress Report to the Pacific States Marine Fisheries Commission.

Dublin, H.T. 1980. Relating deer diets to forage quality and quantity: the Columbian White-tailed deer (*Odocoileus virginianus leucurus*). M.S. Thesis. Univ. Washington, Seattle. 135 pp.

Durkin, J.T. 1982. Migration Characteristics of Coho Salmon (*Oncorhynchus kisutch*) Smolts in the Columbia River and Its Estuary, in Estuarine Comparisons, edited by V.S. Kennedy, pp 865-876. Academic Press, New York, New York.

Ebbesmeyer, C.C. and W. Tangborn. 1992. Linkage of reservoir, coast and strait dynamics, 1936-1990: Columbia River basin, Washington Coast, and Juan de Fuca Strait. *In* Interdisciplinary Approaches in Hydrology and Hydrogeology, M.E. Jones and A. Laenen, *eds*., American Institute of Hydrology, Minneapolis, Minnesota.

Elliott J.E., and M.L. Harris. 2001-2002. An ecotoxicological assessment of chlorinated hydrocarbon effects on bald eagle populations. Reviews in Toxicology 4:1-60.

Emmett, R. L, G.T. McCabe, Jr., T.C. Coley, R.J. McConnell, and W.D. Muir. 1986. Benthic sampling in Cathlamet Bay, Oregon – 1984. Report to the U.S. Army Corps of Engineers, Contract DACW57-84-F-0348. 11p.

Emmett, R. L and M. H. Schiewe (*eds*.). 1997. Estuarine and ocean survival of Northeastern Pacific salmon: proceedings of the workshop. U. S. Dept. Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NOAA Tech. Memo. NMFS-NWFSC-29.

Engler, J. D. and J. E. Brady. 2000. Final report 2000 greater sandhill crane nesting season at Conboy Lake National Wildlife Refuge. Unpubl. rep., USDI-Fish and Wildife Service, Ridgefield NWR, Ridgefield, Washington. 9 pp.

Falter 1969

Farnell, J.E. 1980. Clatskanie River navigability study. Oregon Division of Lands.

Farr, R.A. and D.L. Ward. 1993. Fishes of the lower Willamette River, near Portland, Oregon. Northwest Science 67:16-22.

Fies, T.T. 1971. Surveys of some sloughs of the lower Columbia River. Oregon State Game Commission, Fishery Division.

Fraser, F. J., D.D. Bailey, and M.J. Wood. 1978. Big Qualicum River salmon development project. Vol. III: Experimental rearing of chum salmon juveniles *(Oncorhynchus keta)* in fresh water (1968-70). Can. Fish. and Mar. Service Technical Report 752. 22 pp.

Gabrielson, I. N., and S. G. Jewett. 1940. Birds of Oregon. Oregon State College, Corvallis, Oregon. 650 pp.

Gardner, J.A., W.R. Woodall, A.A. Staats, and J.F. Napoli. 1976. The invasion of the Asiatic clam (*Corbicula manilensis* Philippi) in the Altamaha River, Georgia. Nautilus 90:117-124.

Garono, R.J., R. Robinson, and C. Simenstad. 2002. Estuarine landcover along the Columbia River estuary determined from Landsat 7 ETM+ imagery. Report submitted to the Lower Columbia River Estuary Partnership. Portland, Oregon.

Garono, R.J., B.D. Anderson, R. Robinson, and C. Simenstad. 2003a. Change in land cover along the lower Columbia River estuary as determined from Landsat TM imagery. Report submitted to the Lower Columbia River Estuary Partnership. Portland, Oregon.

Garono, R.J., R. Robinson, and C. Simenstad. 2003b. Estuarine landcover along the Columbia River estuary determined from compact airborne spectrographic imager (CASI) imagery. Report submitted to the Lower Columbia River Estuary Partnership. Portland, Oregon.

Garono, R.J., R. Robinson, and C. Simenstad. 2003c. Estuarine and tidal freshwater habitat cover types along the Columbia River estuary determined from Landsat 7 ETM+ imagery. Report submitted to the Lower Columbia River Estuary Partnership. Portland, Oregon.

Garrett, M., R.G. Anthony, J.W. Watson, and K. McGarigal. 1988. Ecology of bald eagles on the lower Columbia River. Final report submitted to the U.S. Army Corp of Engineers, Contract No. DACW57-83-C-0100. 189 pp.

Garrett, M. G., J. W. Watson, and R. G. Anthony. 1993. Bald eagle home range and habitat use in the Columbia River Estuary. J. of Wildlife Management 57:19-27.

Garrison, K.J. and B.S. Miller. 1982. Review of the early life history of Puget Sound fishes. Fisheries Research Institute. University of Washington, Seattle. NMFS contract No. 80-ABA-3680.

Gates, E.B. 1994. The Holocene framework of the lower Columbia River basin. M.S. Thesis, Portland State University, Portland, Oregon.

Gaumer, T., D. Demory, and L. Osis. 1973. 1971 Columbia River estuary resource use study. Fish Commision of Oregon, Division of Management and Research.

Gavin et al. 1984

Gelfenbaum, G., C.R. Sherwood, C.D. Peterson, G. Kaminsky, M. Buijsman, D. Twichell, P. Ruggiero, A. Gibbs, and C. Reed. 1999. The Columbia River littoral cell: a sediment budget overview. Coastal Sediments, Proceedings of the Conference, American Society of Civil Engineers, June 21-23, 1999, Hauppauge, Long Island, New York.

Gerrard, J. M., and G. R. Bortolotti. 1988. The bald eagle: haunts and habits of a wilderness monarch. Smithsonian Institution Press, Washington and London. 177 pp.

Gerrard, J. M., P. N. Gerrard, P. Naomi Gerrard, G. R. Bortolotti, and E. H. Dzus. 1992. A 24-year study of bald eagles on Besnard Lake, Saskatchewan. J. of Raptor Research 26:159-166.

Gershunov, A., T.P. Barret, and D.R. Cayan. 1999. North Pacific interdecadal oscillation seen as factor in ENSO-related North American climate anomalies. EOS, Trans. Am. Geophysical Union 80(3).

Gill, R. E., Jr. 1976. Notes on the foraging of nesting Caspian terns *Hydroprogne caspia* (Pallas). California Fish and Game 62:155.

Gilligan, J., M. Smith, D. Rodgers, and A. Contreras [Eds.]. 1994. Birds of Oregon: status and distribution. Cinclus Publications, McMinnville, Oregon.

Golder Associates. 2003. White sturgeon investigations in the Priest Rapids and Wanapum Reservoirs of the middle Columbia River, Washington. 2003 Final report to Grant Co. (Washington) PUD.

Graves, J. K., J. A. Christy, P. J. Clinton, and P. L. Britz. 1995. Historical Habitats of the Lower Columbia River. Report by the Columbia River Estuary Study Taskforce, Astoria, Oregon.

Gribanov, V.I. 1948. The coho salmon (*Onchorhynchus kisutch* Walb.)- a biological sketch. Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. 28:43-101. (Translated from Russian; Fisheries Research Board of Canada Translation Ser. 370).

Groot, C. and L. Margolis (*eds*.). 1991. Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C. 564p.

Grubb, T. G. 1976. A survey and analysis of bald eagle nesting in western Washington. M. S. Thesis, University of Washington, Seattle. 87 pp.

Haertel, L., C. Oserberg, H. Curl, Jr., and P.K. Park. 1969. Nutrient and plankton ecology of the Columbia River estuary. Ecology 50:962-978.

Hamilton, W.J. and W.R. Eadie. 1964. Reproduction in the otter, *Lutra canadensis*. Journal of Mammology 45:242-252.

Hamlet, A.F., and D.P. Lettenmaier. 1999. Effects of climate change on hydrology and water resources in the Columbia River Basin. J. Am. Water Resour. Assoc. 35:1597-1623.

Harmata, A. R., and D. W. Stahlecker. 1993. Fidelity of migrant bald eagles to wintering grounds in southern Colorado and northern New Mexico. J. Field Ornithology 64:129-134.

Harrison, C.S. 1984. Terns family Laridae. Pp. 146-160 *in* D. Haley, D. *ed*. Seabirds of eastern North Pacific and Arctic waters. Pacific Search Press. Seattle, WA. 214 pp.

Hazel, C.R. 1984. Avifauna of the Columbia River estuary. Columbia River Estuary Data Development Program, Columbia River Estuary Study Taskforce, Astoria, Oregon.

Healey, M.C. 1979. Detritus and juvenile salmon production in the Nanaimo Estuary. I. Production and feeding rates of juvenile chum salmon (*Onchorhynchus keta*). J. Fish. Res. Board Can. 36:488-496.

Healey, M.C. 1982. Juvenile pacific salmon in the estuaries: the life support system. *In*: V.S. Kennedy *ed*., Estuarine Comparisons, pp. 315-341. Academic Press, Inc., New York, NY.

Healey, M.C. 1991. Life History of Chinook Salmon. *In*: C. Groot, and L. Margolis. Pacific Salmon Life Histories. University of British Columbia Press. Vancouver, BC.

Healey, M. C., and A. Prince. 1995. Scales of variation in life history tactics of Pacific salmon and the conservation of phenotype and genotype. Am. Fish. Soc. Symp. 17:176-184.

Hebert, P. D. N., C. C. Wilson, M. H. Murdoch, and R. Lazar. 1991. Demography and ecological impacts of the invading mollusc *Dreissena polymorpha*. Canadian Journal of Zoology 69:405-409.

Henny, C.J., L.J. Blus, S.V. Gregory, and C.J. Stafford. 1981. PCBs and organochlorine pesticides in wild mink and river otters from Oregon. Worldwide Furbearer Conference Proceedings, August 3-11, 1980, pages 1763-1780. Frostburg, MO.

Henny, C.J., R.A. Grove, and O.R. Hedstrom. 1996. A field evaluation of mink and otter on the lower Columbia River and the influence of environmental contaminants. Final report to the Lower Columbia Bi-State Water Quality Program, Portland, Oregon. 206 pp.

Henny, C.J., R.A. Grove, J.L. Kaiser, and V.R. Bentley. 2003a. An evaluation of osprey eggs to determine spatial residue patterns and effects of contaminants along the lower Columbia River. US Geologic Survey, Forest and Rangeland Ecosystem Science Center, Corvallis, OR.

Henny, C .J., J. L. Kaiser, R. A. Grove, V.R. Bentley, and J.E. Elliott. 2003b. Biomagnification factors (fish to osprey eggs from the Willamette River, Oregon, U.S.A.) for PCDDs, PCDFs, PCBs and OC pesticides. Environ. Monitoring and Assessment 84:275-315.

Hickey et al. 1998

Hinton, S.A., G.T. McCabe, Jr., and R.L. Emmett. 1990. Fishes, benthic invertebrates, and sediment characteristics in intertidal and subtidal habitats at five areas in the Columbia River estuary. Report to the U.S. Army Corps of Engineers, Contracts E86880158, E86890107, and E86900048. 92p.

Houston, J. J. 1988. Status of the green sturgeon, Acipenser medirostris, in Canada. The Canadian Field Naturalist 102:286-290.

Howerton, J., J. Dunn, G. Hockman, and J. Tabor. 1984. Key mammals of the Columbia River estuary. Final Report on the Wildlife Work Unit of the Columbia River Estuary Data Development Program, Columbia River Estuary Study Taskforce, Astoria, Oregon.

Hubbell, D.W. and J.L. Glenn. 1973. Distribution of radionuclides in bottom sediments of the Columbia River estuary. USGS Professional Paper 433-L, GPO, Washington, D.C.

Huiskes, A.H.L., B.P. Koutstaal, P.M.J. Herman, W.G. Beeftink, M.M. Markusse, and W. DeMunck. 1995. Seed dispersal of halophytes in tidal salt marshes. Journal of Ecology 83:559-567.

IBIS. 2003. Interactive Biodiversity Information System (http://ibis.nwhi.org), Northwest Habitat Institute, Corvallis, OR.

Idaho Power Company (IPC). 2003. Draft Snake River White Sturgeon Conservation Plan. Idaho Power CO., Boise, Idaho. 260 pp.

Independent Scientific Advisory Board (ISAB) of the Northwest Power Planning Council. November 28, 2000. The Columbia River estuary and the Columbia River Basin Fish and Wildlife Program. ISAB 2000-5.

Ingram, W.M. 1948. The large freshwater clams of California, Oregon, and Washington. J. Entom. Zool. 40:72-92.

Isaacs, F.B., R.G. Anthony, and D.P. Anderson. 1997. Bald eagle nest locations and and history of use in Oregon and the Washington portion of the Columbia River recovery zone, 1971 through 1997. Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis. 18p.

Isaacs, F.B., and R.G. Anthony. 2003. Bald eagle nest locations and history of use in Oregon and the Washington portion of the Columbia River Recovery Zone, 1971 through 2003. Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis. 36 pp.

Ivey, G.L., T.J. Hoffmann, and C. P. Herziger. In prep. Tracking movements of sandhill cranes using Ridgefield National Wildlife Refuge, Washington and Sauvie Island Wildlife Area, Oregon though their annual cycle.

Jager, H. I., VanWinkle, W., J. A. Chandler, K. B. LePla, P. Bates, and T. D. Counihan. 2002. A simulation study of factors controlling white sturgeon recruitment in the Snake River. Pages 127 -150 In: W. VanWinkle, P. Anders, D. Dixon, and D. Secor, eds. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Symposium 28.

Jay, D. A. 1984. Circulatory processes in the Columbia River estuary. Columbia River Estuary Study Taskforce, Internal report, CREST, 750 Commercial Street, Room 205. Astoria, Oregon, 97103. 169 p. plus appendices.

Jay, D.A. and P. Naik. 2002. Separating human and climate impacts on Columbia River hydrology and sediment transport. In: Southwest Washington Coastal Erosion Workshop Report 2000, G. Gelfenbaum and G.M. Kaminsky, eds., USGS Open File Report 02-229.

Jenkins, J. M. and R. E. Jackman 1993. Mate and nest site fidelity in a resident population of Bald Eagles. Condor 95:1053-1056.

Jenkins, J. M. and R. W. Risebrough. 1995. Chronic reproductive failures at a bald eagle (*Haliaeetus leucocephalus*) nesting territory in northern California. J. Raptor Research 29:33-36.

Johnson, D.H. and T.A. O'Neil (Managing Directors). 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis. 736p.

Johnson, G.E., H. Diefenderfer, T. Berquam, B.D. Ebberts, and J.D. Wilcox. September 30, 2003a. Research, monitoring, and evaluation plan for the Columbia River estuary and plume, Draft. Prepared by Bonneville Power Administration, the U.S. Army Corps of Engineers, Portland District, and the Pacific Northwest National Laboratory.

Johnson, G.E., R.M. Thom, A.H. Whiting, G.B. Sutherland, N. Ricci, J.A. Southard, B.D. Ebberts, and J.D. Wilcox. September 30, 2003b. An ecosystem-based approach to habitat restoration projects with emphasis on salmonids in the Columbia River estuary, Final Draft. Prepared by the Pacific Northwest National Laboratory, Columbia River Estuary Study Taskforce, Lower Columbia River Estuary Partnership, Bonneville Power Administration, and U.S. Army Corps of Engineers, Portland District.

Jones, K.K., C.A. Simenstad, D.L. Higley, and D.L. Bottom. 1990. Community structure, distribution, and standing stock of benthos, epibenthos, and plankton in the Columbia River estuary. *In* Columbia River: Estuarine System. Vol. 25. L.F. Small, *editor*. Progress in Oceanography. pp. 211-241.

Junge, C.O. and A.L. Oakley. 1966. Trends in production rates for upper Columbia runs of salmon and steelhead and possible effects of changes in turbidity. Fish Commission of Oregon Research Briefs 12(1):22-43.

Kaminsky, G.M., M.C. Buijsman, G. Gelfenbaum, P. Ruggiero, H.M. Jol, A.E. Gibbs, and C.D. Peterson. 1999. Synthesizing geological observations and processes – response data for modeling coastal change at management scale. Coastal Sediments, Proceedings of the Conference, American Society of Civil Engineers, June 21-23, 1999, Hauppauge, Long Island, New York.

Kaminsky, G.M., M.C. Buijsman, and P. Ruggiero. 2000. Predicting shoreline change at decadal scale in the Pacific Northwest, USA. Coastal Engineering, Proceedings of the Conference, American Society of Civil Engineers, June 16-21, 2000, Sydney, Australia.

Kaminsky, G.M. 2002a. A review of Columbia River dredging: past practices and recent proposals. *In* Southwest Washington Coastal Erosion Workshop Report, 2000, G. Gelfenbaum and G.M. Kaminsky, *eds*. United States Geological Survey, Open File Report 02-229, prepared in cooperation with the Washington State Department of Ecology.

Kaminsky, G.M. 2002b. Regional sediment management in the Columbia River littoral cell: problems and opportunities. *In* Southwest Washington Coastal Erosion Workshop Report, 2000, G. Gelfenbaum and G.M. Kaminsky, *eds*. United States Geological Survey, Open File Report 02-229, prepared in cooperation with the Washington State Department of Ecology.

Kaminsky, G.M., M.C. Buijsman, and P. Ruggiero. 2002a. Predicting shoreline change at management scale. *In* Southwest Washington Coastal Erosion Workshop Report, 2000, G. Gelfenbaum and G.M. Kaminsky, *eds*. United States Geological Survey, Open File Report 02-229, prepared in cooperation with the Washington State Department of Ecology.

Kaminsky, G.M., M.C. Buijsman, P. Ruggiero, and G. Gelfenbaum. 2002b. An integrated contemporary sediment budget for the Columbia River littoral cell. *In* Southwest Washington Coastal Erosion Workshop Report, 2000, G. Gelfenbaum and G.M. Kaminsky, *eds*. United States Geological Survey, Open File Report 02-229, prepared in cooperation with the Washington State Department of Ecology.

Kan, T.T. 1975. Systematics, variation, distribution and biology of lampreys of the genus *Lampetra* in Oregon. Dissertation for the Doctor of Philosophy, Oregon State University, Corvallis, OR.

Keister, G. P. Jr., R. G. Anthony, and H. R. Holbo. 1985. A model of energy consumption in bald eagles: an evaluation of night communal roosting. Wilson Bulletin 97:148-160.

Kirn, R.A., R.D. Ledgerwood, and R.A. Nelson. 1986. Increased abundance and the food consumption of northern pikeminnow (*Ptychocheilus oregonensis*) at River Kilometer 75 in the Columbia River. Northwest Sci. 60:197-200.

Kjelson, M.A. 1982. Life history of fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California. pp. 393-411 in V.S. Kennedy ed., Estuarine Comparisons, Academic Press, New York.

Knight, R. L., P. J. Randolph, G. T. Allen, L. S. Young, and R. J. Wigen. 1990. Diets of nesting bald eagles, *Haliaeetus leucocephalus*, in western Washington. Canadian Field-Naturalist 104:545-551.

Knight, R. L., V. Marr, and S. K. Knight. 1983. Communal roosting of bald eagles in Washington. *In* Anthony, R. G., F. B. Isaacs, and R. W. Frenzel (*eds*.). Proceedings of a workshop on habitat management for nesting and roosting bald eagles in the western United States. Sept. 7-9, 1983. Corvallis, OR.

Knutson, K.L. and V.L. Naef. December 1997. Management recommendations for Washington's Priority Habitats, Riparian. Washington Department of Fish and Wildlife, Olympia.

Kostow, K. 2002. Oregon lampreys: natural history status and analysis management issues. Oregon Department of Fish and Wildlife.

Kukulka, T. and D. A. Jay. 2003. Impacts of Columbia River discharge on salmonid habitat; changes in shallow-water habitat. Journal of Geophysical Research – Oceans.

Kynard, B. 1997. Life history, latitudinal patterns, and status of shortnose sturgeon, Acipenser brevirostrum. Environmental Biology of Fishes 48:319-334.

Lampman, B. 1946. The coming of the pond fishes. Benford and Mart, Portland, OR.

Larson, K.W. and Moehl, C.E. 1990. Entrainment of anadromous fish by hopper dredge at the mouth of the Columbia River. In: Effects of Dredging on Anadromous Pacific coast fishes. Workshop Proceedings, Seattle, September 8-9, 1988. p.102-112.

Lauritsen, D.D. 1986. Filter-feeding, food utilization, and nutrient remineralization by *Corbicula fluminea* (Bivalvia) and its contribution to nutrient cycling in a North Carolina river. Ph.D. Dissertation. Diss. Abst. Int. Pt. Sci. Eng. 46. 134p.

Lee, R.M. and J.N. Rinne. 1980. Critical thermal maxima of five trout species in the Southwestern United States. Transactions of the American Fisheries Society 109:632-635.

Levings, C.D., C.D. McAllister, and B.D. Chang. 1986. Differential use of the Campbell River estuary, British Columbia, by wild and hatchery-reared juvenile chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 43(7): 1386-1397.

Levy, D.A., and T.G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. Can. J. Fish. Aquat. Sci. 39:270-276.

Lichatowich, J. 1993. Ocean carrying capacity: recovery issues for threatened and endangered Snake River salmon. Bonneville Power Administration, U.S. Department of Energy, Technical Report, DOE/BP-99654-6. Portland, Oregon.

Lichatowich, J. 1999. Salmon without rivers: a history of the pacific salmon crisis. Island Press, Washington, D.C.

Lichatowich, J.A. and J.D. McIntyre. 1987. Use of hatcheries in the management of Pacific anadromous salmonids. American Fisheries Society Symposium 1: 131-136.

Littlefield, C. D., and G. L. Ivey. 2000. Conservation assessment for Greater Sandhill Cranes wintering on the Cosumnes River Floodplain and Delta regions of California. The Nature Conservancy, Galt, California.

Logerwell, E.A., N. Mantua, P. Lawson, R.C. Francis, and V. Agostini. 2003. Tracking environmental processes in the coastal zone for understanding and predicting Oregon coho (*Oncorhynchus kisutch*) marine survival. Fisheries Oceanography 12:1.

Lower Columbia Fish Recovery Board (LCFRB). July 24, 2003. Draft Washington lower Columbia River fish recovery plan technical foundation. Volume I: Salmonid species descriptions, limiting factors analysis, and recovery options. Volume II: Subbasin assessments. Volume III: Other fish and wildlife species. Volume IV: Conceptual framework. LCFRB, Longview, Washington.

Lowther, P.E., C. Celada, N.K. Klein, C.C. Rimmer, and D.A. Spector. 1999. Yellow Warbler Dendroica petechia. Pages 1-32 *in* Poole, A. and F. Gill (*editors*), The birds of North America, No. 454. The Birds of North America, Inc., Philadelphia, PA.

Mahaffy, M.S., K. M. Ament, A.K. McMillan, and D. E. Tillit. 2001. Environmental contaminants in bald eagles nesting in Hood Canal, Washington, 1992-1997. Final Report, Study: 13410-1130-1F05, U. S. Fish and Wildife Service, Olympia, Washington.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bull. Am. Meteorol. Soc. 78:1069-1079.

Marriott, D. and many others. 2002. Draft Lower Columbia River and Columbia River Estuary Subbasin Summary. Prepared for the Northwest Power Planning Council.

Martell, M.S., C.J. Henny, P.E. Nye and M.J. Solensky. 2001. Fall migration routes, timing, and wintering sites of North American Ospreys as determined by satellite telemetry. *Condor*: 103:715-724.

Martin, D.J., D.R. Glass, C.J. Whitmus, C.A. Simenstad, D.A. Milward, E.C. Volk, M.L. Stevenson, P. Nunes, M. Savvoie, and R.A. Grotefendt. 1986. Distribution, seasonal abundance, and feeding dependencies of juvenile salmon and non-salmonid fishes in the Yukon River Delta. NOAA OCSEAP Final Rep. 55(1988):381-770.

Mathews, S.B., and H.B. Senn. 1975. Chum salmon hatchery rearing in Japan, in Washington. Washington Sea Grant Publication WSG-TA 75-3:24 p.

Mazer, J.I., and M.P. Shepard. 1962. Marine survival, distribution and migration of pink salmon off the British Columbia coast. H.R. MacMillan Lectures in Fisheries, University of British Columbia, Vancouver. p. 113-121.

McCabe, G.T.. Jr., R.L. Emmett, W.D. Muir, and T.H. Blahm. 1986. Utilization of the Columbia River estuary by subyearling chinook salmon. Northwest Science 60(2):113-124.

McCabe, G.T., Jr., W.D. Muir, R.L. Emmett, and J.T. Durkin. 1983. Interrelationships between juvenile salmonids and non-salmonid fish in the Columbia River estuary. Fishery Bulletin, U.S. 81:815-826.

McConnell, R.J., S.J. Lipovsky, D.A. Misitano, D.R. Craddock, and J.R. Hughes. 1978. Habitat development field investigations, Miller Sands marsh and upland development site, Columbia River, Oregon. Technical Report D-77-38, Appendix B: Inventory and assessment of predisposal and postdisposal aquatic habitats. Report by the National Marine Fisheries Service to the U.S. Army Corps of Engineers, Portland, OR. 344p.

McIvor and Odum 1998 (note that this reference was unconfirmed at time of press)

Melquist, W.E. and A.E. Dronkert. 1987. Chapter 47: River Otter. *In* Wild Furbearer Management and Conservation in North America. Edited by M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch. Ontario Ministry of Natural Resources, Ontario Trappers Association, Toronto, Ontario, Canada. pp. 626-641.

Melquist, W.E. and M.G. Hornocker. 1983. Ecology of river otters in west Idaho. Wildlife Monographs Number 83. 60 pp.

Miles, E.L., A.K. Snover, A.F. Hamlet, B. Callahan, and D. Fluharty. 2000. Pacific Northwest regional assessment: the impacts of climate variability and climate change on the water resources of the Columbia River basin. Journal of the American Water Resources Association 36:399.

Miller, D.R. and C.W. Sims. 1983. Effects of flow on the migratory behavior and survival of juvenile fall and summer chinook salmon in John Day Reservoir. Report to the Bonneville Power Administration, Contract DE-A179-81BP-27602. 22p.

Miller, E.G. 1958. Clatsop County, Oregon: its history, legends, and industries. Metropolitan Press, Portland, OR.

Miller, J.A. and C.A. Simenstad. 1997. A comparative assessment of a natural and created estuarine slough as rearing habitat for juvenile chinook and coho salmon. Estuaries 20:792-806.

Moser, M. L., A. F. Olson, and T. P. Quinn. 1991. Riverine and estuarine migratory behavior of coho salmon (*Oncorhynchus kisutch*) smolts. Can. J. Fish. Aquat. Sci. 48:1670-1678.

Moritz, H.R., N.C. Kraus, E.B. Hands, and D.B. Slocum. 1999. Correlating oceanographic processes with seabed change, mouth of the Columbia River, USA. Coastal Sediments p. 1643-1659.

Moritz, R. 2002. Mouth of the Columbia River – trends in sediment management. *In* Southwest Washington Coastal Erosion Workshop Report, 2000, G. Gelfenbaum and G.M. Kaminsky, *eds*. United States Geological Survey, Open File Report 02-229, prepared in cooperation with the Washington State Department of Ecology.

Morrow, J. E.1980. The freshwater fishes of Alaska, Alaska Northwest Pub Co. Anchorage, Alaska.

Mote, P.W., E.A. Parson, A.F. Hamlet, W.S. Keeton, D. Lettenmaier, N. Mantua, E.L. Miles, D.W. Peterson, D.L. Peterson, R. Slaugther, and A.K. Snover. 2003. Preparing for climate change: the water, salmon, and forests of the Pacific Northwest. Climate Change 61:45-88.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Green sturgeon. Pages 26-34 in Fish species of Special Concern in California, 2nd edition. Final Report to the Department of Fish and Game (contract 2128IF).

Myers, K. W., and H.F. Horton. 1982. Temporal use of an Oregon estuary by hatchery and wild juvenile salmon, p. 377-392. *In*: V.S. Kennedy (*ed*.). Estuarine comparisons. Academic Press, New York, NY.

Nalepa, T. F. 1994. Decline of native unionid bivalves in Lake St. Clair after infestation by the zebra mussel, *Dreissena polymorpha*. Canadian Journal of Fisheries and Aquatic Sciences 51:2227-2233.

National Marine Fisheries Service (NMFS). 1998. Ecology of marine predatory fishes: Influence on salmonid ocean survival, 1998-present.

National Marine Fisheries Service (NMFS). 2000a. White paper: passage of juvenile and adult salmonids past Columbia and Snake River dams. Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, Washington, 98112-2097.

National Marine Fisheries Service (NMFS), Northwest Fisheries Science Center. 2000b. Preliminary data on contaminant concentrations in salmonids and prey from the Columbia River estuary. EC Division. Interim Report, Sept. 2000.

National Marine Fisheries Service (NMFS). December 21, 2000c. Biological Opinion, Reinitiation of consultation on the operation of the Federal Columbia River Power System, including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin.

National Marine Fisheries Service (NMFS). May 20, 2002. Biological opinion, Columbia River Federal navigation channel improvements project. Endangered Species Act – Section 7 Consultation and Magnuson-Stevens Act Essential Fish Habitat Consultation. National Marine Fisheries Service, Northwest Region, Seattle, WA.

National Marine Fisheries Service, Army Corps of Engineers, University of Washington, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, and the Oregon Graduate Institute. Estuarine habitat and juvenile salmon – current and historical linkages in the lower Columbia River and estuary, 2000-present.

National Marine Fisheries Service (NMFS), Oregon State University, and Oregon Graduate Institute. 1998 to present. Ocean survival of juvenile salmonids in the Columbia River plume.

Neal, V.T. 1972. Physical aspects of the Columbia River and its estuary. pp. 19-40 *In* A.T. Pruter and D.L. Alverson (*eds*.). The Columbia River estuary and adjacent ocean waters. Bioenvironmental Studies. Univ. Wash. Press, Seattle, WA.

Neeley et al. 1993 (note that this reference was unconfirmed at time of press)

Neeley et al. 1994 (note that this reference was unconfirmed at time of press)

Neilson, J.D., G.H. Green, and D. Bottom. 1985. Estuarine growth of juvenile chinook salmon (*Oncorhynchus tshawytscha*) as inferred from otolith mircrostructure. Canadian Journal of Fisheries and Aquatic Sciences 42:899-908.

Neilson, J.D. and G.H. Geen. 1986. First year growth rate of Sixes River chinook salmon as inferred from otoliths: effects on mortality and age at maturity. Transactions of the American Fisheries Society 115:28-33.

Nez Perce, Umatilla, Warm Springs, and Yakama Tribes. 1995. Wy-Kan-Ush-Mi Wa-Kish-Wit Spirit of the Salmon The Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes.

Noggle, C.C. 1978. Behavioral, physiological, and lethal effects of suspended sediments on juvenile salmonids. Thesis, University of Washington, Seattle. 87p.

Northwest Fisheries Science Center (NWFSC) Environmental Conservation Division. 2001 Draft. Potential impacts of toxic contaminants in salmonids and prey from the Columbia River estuary. 26p.

Northwest Habitat Institute (NHI). 2003. Webpage: www.nwhi.org.

Northwest Power Planning Council. 2001. Technical guide for subbasin planners. Northwest Power Planning Council Document 2001-20.

Office of Technology Assessment (OTS). 1993. Harmful nonindigenous species in the United States. Office of Technology Assessment, U.S. Congress, Washington, D.C., 391 p.

Olney, F.E. 1975. Life history and ecology of the northern pikeminnow *Ptychocheilus oregonensis* (Richardson) in Lake Washington. M. S. thesis, University of Washington, Seattle.

Paragamian, V. L., and G. Kruse. 2001. Kootenai River white sturgeon spawning migration behavior and a predictive model. North American Journal of Fisheries Management 21:10-21.

Paragamian, V. L., G. Kruse, and V. Wakkinen. 2001 Spawning habitat of Kootenai River white sturgeon, post-Libby Dam. North American Journal of Fisheries Management 21:22-33.

Parker, R.M., M.P. Zimmerman, and D.L. Ward. 1995. Variability in biological characteristics of northern squawfish in the lower Columbia and Snake Rivers. Transactions of the American Fisheries Society 124(3):335-346.

Parsley, M. J., D. Gallion, and M. B. Sheer. 2001. Effect of proposed reservoir drawdowns on productivity of white sturgeon Acipenser transmontanus populations. In: Proceedings of the Fourth International Symposium on Sturgeons, Oshkosh, Wisconsin. 8-13 July, 2001.

Parsley, M. J., L. G. Beckman, and G. T. McCabe, Jr. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society 122(2):217-227.

Parsley, M. J., P. J. Anders. A. I. Miller, L. G. Beckman, and G. T McCabe Jr. 2002. Recovery of white sturgeon populations through natural production: Understanding the influence of abiotic and biotic factors on spawning and subsequent recruitment. Pages 55-66 *In*: W. VanWinkle, P. Anders, D. Dixon, and D. Secor, *eds*. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Symposium 28.

Pearcy, W.G. 1992. Ocean ecology of North Pacific salmonids. University of Washington Press, Seattle, WA. 179p.

Perrin, C. J., A. Heaton, and M. A. Laynes. 1999. White sturgeon (*Acipenser transmontanus*) spawning habitat in the Lower Fraser River, 1988. Limnotek Research and Development Inc., Vancouver, BC Report to British Columbia Ministry of Fisheries, Victoria, BC.

Peterjohn, B. G. 2001. The birds of Ohio. Wooster Book Company, Wooster, OH.

Peterman, R.M. 1978. Testing for density dependent marine survival in Pacific salmonids. Journal of the Fisheries Research Board of Canada 35:1434-1450.

Petersen, J.H., R.A.Hinrichsen, D.M.Gadomski, D.H. Feil and D.W. Rondorf. In press. American shad in the Columbia River. American Fisheries Society Symposium.

Poe, T.P., H.C. Hansel, S. Vigg, D.E. Palmer, and L.A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in the John Day Reservoir, Columbia River. Trans. Am. Fish. Soc. 120:405-420.

Poe, T.P., R.S. Shively, And R.A. Tabor. 1994. Ecological consequences of introduced piscivorous fishes in the lower Columbia and Snake Rivers, p. 347-360. *In* D.J. Strouder, K.L. Fresh, and R.J. Feller (*ed*.) Theory and application in fish feeding ecology. University of South Carolina Press, Columbia, South Carolina.

Poole. A.F., R.O. Bierregaard, and M.S. Martell. 2002. Osprey *(Pandion haliaetus*). *In* The birds of North America, No. 683 (A. Poole and F. Gill, *eds*). The Birds of North America, Inc., Philadelphia, PA.

Puig, M.A., J. Armengol, G. Gonzalez, J. Peñuelas, S. Sabater, and F. Sabater. 1987. Chemical and biological changes in the Ter River induced by a series of reservoirs. *In* J.F. Craig and J.B. Kemper (*eds*.), Regulated streams, Plenum Press, New York, NY.

Quinn, J. S., and J. Sirdevan. 1998. Experimental measurement of nesting substrate preference in Caspian terns, Sterna caspia, and the successful colonization of human constructed islands. Biological Conservation 85:63-68.

R2 Resource Consultants, Inc. (R2). 2003. 2003 Lower Columbia River and estuary research needs identification workshop proceedings. Prepared for U.S. Army Corps of Engineers, Portland District, Oregon.

Raymond, H.L. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon and steelhead from the Snake River, 1966 to 1975. Transactions of the American Fisheries Society 108:505-529.

Reid, D.G., T.E. Code, A.C.H. Reid, and S.M. Herrero. 1994a. Food habits of the river otter in a boreal ecosystem. Can. J. Zool. 72: 1307-1313.

Reid, D.G., T.E. Code, A.C.H. Reid, and S.M. Herrero. 1994b. Spacing, movements, and habitat selection of the river otter in boreal Alberta. Can. J. Zool. 72: 1314-1324.

Reimers, P.E. 1971. The length of residence of juvenile chinook salmon in the Sixes River, Oregon. Doctoral dissertation, Oregon State University, Corvallis. 99p.

Reimers, P.E. 1973. The length of residence of juvenile chinook salmon in the Sixes River, Oregon. Fish Commission of Oregon Research Reports 4(2):1-43.

Rich, W.H. 1920. Early history and seaward migration of chinook salmon in the Columbia and Sacramento Riverss. Bull. Bur. Fish. (U.S.) 37:74 p.

Ricker, W.E. 1941. The consumption of young sockeye salmon by predaceous fish. J. Fish. Res. Board Can. 5:293-313.

Ridgway, R. 1895. The ornithology of Illinois. H. W. Rokker, Printer and Binder, Springfield, Illinois, Vol. II. 282 pp.

RL&L Environmental Services Ltd. 1994. Status of white sturgeon in the Columbia River, BC report prepared for BC Hydro, Environmental Affairs, Vancouver, BC by RL&L Environmental Services Ltd, Vancouver, BC Report No. 377F: 101 pp.

RL&L Environmental Services Ltd. 1996. Columbia River white sturgeon investigations. 1995 study results. Report prepared for BC Hydro, Kootenay Generation, Vancouver, BC, and BC Ministry of Environment, Lands, and Parks, Nelson Region. RL&L Report No. 96-377F: 94pp.

Robeck, G.G., C. Henderson, and R.C. Palange. 1954. Water quality studies on the Columbia River. U.S. Dept. Health Educ. Welfare, Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati, OH. 99p.

Roby, D.D., D.P. Craig, K. Collis, and S.L. Adamany. 1998. Avian Predation on Juvenile Salmonids in the Lower Columbia River 1997 Annual Report. Bonneville Power Administration Contract 97BI33475 and U.S. Army Corps of Engineers Contract E96970049. 70 pp.

Roby, D. D., K. Collis, D. E. Lyons, D. P. Craig, J. Y. Adkins, A. M. Myers, and R. M. Suryan. 2002. Effects of colony relocation on diet and productivity of Caspian terns. Journal of Wildlife Management 66:662-673.

Rolph, D.N. 1998. Assessment of neotropical migrant landbirds on McChord Air Force Base, Washington. Unpubl. rep. The Nature Conservancy of Washington, Seattle.

Romano, M.D., M.D. Howell, T.A. Rien.2002. Use of an Artificial Substrate to Capture Eulachon Eggs in the Lower Columbia River. Report C *In*: Eulachon Studies Related to Lower Columbia River Channel Deepening Operations. Final Report to US Army Corps of Engineers Contract No. W66QKZ13237198.

Roy, E.H., J.S. Creager, G.R. Gelfenbaum, C.R. Sherwood, and R.J. Stewart. 1982. An investigation to determine the sedimentary environments near the entrance to the Columbia River entrance. Contract Number DACW57-80-C0012, Final Report to the US Army Corps of Engineers, Portland District, Oregon.

Ruggiero, L.F., K.B. Aubry, A.B. Carey, and M.H. Huff. 1991. Wildlife and vegetation of unmanaged Douglas-fir forests. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-285. Portland, OR.

Ryan et al. 2001, 2002

Sakuramoto, K., and S. Yamada. 1980. A study on the planting effect of salmon. 1. A mathematical model for the derivation of their rate of return and its applications. Bull. Japanese Soc. Sci. Fish. 46(6):653-661.

Salo, E. O. 1991. Life history of chum salmon. *Pages 231-309 in* Pacific salmon life histories, C. Groot and L. Margolis *eds*. UBC Press, University of British Columbia, Vancouver.

Salo, E.O., and R.E. Noble. 1953. Chum salmon upstream migration, Pages 1-9. *In*: Minter Creek Biological Station progress report, September through October 1953. Washington Department of Fisheries, Olympia. 14 p.

Schempf, P. 1997. Bald eagle longevity record from southeastern Alaska. Journal of Field Ornithology 68:150-151.

Schloesser, D. W., and T. F. Nalepa. 1994. Dramatic decline of native unionid bivalves in offshore waters of western Lake Erie after infestation by the zebra mussel, *Dreissena polymorpha*. Canadian Journal of Fisheries and Aquatic Sciences 51:2234-2242.

Schluchter, M.D. and J.A. Lichatowich. 1977. Juvenile life histories of Rogue River spring chinook salmon (*Oncorhynchus tshawytscha* Walbaum), as determined by scale analysis. Information Report Series, Fisheries Number 77-5. Oregon Department of Fish and Wildlife, Research Section, Corvallis, OR.

Schreiner, J.V. 1977. Salmonid outmigration studies in Hood Canal, Washington. M.S. Thesis, Univ. of Washington, Seattle, 91p.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Ottawa.

Secor, D. H., P. J. Anders, W. Van Winkle, and D. A. Dixon. 2002. Can We Study Sturgeons to Extinction? What We Do and Don't Know about the Conservation of North American Sturgeons. Pages 3-12 *In* W. VanWinkle, P. Anders, D. Dixon, and D. Secor, *eds*. Biology, Management and Protection of North American Sturgeons. American Fisheries Society Symposium 28.

Sheridan, A.K. 1995. The genetic impacts of human activities on wild fish populations. Rev Fish Sci 3:91-108.

Sherwood, C.R. and J.S. Creager. 1990. Sedimentary geology of the Columbia River estuary. Prog. Oceanogr. 25: 15-79.

Sherwood, C.R., J.S. Creager, G. Gelfenbaum, and T. Dempsey. 1984. Sedimentary processes and environments in the Columbia River estuary. Columbia River Estuary Data Development Program, Columbia River Estuary Study Taskforce, Astoria, Oregon.

Sherwood, C.R., D.A. Jay, R.B. Harvey, P. Hamilton, and C.A. Simenstad. 1990. Historical changes in the Columbia River estuary. Pages 299-352 *in* M.V. Angel and R.L. Smith *eds*., Columbia River: estuarine system. Progress in Oceanography 25(1-4).

Simenstad, C.A., C.A. Morgan, J.R. Cordell, and J.A. Baross. 1994a. Flux, passive retention, and active residence active residence of zooplankton in Columbia River estuarine turbidity maxima. *In* K.R. Dyer and R.J. Orth (*eds*.). Changes in Fluxes in Estuaries: Implications from Science to Management. Olsen & Olsen. Fredensborg, Denmark.

Simenstad, C.A., D. Jay, C.D. McIntire, W.Nehlsen, C.R. Sherwood, and L.F. Small. 1984. The Dynamics of the Columbia River Estuarine Ecosystem, Vol. I and II. Columbia River Estuary Data Development Program, Astoria, OR.

Simenstad, C.A., D.J. Reed, D.A. Jay, J.A. Baross, F.G. Prahl, and L.F. Small. 1994b. Land-margin ecosystem research in the Columbia River estuary: an interdisciplinary approach to investigating couplings between hydrological, geochemical and ecological processes within estuarine turbidity maxima. *In* K.R. Dyer and R.J. Orth (*eds*.). Changes in Fluxes in Estuaries: Implications from Science to Management. Olsen & Olsen. Fredensborg, Denmark.

Simenstad, C. A., D. J. Reed, D. A. Jay, J. A. Baross, F. G. Prahl, and L. F. Small. 1995. Land-margin ecosystem research in the Columbia River estuary: investigations of the couplings between physical and ecological processes within estuarine turbidity maxima. *In* K. Dyer and R. Orth, (editors), Changing Particle Fluxes In Estuaries: Implications from Science to Management, p. 437-444. ECSA/ERF22 Symposium, Olsen & Olsen Press, Fredensborg.

Simenstad, C.A., and J.R. Cordell. 2000. Ecological assessment criteria for restoring anadromous salmonid habitat in Pacific Northwest estuaries. Ecological Engineering 15:283-302.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. pp. 343-364 in V.S. Kennedy ed., Estuarine Comparisons, Academic Press, New York.

Simenstad, C. A., L. F. Small, and C. D. McIntire. 1990. Consumption processes and food web structure in the Columbia River estuary. Prog. Oceanogr. 25:271-297.

Simenstad, C.A., W.G. Hood, R.M. Thom, D.A. Levy and D.L. Bottom. 2000. Landscape structure and scale constraints on restoring estrarine wetlands for Pacific Coast juvenile fishes. In M.P. Weinstein and D.A. Kreeger (editors), Concepts and Controversies in Tidal Marsh Ecology, - 597-630. Kluwer Academic Publ. Dordrecht, Norway.

Simenstad et al. in press (note that this reference was unconfirmed at time of press)

Simenstad and Wissmar 1983 (note that this reference was unconfirmed at time of press)

Simpson, J., and R. Wallace. 1981. Fishes of Idaho. University of Idaho Press, Moscow, Idaho.

Sinclair, R.M. 1971. Annotated bibliography on the exotic bivalve *Corbicula* in North America: 1900-1971. Sterkiana 43:11-18.

Skubinna, J.P., T.G. Coon, and T.R. Batterson. 1995. Increased abundance and depth of submersed macrophytes in response to decreased turbidity in Saginaw Bay, Michigan. Journal of Great Lakes Research 21(4): 476-488.

Smith, C.L. 1985. The inland fishes of New York state. New York State Department of Environmental Conservation, Albany. 522p.

Smith, D.G. 2001. Pennak's freshwater invertebrates of the United States, 4th Edition. John Wiley & Sons, Inc., New York, NY. 639p.

Smith, D.W. 1978. Tolerance of juvenile chum salmon (*Oncorhynchus keta*) to suspended sediments. Thesis, University of Washington, Seattle. 86p.

Smith et al. 1997

Smith, W.E., R.W. Saalfeld. 1955. Studies on Columbia River Smelt, *Thaleichthys pacificus* (Richardson). Fisheries Research Papers. Washington Dept. Fisheries 1:3-26.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services, Inc., Corvallis, Oregon, report to the National Marine Fisheries Service, Habitat Conservation Division, Portland, OR, Project TR-4501-96-6057.

Sprague et al. 1993

Stalmaster, M. V. 1981. Ecological energetics and foraging behavior of wintering bald eagles. Ph.D. Thesis, Utah State Univ., Logan. 157 pp.

Stalmaster, M. V. 1987. The Bald Eagle. Universe Books. New York. 227 pp.

Stehr C.M., D.W. Brown, T. Hom, B.F. Anulacion, W.L. Reichert, and T.K. Collier. 2000. Exposure of juvenile chinook and chum salmon to chemical contaminants in the Hylebos Waterway of Commencement Bay, Tacoma Washington. Journal of Aquatic Ecosystem Stress and Recovery 7: 215–227

Stein, J.E., T. Hom, T.K. Collier, D.W. Brown, and U. Varanasi. 1995. Contaminant exposure and biochemical effects in outmigrant juvenile chinook salmon from urban and nonurban estuaries of Puget Sound, Washington. Environmental Toxicology and Chemistry 14:1019-1029.

Stellini, J. 1987. Microclimate monitoring and protection policies of a deciduous bald eagle communal roost in Skagit County, Washington. Thesis, Evergreen State College, Olympia, WA.

Stinson, D.W., J.W. Watson, and K.R. McAllister. 2001. Washington state status report for the bald eagle. Washington Department of Fish and Wildlife, Olympia. 92p.

Stober, Q.J., M.R. Griben, R.V. Walker, A.L. Setter, I. Nelson, J.C. Gislason, R.W. Tyler, and E.O. Salo. 1979. Columbia River irrigation withdrawal environmental review: Columbia River fishery study. Report to the U.S. Army Corps of Engineers, Contract DACW 57-79-C-0090. 244p.

Tabor, J.E. 1976. Inventory of Riparian Habitats and Associated Wildlife Along the Columbia River, Oregon Cooperative Wildlife Research Unit, Oregon State University. 861 p.

Tabor, J.E. and H.M. Wight. 1977. Population status of river otter in western Oregon. Journal of Wildlife Management 41(4): 692-699.

Taylor, P. 1992. Bald eagles steal fish from river otters. Blue Jay 50(4):223-224.

Tetra Tech. 1993. Reconnaissance survey of the lower Columbia River. Task 6, Reconnaissance Report, Volume 1.

Tetra Tech. 1996. The health of the river 1990-1996. Integrated Technical Report 0253-01. Prepared for the Lower Columbia River Bi-State Water Quality Program.

Thomas, D. W. 1983. Changes in the Columbia River estuary habitat types over the past century. Columbia River Estuary Data Development Program, Columbia River Estuary Task Force, Astoria, Oregon. 51p.

Thompson, C. January 7, 2001. Chinook quest opens a new era. The Oregonian.

Thompson, R.B. 1959. Food of the pikeminnow *Ptychocheilus oregonensis* (Richardson) of the Lower Columbia River. Fish. Bul. 60:43-58.

Thorpe, J.E. 1994. Salmonid fishes and the estuarine environment. Estuaries 17(1A):76-93.

Tiffan, K.F., D.W. Rondorf, and P.G. Wagner. 2000. Physiological development and migratory behavior of subyearling fall chinook in the Columbia River. North American Journal of Fisheries Management 20:28-40.

Toweill, D.E., and J.E. Tabor. 1982. The northern river otter. *In* Wild mammals of North America: biology, management, and economics. Edited by J.A. Chapman and G.A. Feldhamer. John Hopkins University Press, Baltimore, MD. pp. 688-703.

U.S. Army Corps of Engineers (USACE). 1996. Lower Columbia River Bi-State Water Quality Program Fish, Wildlife and Wetlands GIS Mapping. USACE Portland District, Geotechnical Engineering Branch, GIS, Survey, and Mapping Section. Report submitted to the Bi-State Water Quality Program. Portland, Oregon.

U.S. Army Corps of Engineers (USACE). 1999. Columbia River channel improvement study – final integrated feasibility report and environmental impact statement.

U.S. Army Corps of Engineers (USACE). December 28, 2001. Biological assessment, Columbia River channel improvements project.

U.S. Army Corps of Engineers (USACE). 2002. Draft Columbia River 43-ft. navigation channel deepening sedimentation impacts analysis. U.S. Army Corps of Engineers, Portland District, Oregon.

U.S. Fish and Wildife Service (USFWS). 1976. Columbian White-tailed deer recovery plan.

U.S. Fish and Wildife Service (USFWS). 1978. Determination of certain Bald Eagle populations as Endangered or Threatened: Final rulemaking. Department of the Interior, Fish and Wildife Service. Federal Register Vol. 43 No.31(14 February):6230-6233.

U.S. Fish and Wildife Service (USFWS). December 6, 1999a. Biological opinion for the Columbia River channel deepening. U.S. Fish and Wildife Service, Oregon State Office, Portland.

U.S. Fish and Wildife Service (USFWS). 1999b. Changes in productivity and environmental contaminants in bald eagles nesting along the lower Columbia River, Final Report. U.S. Fish and Wildife Service, Oregon State Office, Portland.

U.S. Fish and Wildife Service (USFWS). May 20, 2002. Biological and conference opinions for the Columbia River channel improvements project. U.S. Fish and Wildife Service, Oregon State Office, Portland.

U.S. Fish and Wildife Service. 2002. Environmental contaminants in aquatic resources from the Columbia River. Final Draft Report, Oregon State Office, Portland.

U.S. Geological Survey (USGS). 2002. USGS Biological Resources Division, Center for Aquatic Resource Studies, Nonindigenous Aquatic Species webpage http://nas.er.usgs.gov/

U.S. National Science Foundation (NSF). 2003. Columbia River Estuarine Turbidity Maxima, Land-Margin Ecosystem Research Project (http://depts.washington.edu/cretmweb/CRETM.html).

Van Eenennaam, J. P., and S. I. Dorsohov. 2001. Reproductive conditions of Klamath River green sturgeon (Acipenser medirostris). Proceedings of International Symposium on Sturgeon, Wisconsin. (In review for Journal of Applied Ichthyology).

Wagner, H.H., E.P. Conte, and J.L. Fessler. 1969. Development of osmotic and ionic regulation in two races of chinook salmon *Oncorhynchus tshawytscha*. Comparative Biochemistry and Physiology 29:325-341.

Walburg, C.H. and P.R. Nichols. 1967. Biology and management of the American shad and status of the fisheries, Atlantic coast of the United States, 1960. U.S. Fish and Wildife Service, Spec. Sci. Rep. Fish. 550. 105p.

Waldeck, R.D., C. Chapman, J. Cordell, and M. Sytsma. May 2003. Lower Columbia River aquatic nonindigenous species survey, 2001-2003, Interim Report.

Walker, R.V., K.W. Myers, N.D. Davis, K.Y. Aydin, K.D. Friddland, H.R. Carlson, G.W. Boehlert, S. Urawa, Y. Ueno, and G. Anma. 2000. Diurnal variation in the thermal environment experienced by salmonids in the North Pacific as indicated by data storage tags. Fisheries Oceanography 11:171.

Wang, Y. L., F. P. Binkowski, and S. I Doroshov. 1985. Effect of temperature on early development of white and lake sturgeon Acipenser transmontanus, and A. fulvescens. Environmental Biology of Fishes 14:43-50.

Washington Department of Ecology (WDOE). 2003. Water Quality, Noxious Freshwater Weed Program webpage http://www.ecy.wa.gov/programs/wq/plants/weeds/index.html.

Washington Department of Fish and Wildlife (WDFW). 2001. Washington and Oregon Eulachon Management Plan. WDFW, ODFW. Olympia, Washington.

Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW) 2002. Status report—Columbia River fish runs and fisheries, 1938-2000.

Washington Department of Natural Resources (WDNR). 1996. Draft environmental impact statement, habitat conservation plan. Washington Department of Natural Resources in cooperation with the U.S. Fish and Wildife Service and the National Marine Fisheries Service. Olympia, WA.

Washington Department of Natural Resources (WDNR). 1998. Our changing nature, natural resource trends in Washington State. Washington Department of Natural Resources, Olympia, WA.

Watson, J. W., M. G. Garrett, and R. G. Anthony. 1991. Foraging ecology of bald eagles in the Columbia River estuary. J. Wildlife Management 55(3):492-499.

Watson, J. W., and D. J. Pierce. 1998. Ecology of bald eagles in western Washington with an emphasis on the effects of human activity. Final Report. Washington Dept. of Fish and Wildlife, Olympia, WA.

Watt, J., B. Krausse, and T. M. Tinker. 1995. Bald eagles kleptoparasitizing sea otters at Amchitka Island, Alaska. Condor 97:588-590.

Weitkamp, D. May 2001. Presentation at Sustainable Ecosystems Institute workshop.

Weitkamp, L.A. 1994. A review of the effects of dams on the Columbia River estuarine environment, with special reference to salmonids. Bonneville Power Administration, Portland, Oregon, and Coastal Zone and Estuarine Studies Division, National Marine Fisheries Service, Seattle, Washington.

Welander, A.D. 1940. Notes on the dissemination of shad, *Alosa sapidissima* (Wilson), along the Pacific coast of North America. Copeia 1940(4): 221-223.

Welch, D.W., Y. Ishida, and K. Nagasawa. 1998. Thermal limits and ocean migrations of sockeye salmon (*Oncorhynchus nerka*): long-term consequences of global warming. Canadian Journal of Fisheries and Aquatic Sciences 55:937.

Western Regional Climate Center (WRCC). 2003. Monthly climate summaries for select Oregon stations: Astoria WSO Airport (350328), St. Helens RFD (357466), and Bonneville Dam (350897). WRCC website, www.wrcc.dri.edu.

Whetten, J.T., J.C. Kelly, and L.G. Hanson. 1969. Characteristics of Columbia River sediment and sediment transport. Journal of Sedimentary Petrology 39:1149-1166.

Wiemeyer, S.N., C.M. Bunck, and A.J. Krynitsky. 1988. Organochlorine pesticides, polychlorinated biphenyls, and mercury in osprey eggs – 1970-1979 – and their relationship to shell thinning and productivity. Arch. Environ. Contam. Toxicol. 17:767-787.

Williams, R.N., L.D. Calvin, C.C. Coutant, M.W. Erho, J.A. Lichatowich, W.J. Liss, W.E. McConnaha, P.R. Mundy, J.A. Stanford, and R.R. Whitney. 1996. Return to the river: restoration of salmonid fishes in the Columbia River ecosystem. The Independent Scientific Group, Northwest Power Planning Council (NPPC 96-6), Portland, Oregon.

Williams, R.N., L.D. Calvin, C.C. Coutant, M.W. Erho, J.A. Lichatowich, W.J. Liss, W.E. McConnaha, P.R. Mundy, J.A. Stanford, and R.R. Whitney. 2000. Return to the river: restoration of salmonid fishes in the Columbia River ecosystem (Revised). The Independent Scientific Group, Northwest Power Planning Council, Portland, Oregon.

Wissmar, R.C. and C.A. Simenstad. 1988. Energetic constraints of juvenile chum salmon (*Oncorhynchus keta*) migrating in estuaries. Canadian Journal of Fisheries and Aquatic Sciences 45:1555-1560.

Wissmar, R.C., and C.A. Simenstad. 1998. Variability of riverine and estuarine ecosystem productivity for supporting pacific salmon. *In* Change in Pacific Northwest Coastal Ecosystems. G.R. McMurray and R.J. Bailey, *editors*. NOAA Coastal Ocean Program, Decision Analysis Series No. 11. Pp. 253-301.

Witty, K., C. Willis, and S. Cramer. 1995. A review of potential impacts of hatchery fish on naturally produced salmonids in the migration corridor of the Snake and Columbia Rivers. *In*: Columbia Basin Fish and Wildlife Authority. 1996. Impacts of artificial salmon and steelhead production strategies in the Columbia River Basin. Prepared for the U.S. Fish and Wildife Service, National Marine Fisheries Service, and Bonneville Power Administration, Portland, OR.

Wright, P.L. 1963. Variations in reproductive cycles in North American mustelids. *In* Delayed Implantation. Edited by A.C. Enders. University of Chicago Press, Chicago, Illinois. p. 77-97.

Wydowski, R. S., and R. R. Whitney. 1979. Inland Fishes of Washington. University of Washington Press. Seattle.

2.2 Western Oregon Tributaries

2.2.1 *Overview and General Purpose*

Section 2.1, The Estuary and Mainstem Assessment (EMA), identified limiting factors and describes the mechanisms by which the ecosystem functions of the subbasin are connected to the focal species, species of management interest, species of recreational interest, and species of ecological concern. Because EMA is focused primarily on the key processes of the Estuary and Mainstem, a need was identified early in the subbasin planning process to have a supplementary assessment effort that provided a means to include Oregon's western most watersheds (referred to throughout this document as the Western Oregon tributaries, or "WOTs") in the basin that were not otherwise part of other subbasin planning efforts. The Western Oregon tributaries (WOTs) are not considered a distinct subbasin by the Northwest Power and Conservation Council (NPCC): the planning group for the Mainstem Lower Columbia River and Columbia River Estuary subbasin planning team adopted the term "subbarea" to refer to this area that needed some separate treatment and consideration, but which did not warrant its own subbasin management plan.

Inclusion of this subbarea in the Mainstem Lower Columbia River and Columbia River Estuary subbasin planning process was a task added by the Oregon Tier II group, and a small budget was established for this additional work. Oregon Tier II was not seeking a full assessment, as watershed assessments already exist for much of this area. The following watersheds are adjacent to the Columbia River Estuary, have completed assessments, and are not part of other subbasins in the province:

- Lower Columbia-Klaskanine
- Scappoose Bay
- Nicolai-Wickiup
- Youngs Bay
- Skipanon

Subbasin planning in the Western Oregon tributaries (WOTs) subarea was limited to extracting key information and recommendations from existing completed watershed assessements; supplementing these assessments with an assessment process known as "Qualitative Habitat Assessment (QHA)" for key tributaries to provide a focal species context for recommendations; and identifying goals and objectives resulting from the efforts of the Willamette/Lower Columbia River Technical Recovery Team(WLC-TRT) that would fit within the context of the subbasin planning effort.

The products of these integrated assessments are "working hypotheses" that characterize the functionality and qualities of the WOTs subarea and a list of prioritized reaches that may be candidates for restoration or protection work. While not exhaustive, this list provides an indication of key habitat attributes that may be considered "limiting" with respect to the selected focal species.

These working hypotheses and limiting factors are integrated into the subbasin management plan. First, the prescribed biological and physical objectives for the focal species in

the management plan have been adjusted to reflect needs that are unique to the WOTs subarea. Second, the applicability of other measures identified as part of the Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan to the WOTs subbarea are identified.

2.2.2 *General Description of the Western Oregon Tributaries Subarea*

Throughout the Pacific Northwest there have been substantial declines in salmonid runs. This fact has prompted the National Marine Fisheries Service (NMFS) and US Fish and Wildife Service (USFWS) to list several species of salmonids as threatened or endangered within the Columbia River system. In the NMFS final rule for "Designated Critical Habitat for 19 Evolutionarily Significant Units (ESU) of Salmon and Steelhead in Washington, Oregon, Idaho, and California" the Western Oregon tributaries are listed under nine different ESU's as critical habitat (NMFS, FEB 16, 2000). This population trend is not new; it has its roots in the colonization and subsequent industrialization of the northwest. Because the depletion is the cumulative effect of multiple human activities over a wide geographic area, identification of a single cause is not possible. Factors for the declining populations include a variety of factors from hydroelectric developments and habitat loss to unsuccessful management strategies and competition from hatchery fish. (PSU, 2002)

Watershed assessments produced by local watershed councils in Oregon identified issues of concern and potential causes for locally depleted salmonid runs. These issues are based on regulatory listings and land use categories and provided an outline of potential watershed issues during the initial phases of the assessment. The issues identified include:

- Declining wild salmon and steelhead populations;
- Water quality parameters for E. Coli and dissolved oxygen which exceed the state standards in the Clatskanie River;
- Loss of streamside vegetation and function and increased amount of sediment entering streams from forestry activities;
- High summer water temperatures in streams;
- Stream straightening and channeling;
- Undersized or failing culverts creating migration barriers and potential for slopefailures;
- Degraded instream salmonid habitat due to flow alteration, lack of woody debris, and channel scouring.

2.2.3 *Summary of Existing Watershed Assessments*

In 1999 and 2000, watershed assessments were completed throughout the region as part of an Oregon Watershed Enhancement Board (OWEB) to ensure that local watershed councils were provided with the data and structure necessary to launch projects in their watersheds in a systematic, scientifically based manner. The watershed assessments lay the foundation for restoration and protection projects by intentorying riparian conditions, habitat types, geomorphology, and water quality parameters. In integrating the WOTs subarea with the Mainstem Lower Columbia River and Columbia River Estuary subbasin plan, a key goal identified by the planning group was to not duplicate work that had already been completed. Rather, the intent was to provide a mechanism whereby the subarea could affiliate itself with a

larger body of work being completed for the mainstem and estuary as part of the Northwest Power and Conservation Council's (NPCC) fish and wildlife program.

Key information from watershed assessments is reproduced here. Every effort has been made to reference the appropriate assessment while minimizing the number of citations needed to do so.

2.2.3.1 Lower Columbia-Clatskanie

Portland State Unversity (PSU, 2000) prepared a watershed assessment for the Lower Columbia River Watershed Council. The goal of the assessment was to evaluate the conditions within the watershed and develop habitat protection plans and enhancement and restoration priorities. This assessment forms part of the technical foundation upon which the Western Oregon tributaries assessment builds, and should be viewed as the primary reference guide for planners and landowners wishing to put watershed information in the context of subbasin planning.

2.2.3.1.1 Setting

The Lower Columbia-Claskanie Watershed Assessment (PSU, 2000) describes the subbasin as follows:

"Located in the northwest corner of Oregon, the subbasin spans two counties and contains five cities with the largest, St. Helens, being partially contained within its boundaries. Bounded by the Columbia River to the north, the Coast Range and Willamette Valley to the south, the subbasin contains a broad range of climatic and geographic characteristics. Elevations range from sea level along the tidally influenced Columbia River to 3007 feet on the slopes of Nicolai Mountain. The subbasin drains 298 square miles and contains three fifth field watersheds Plympton Creek, Clatskanie River, and Beaver Creek. These fifth field watersheds are based on the Regional Ecosystem Office's 1996 designations. Of these three, the Clatskanie River is the only true watershed, within which all of the streamflow is channeled through a common outlet."

2.2.3.1.2 Key Findings/Recommendations

The watershed assessment is being used as a guide for the prioritization and design of restoration projects. The assessment identifies the following list of needs:

- Complete fieldwork to verify impacts to wetlands from road building within the interior of the subbasin
- Incorporate the list of data gaps identified in each section of the watershed assessment in a monitoring program
- Conduct culvert inventories and natural barrier evaluations to determine if all potential habitat is accessible and being utilized by the species of concern
- Conduct aquatic habitat surveys and biological surveys for some watersheds to determine the current status of habitats and verify the assumptions made for the distribution of the species of concern. Watersheds that need to be surveyed include: Green Creek, Goble Creek, Beaver Creek (below the falls), Merrill Creek, Tide Creek, Fox Creek, Nice Creek and McBride Creek
- Include the following subwatersheds, within the Clatskanie River watershed, in the surveys: Page Creek, North Fork Clatskanie River and Little Clatskanie River

- Address the lack of large woody debris for instream habitat complexity, high stream temperatures, a lack of large conifers within the riparian zone and floodplain connectivity

2.2.3.2 Scappoose Bay

David Evans Associates (DEA, 2000) prepared the watershed assessment for the Scapoose Bay Watershed Council. The goal of the assessment was to evaluate the conditions within the watershed and develop habitat protection plans and enhancement and restoration priorities. This assessment forms part of the technical foundation upon which the Western Oregon tributaries assessment builds, and should be viewed as the primary reference guide for planners and landowners wishing to put watershed information in the context of subbasin planning.

2.2.3.2.1 Setting

DEA (2000) described the setting for the watershed as follows:

"Although relatively small in size (85,000 acres), the Scappoose Bay watershed historically supported four of six species of salmon found in the Pacific Northwest. It contained a broad diversity of habitats, ranging from small, steep mountain streams to extended low-gradient stream valleys to the lowland floodplain of the Columbia River estuary. Over the past 150 years, the watershed has been impacted by a broad range of uses: agriculture, forestry, surface mining, and residential and industrial development. The dramatic decline in all species of salmonids in the watershed is not due to one or even several independent habitat-impacting activities, but rather to a complex interplay of activities that have degraded specific habitats used at particular times in the life histories of the fish. Included in this complex scenario is the effect of introduced hatchery fish and fishery management policies, as well as the shift to poor ocean conditions along the Oregon and Washington coasts throughout the 1980s."

2.2.3.2.2 Key Finding/recommendations

The following findings and recommendations are excerpted from DEA (2000):

"Protection projects are a higher priority than restoration projects. Protecting habitat is generally much more cost-effective and successful than trying to restore it after it is degraded. Salmon refugia areas, especially high priority focal watersheds and nodal habitats, are the most important areas in which to focus protection efforts."

"Salmon refugia areas should also be the focus for restoration efforts. Restoration is more critical in refugia areas that are strongholds for salmon production in the basin. For example, a higher priority would be placed on removing an unstable road that threatens habitat in a focal watershed than in a highly degraded watershed. Restoration projects should focus on identified high priority focal watershed and nodal salmon refugia areas and then expand to adjunct habitats."

DEA proposd that the watershed council complete projects with a low risk of potential environmental impacts and a high probability of success. For example, in most cases, a riparian planting project or fish passage barrier removal project would be of higher priority than a large wood placement project. DEA proposed that “as more is learned about the watershed, higher risk and more experimental projects can be pursued with more confidence and greater chance of success”.

DEA also suggested that the watershed council use non-regulatory approaches for habitat protection and restoration. The projects proposed by DEA are intended as cooperative projects with willing landowners. Regulatory means of protecting and restoring habitat are a critical tool for protecting habitat, but are not discussed here.

2.2.3.2.3 Protection and Restoration Criteria

The following strategies are excerpted from the Scappoose Bay Watershed Assessment (DEA, 2000).

Protection

"Refugia were evaluated for the purpose of identifying the highest priority areas for protection through land acquisition or conservation easement from willing land owners. Key criteria used to prioritize areas are based on the Washington Inter-Agency Committee for Outdoor Recreation (IAC). (IAC) criteria for evaluating critical habitat proposals for state funding, as listed below:

- Ecological quality
  - Salmonid species diversity
  - Other fish and wildlife species diversity
  - Rarity of habitat type in watershed and region
- Connectivity
  - Ecological importance to surrounding areas
- Long-term manageability
  - Agency or Land Trust for long-term management
  - Risk of adjoining land uses impacting the area
- Public support
  - Likely support from the Watershed Council, county, agencies
  - Landowner support
- Cost efficiency
  - Opportunity for funding partners, cost-share
  - Cost per acre of habitat
- Threats
  - Likelihood of adverse impact if not protected

Protection is recommended for the four biologically highest priority refugia areas in Table 2-18 below. Acquisition or a permanent conservation easement is recommended for all the Scappoose Estuary wetland areas, with highest priority being refugium 18SC at the south end of Scappoose Bay. As a means of protecting headwater refugia, BLM, the City of Scappoose, and private timber companies may be willing to increase protection standards for riparian areas and potential unstable slopes or sell conservation easements to protect these areas or entire

watersheds. BLM owns a large percentage of the remaining headwater refugia areas. BLM's cooperation in protecting these refugia may be critical to the survival and restoration of salmon populations in the watershed."

Restoration

A list of general restoration projects was developed and prioritized based on the following considerations.

- Addresses key habitat problems or limiting factors identified in assessment
- Cost efficiency (large habitat gain for cost)
- Long-term effectiveness
- High degree of confidence in successful project
- Non-confrontational approach
- Located in identified salmon refugia area
- Adequate information is available to conduct project

Specific restoration recommendations are premature in most cases because of the lack of comprehensive field data. Thus, a high priority should be placed on further study directed at the top five data gaps. Completion of this work will provide a solid comprehensive baseline of fish and habitat data for the watershed and allow project level planning for specific fish passage and road maintenance projects.

As an interim step, riparian planting projects in adjunct refugia areas can be completed at any time. These projects pose a low risk of unanticipated environmental impacts and are very good projects for gaining volunteer involvement in watershed restoration. Areas shown on the riparian condition map as "grass/forb" and some "shrub/partial forest" areas are the highest priorities for planting. Native conifer and hardwoods should be planted.

Riparian and channel treatments need more intense evaluation. LWD placement is probably warranted in much of the adjunct habitat areas, but high flows in the lower reaches make long-term success difficult. More intensive restoration includes restoring the floodplains of adjunct habitat areas. This can be done by placement of abundant large wood in the channel, restoring historic meanders and side-channels, riparian planting, and possibly even re-introduction of beaver following several years of site planting. These projects generally require engineered designs and careful consideration of the historical and current geomorphology of the site, as well as potential impacts to adjacent property owners. "

Table 2-18. Prioritized List of Protection and Restoration Opportunities From Scappoose Bay Watershed Assessment (DEA, 2000)

Priority	Protection/Restoration Opportunity	Location	Comprehensive Study Needed	Field Recon. Needed
1	Protect Scappoose Estuary	Nodal refugia # 18SC, 19JA, 20JA, 21JA		X
2	Protect South Scappoose Creek Headwaters	Headwater refugium # 9SC		X
3	Protect North Scappoose Creek Headwaters	Headwater refugium # 8SC		X
4	Protect Gourlay Creek	Refugium # 11SC		X
5	Address 5 top priority data gaps		X	
6	Fish passage barrier correction projects	Undefined areas throughout watershed	X	
7	Road maintenance/ removal projects	Undefined areas throughout watershed	X	
8	Riparian planting	Adjunct refugia – grass/forb riparian vegetation type		X
9	Large woody debris placement	Adjunct refugia		X
10	Floodplain restoration	Adjunct refugia		X

2.2.3.3 Youngs Bay, Nicolai-Wickiup River and Skipanon River Watershed

Watershed assessments were completed in 1999 and 2000 to inventory and characterize watershed conditions of the Youngs Bay, Nicolai-Wickiup and Skipanon River watersheds and to provide recommendations that address the issues of water quality, fisheries and fish habitat, and watershed hydrology. These assessments were conducted by reviewing and synthesizing existing data sets and some new data collected by the watershed council, following the guidelines outlined in the Oregon Watershed Enhancement Board (OWEB) watershed assessment manual (WPN 1999).

2.2.3.3.1 Setting

.2.2.3.3.1.1 Skipanon Watershed

The Skipanon Watershed Assessment (Bischoff *et.al*., 2000b) has only a slim northern boundary which adjoins the estuary at the mouth of the Columbia River. Treatmnent of this watershed in this assessment is provided as background only. Bsichoff et al (2000b) describe the watershed as follows:

"The Skipanon River is a small fifth watershed located in the northwest corner of Clatsop County and includes a major portion of the city of Warrenton. The Skipanon River is the first tributary to the Columbia River estruary on the Oregon side and drains approximately 28 square miles. The Skipanon Watershed is unique in that it is located on the Clatsop Plains and characterized by coastal dunes, wetlands in the low inter-dune and floodplain areas, and forested in the uplands. There is significant development pressure in the City of Warrenton and conflicts between development and wetland protections".

"Lakes are also a prominent landscape feature in the Clatsop Plains area. Major lakes in the Skipanon Watershed include Coffenberry Lake, Smith Lake, and Cullaby Lake. The 8th Street Dam project on the mainstem Skipanon River is a prime example of successful community-based restoration in the Skipanon. The tide gate structure was retrofitted with a lifting mechanism to support estuarine tidal flushing and fish passage during times of the year

when flooding is not a concern. The Watershed Council has collected significant water quality information documenting the success of the restoration and is also conducting spawning surveys in the upper portions of the watershed at Cullaby Creek where increased adult spawning activity as a result of the project has been documented. "

"The Skipanon Watershed Assessment indicates that Coho, Coastal Cutthroat, Chum, Chinook, and Steelhead salmon species utilize Skipanon River and its watershed. Additionally, several species of threatened and endangered salmon species either reside in the Skipanon or utilize estuarine portions of the Skipanon watershed as a rearing, foraging, and migratory transition area in parts of their life cycles. This makes conditions in lower Skipanon tributaries, particularly the estuary, critical habitat for local as well as up river Columbia Basin fish populations."

.2.2.3.3.1.2 Youngs Bay Watershed

The following description is excerpted from Bsichoff et al (2000a):

"Youngs Bay watershed is a fifth field watershed located in the northwest corner of Clatsop County. Youngs Bay itself is an arm of the Columbia River Estuary situated between the cities of Astoria and Warrrenton and is approximately two miles wide at its confluence with the estuary. The Lewis and Clark River, Youngs River, Klaskanine River, and Walluski River flow into Youngs Bay, drain approximately 184 square miles. The primary land use in the Youngs Bay watershed is timber harvest, with agriculture in the lowlands, and rural residential."

"Restoration projects that improve water quality and fish passage in tidal areas of the Youngs Bay Watershed have been a focus of the Watershed Council. Significant efforts have been made in improving slough habitats and riparian habitat on the lower Lewis and Clark River. Enhancement activities include repairing and replacement of older non-functioning tide gate structures at Hanson Creek and Green Slough in the summer or 2002 with lighter tide gates retrofitted for fish passage. Fish monitoring at Hanson Creek documented successful juvenile salmon passage and use of the area behind the tidegate in a matter of days after the project was complete. Riparian restoration activities in the watershed and wood crib installation in tidal areas is also occurring in Youngs Bay. Monitoring demonstrates juveline salmon use of areas behind tide gates after improvement projects were completed and efforts continue to work with the community on these types of projects in Youngs Bay. "

"The Youngs Bay Watershed Assessment indicates that Coho, Coastal Cutthroat, Chum, Chinook, and Steelhead salmon species utilize Youngs Bay and its watershed. Additionally, several species of threatened and endangered salmon species either reside in Youngs Bay or utilize estuarine portions of Youngs Bay as a rearing, foraging, and migratory transition area in parts of their life cycles. This makes conditions in lower Youngs Bay tributaries particularly the estuary critical habitat for local as well as up river Columbia Basin fish populations".

.2.2.3.3.1.3 Nicola-Wickiup Watershed

E&S Environmental Chemistry (2000) describe the watershed as follows:

"The Nicolai Wickiup watershed is a fifth field watershed located in the northwest corner of Clatsop County. The watershed consists of three major creeks that flow directly into the Columbia River Estuary including Bear Creek, Big Creek, and Gnat Creek. The watershed

drains approximately 114 square miles. The primary land use in the Nicolai Wickiup watershed is timber harvest, with some agriculture in the lowerlands, and rural residential.

The majority of the Bear Creek subwatershed is owned by the City of Astoria and acts as the primary source of municipal water. Bit Creek subwatershed supports the ODFW Big Creek Fish Hatchery, which limits access by anadromous fish in the upper protions of the watershed. ODFW has experimented with fish passage above the hatchery, and the local watershed council is very interested in pursuing additional passage efforts".

The Nicolai Wickiup Watershed Assessment indicates that Coho, Coastal Cutthroat, Chum, Chinook, and Steelhead salmon species utilize the watershed. Additionally, several species of threatened and endangered salmon species either reside in the watershed or utilize estuarine portions of the watershed as a rearing, foraging, and migratory transition area in parts of their life cycles. This makes conditions in the Nicolai Wickiup watershed and, in particular, the estuary critical habitat for local as well as up river Columbia Basin fish populations (E&S Environmental Chemistry, 2000).

2.2.3.3.2 Key Finding/recommendations

The following needs were commonly identified in the OWEB watershed assessment conducted by most watershed councils in the Columbia River Estuary Subbasin and are consistent with the findings for the Youngs Bay, Nicolai-Wickiup, and Skipannon Watershed Assessments:

- Prioritize restoration and watershed management activities in areas with known salmonid use for both spawning and rearing, following protocols established by state and federal government.
- Maintain data in an accessible location and format.
- Collect additional data in priority areas.
- Get expert advice on data collection and processing.
- Evaluate the GIS data layers.
- Verify all land use categories before restoration actions occur.
- Develop a study to verify the accuracy of the roads coverage.
- Verify the channel habitat type in the field before any restoration actions occur
- Perform a more rigorous analysis of the GIS data. (Field data have been provided to the watershed council.).
- Refine the land use layer. Continue to develop the land use layer to reflect changes in land use. Update the layer with digital NWI data as they become available.
- Develop and update a "fish limits" coverage. This process has been started by ODFW.
- Work with ODFW to identify viable populations and distributions of sensitive species, particularly salmonids. These data are critical in developing watershed enhancement strategies.
- Identify and survey areas currently used by salmonids. Collect stream survey data according to ODFW protocols.

- Work with ODFW to establish a brood stock development program that will provide fish stocks capable of establishing self-sustaining populations of coho, chum, chinook, sea-run cutthroat, and steelhead.
- Field verify the channel habitat type GIS data layer. A statistical approach should be applied to these data.
- Field verify the riparian GIS data layers. A statistical approach should be applied to these data.
- Prioritize stream reaches for restoration of riparian vegetation. Start in areas currently used by salmonids and lacking in LWD recruitment potential, good shade conditions, or instream LWD.
- Plant riparian conifers and native species in areas lacking LWD recruitment potential. Start in areas of known salmonid use, and use the riparian vegetation map provided with the watershed assessments and ODFW stream surveys to identify candidate reaches. Before any reaches are targeted for planting, they should be field verified for suitability and actual conditions. Vegetation planting should use only native species and mimic comparable undisturbed sites.
- Develop a riparian fencing strategy to maintain riparian vegetation.
- Complete a culvert survey of all culverts that have not been evaluated for fish passage. Data should be maintained in a GIS. The road/stream crossing coverage is a good place to start. The culvert survey should begin in priority subwatersheds at the mouth of each of the streams. Establish priorities for culvert replacement.
- Replace priority culverts identified in the culvert survey.
- Install fish passages at known fish passage barriers that are caused by human influences.
- Prioritize estuarine wetlands for restoration options based on their value to salmonids for restoration, creation, or maintenance. Landowners with priority wetlands can then be contacted for possible wetland restoration.
- Prioritize for restoration, creation, or maintenance, palustrine wetlands that are connected to streams and provide back water rearing areas for salmonids. Start in areas with known salmonid rearing and spawning habitat.
- Create, restore, and maintain estuarine wetlands based on their prioritization.
- Create, restore, and maintain palustrine wetlands based on their prioritization.
- Develop a strategy to collect continuous discharge data in the primary rivers that flow into Youngs Bay. Work with OWRD or the USGS to get stream gages installed.
- Collect meteorologic data and rainfall data to improve modeling capabilities for water availability and flooding. This could be accomplished through local high schools or volunteers.
- Develop an outreach program to encourage water conservation. One of the primary water withdrawals is for municipal use. Educate the public about dewatering effects and how water conservation will help salmonids in the watersheds.
- Identify water rights that are not currently in use and that may be available for instream water rights through leasing or conversion.

- Update and refine the roads layer. Keep in contact with ODF as the roads layer is updated. Check with other groups (private land owners) to update the roads layer and evaluate its accuracy.
- Identify roads that have not been surveyed for current conditions and fill these data gaps. Work with ODF to develop road survey methodologies.
- Map road failures in areas where data are lacking. Coordinate with watershed stakeholders that are currently collecting road data such as ODF and private timber companies. Develop a strategy to fill in the data gaps.
- Map culvert locations and conditions in conjunction with the culvert survey conducted for fish passage barriers. Check with ODF, ODFW, and local foresters for the best methodologies and data to collect.
- Map all debris flows and landslides. Begin in the areas most susceptible to landslide activity as identified in the DOGAMI debris flow hazard map.
- Where possible, conduct road restoration activities such as road reconstruction, decommissioning, and obliteration.
- Replace undersized culverts that are at risk of washing out. Prioritize these culverts from the culvert surveys.
- Develop a systematic water quality monitoring program for areas with high priority for restoration activity. Focus the water quality monitoring on constituents that are important for the specific area being restored. Use the water quality data to refine the restoration plans.
- Develop or expand the continuous temperature monitoring network with monitors at strategically located points such as the mouths of tributary streams, at locations of known spawning beds, at the interface between major land use types, or downstream of activities with the potential to influence water temperature.
- Include a plan for long-term monitoring in any restoration plan to measure the effects of the restoration activity. Begin to develop the capacity within the watershed council to conduct high quality, long-term water quality monitoring to document the success of restoration activities.
- Locate and map potential sources of nitrogen, phosphorus, and bacteria in the Watershed. Conduct all water quality monitoring activities according to established guidelines such as those published by the Oregon Plan for Salmon and Watersheds (OPSW 1999), or EPA (1997, 1993). Cooperate with DEQ and other agencies to share data and expertise. Coordinate the council's monitoring activities with those of the agencies, including DEQ's efforts to develop Total Maximum Daily Loads for water quality limited stream segments.

2.2.3.4 Assessment Methodology

The Mainstem Lower Columbia River and Columbia River Estuary Subbasin Planning Group considered a range of assessment methodologies for the WOTs subarea including the Ecosystem Diagnotstics and Treatment (EDT) approach developed by Mobrand Biometrics (Lichatowich et al.1995; Lestelle et al. 1996; Mobrand et al. 1997; Mobrand et al. 1998). Given the qualitative nature of the estuary and mainstem assessment, a highly quantitative EDT model was deemed to be incongruous with the methods and purpose of the assessment in this context. Additionally, the applicability of EDT was limited by the availability of data and budget. The

Planning Group concluded, therefore that application of EDT was neither warranted nor necessary.

In recognizing that a qualitative approach for the WOTs subarea was appropriate, the planning group established that the assessment should:

- follow a logical and replicable sequence,
- use the best available quantitative data as the basis for decisions,
- generate a product that is similar in form to products resulting from other more quantifiable approaches, and
- document the decision process.

2.2.3.4.1 QHA Overview

The planning group elected to utilize an alternative assessment approach called Qualitative Habitat Assessment (QHA), also developed by Mobrand Biometrics (McConnaha, 2003). The following description of QHA is excerpted from the QHA users guide (McConnaha, 2003):

"QHA provides a structured, 'qualitative' approach to analyzing the relationship between a given fish species and its habitat. It does this through a systematic assessment of the condition of several aquatic habitat attributes (sediment, water temperature, etc.) that are thought to be key to biological production and sustainability. Attributes are assessed for each of several stream reaches or small watersheds within a larger hydrologic system. Habitat attribute findings are then considered in terms of their influence on a given species and life stage.

QHA relies on the expert knowledge of natural resource professionals with experience in a given local area to describe physical conditions in the target stream and to create a hypothesis about how the habitat would be used by a given fish species. The hypothesis is the “lens” through which physical conditions in the stream are viewed. The hypothesis consists of weights that are assigned to life stages and habitat attributes, as well as a description of how reaches are used by different life stages. These result in a composite weight that is applied to a physical habitat score in each reach. This score is the difference between a rating of physical habitat in a reach under the current condition and a theoretical 'reference' condition.

The ultimate result is an indication of the relative restoration and protection value for each reach and habitat attribute. QHA also provides a means to compare restoration and protection ratings to other biological and demographic information of the user’s choosing. QHA includes features for documenting the decision process and describing the level of confidence that users have in the various ratings.

QHA should not be viewed as a sophisticated analytical model. QHA simply supplies a framework for reporting information and analyzing the relationships between a species and its environment. It is up to knowledgeable scientists, managers, and planners to interpret results and make actual decisions regarding these relationships and the actions that might be taken to protect or strengthen these relationships."

2.2.3.4.2 QHA versus EDT

The following information about the differences and similarities between QHA and EDT is excerpted from the QHA users guide (McConnaha, 2003):

"QHA relies on the same conceptual framework as the Ecosystem Diagnosis and Treatment (EDT) technique. There are, however, several important differences. While each of the habitat characteristics used in QHA is also used in EDT, EDT considers many more habitat factors and links these more directly to measurable data. QHA, by contrast, relies on the judgment of knowledgeable professionals to draw these linkages.

EDT relies on a set of objective biological rules derived from the technical literature to establish the relationship between a species and its habitat. Again, QHA relies on professional judgment to make this connection. EDT uses a series of life history trajectories to model the movement of fish through its environment over several life stages and over the entire life history. QHA collapses life history into fewer stages. Importantly, QHA treats each stream reach or small watershed as an independent static unit whereas EDT evaluates the connectivity of reaches and the variation in conditions within a year. Again, QHA relies on the knowledge of experts to think through life history dynamics.

EDT analysis can incorporate information on out-of-subbasin effects, i.e., survival outside of the natal subbasin including ocean survival as well as harvest. QHA does not consider conditions outside the subbasin….

Lastly, EDT produces a series of numerical products that estimate productivity, abundance, and related factors that give an indication of how well habitat supports fish. As a qualitative technique QHA does not generate these outputs but rather produces an index of habitat condition and a series of products that suggest directions for management. "

2.2.4 *Aquatic Focal Species*

The life history, status, and designation of the selected aquatic focal species are given through treatment in the technical foundation used in support of the Mainstem and Estuary Assessment (EMA) and the Mainstem Lower Columbia River and Columbia River Estuary Subbasin Management Plan. It is neither the intent, nor the purpose of this assessment to replicate effort found elsewhere. Rather, the reader is directed to Appendix A of the overall plan, and to EMA, Section 2.1 , which provides additional treatment of the ecology and limiting factors of our focal species as they relate the Mainstem Lower Columbia River and Columbia River Estuary. Information on the aquatic focal species for purposes of the WOTs subbarea assessment is limited to information that specifically pertains to the status, distribution, and life history that may be particular to the WOTs subbarea, and not covered elsewhere.

2.2.4.1 Selection

The selection of aquatic focal species for the WOTs sub-area of the Mainstem Lower Columbia River and Columbia River Estuary subbasin followed an iterative process of candidate species brainstorming in the Subbasin Planning Group and with subgroups which included watershed councils, a technical advisory committee, and the QHA workshop participants.

Initially, three aquatic species were chosen by the Planning Group as focal for assessment of the aquatic dimensions of the Western Oregon tributaries subbarea of the Mainstem Lower Columbia River and Columbia River Estuary subbasins. Steelhead/rainbow trout (*Oncorhynchus*

mykiss); fall Chinook (*Onchorynchus tshawytcha*); and Coho Salmon (*Oncorhynchus kistuch*). This list was modified at the QHA workshop, where partipants felt it was important to also assess Chum salmon (*Oncorhynchus keta*); At the workshop, local expertise and priorities meant that the group evaluated fall Chinook as a last priority, and as a result this portion of the habitat assessment was imcomplete. Information on Chinook was supplemented by assessments and by the WLC-TRT population persistence evaluations. The criteria used to select focal species were the aspects of the subbarea ecosystem that the life histories represent; the Endangered Species Act (ESA) status; the cultural importance of the species and whether or not there was enough knowledge of the life history of the species to do an effective assessment.

Consensus was achieved on their selection. Lower Columbia River winter steelhead, fall Chinook and Coho and chum life histories intersect a broad range of the aquatic ecosystem. Spatially, the life histories of these four species cover the entire subbasin from the estuary to the headwaters. These species also occupy all levels of the water column including slack water, swift water and the hyporheic zone. Not only are they present but also the ability of these species to thrive is dependent on being able to successfully occupy these areas. Temporally, these species are present (or were assumed to be present in the past) at one lifestage or another throughout much of the watershed in all seasons. The ability of these species to be present at a particular time in a particular area is also key to the success of these species.

Given the wide range of both the spatial and temporal aspects of these life histories it can be assumed that having habitat conditions that are appropriate for these three species will also produce conditions that allow for the prosperity of other aquatic life in the sub-area. The legal status of these species is important to the sub-area. Three of the species are listed as threatened under the ESA and one is a candidate species for listing (see 2.2.4.4 below) Currently the citizens, governments, state and federal agencies and tribes are engaged in planning for the recovery of each of the salmonids through different processes.

2.2.4.2 The Coast Range Ecological Zone

For purposes of describing the WOTs subarea as it relates to salmonids habitat requirements and population parameters, the description of the coast range ecological zone, as used by the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) in establishing viability criteria for the Lower Columbia ESU suffices. The WLC-TRT (2003) describes the coast range ecological zone as follows:

"The Coast Range ecological zone commences at the mouth of the Columbia River and extends upstream to the mouth of the Cowlitz River in Washington and to the mouth of the Willamette in Oregon. In Washington these basins drain the Willapa Hills. The climate is dominated by moist Pacific marine air, with wet and mild winters and cool dry summers. Average annual precipitation is 200 to 240 cm, with approximately 80% occurring as rain between October and March. Streamflow is dependent on rainfall since drainage elevations do not exceed 500 m. River flows peak in December and January as a result of winter rainstorms. There is very little precipitation in July or August and corresponding flows are at the lowest with the highest water temperatures occurring in August. These rivers are especially prone to low flow during periods of drought. This region was originally forested with Sitka spruce, western hemlock, Douglas fir, and western red cedar."

2.2.4.3 TRT Population and ESU Risk Characterization in the Coastal Strata

The 2003 Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids (TRT, 2003) presents viability criteria for ESU recovery and a risk characterization (scoring) system for assessing population and ESU status with respect to extinction risk.

As developed by the WLC TRT, the approach is as follows:

1. In a recovered ESU, all strata (groups of populations characterized by combinations of distinct life-histories and ecoregion occupancy) that historically existed should have a high level of persistence. Additionally, the populations within the strata that have very high levels of persistence should have other specified characteristics.
2. For a stratum to have a high level of persistence, the status of all distinct independent populations (DIPs) that were present historically must meet certain numerical criteria in terms of population risk characterization.
3. A population's risk characterization is determined by a numerical weighting of risk characterizations for five attributes: adult productivity and abundance, juvenile outmigrants, spatial structure, diversity and habitat.

The foundation of the TRT approach is a system of 5 population persistence categories, presented in Table 2-19 below. Persistence is simply not going extinct. Over any specified time frame, the probability of persistence is 1- the probability of extinction and vice versa. Note that Note that only populations in categories 3 and 4 meet the viability criterion of probability of persistence of 95% described in McElhany et al. (2000) Populations in categories 0,1, and 2 are subviable. All scores, whether for populations overall, individual attributes for populations, or strata, refer to these persistence levels.

Table 2-19: Population persistence categories for use in recovery planning

Population Persistence Category	Probability of persistence over 100 yrs	Description
4	>99%	Very low risk of extinction in 100 yrs
3	95-99%	Low(negligible) risk of extinction in 100 yrs (VSP)
2	75-95%	Moderate risk of extinction in 100 yrs
1	40-75%	Relatively high risk of extinction in 100 yrs
0	0-40%	Either extinct or at high risk of extinction

In December of 2003, the TRT and staff from ODF&W met to evaluate the current status of the 46 Oregon State salmonids populations within the WLC Domain (TRT 2004). The scores from each entity for the Coastal stratrum are represented in **Error! Reference source not found.** below.

Table 2-20: TRT and ODFW evaluation of population persistence for Oregon salmonid populations wihtin the coastal stratum of the WLC Domain (TRT, 2004)

Lower Columbia River Chinook Salmon	WLC TRT Population Score	ODFW Population Score
Youngs Bay Fall Run	1.12	1.59
Big Creek Fall Run	1.19	1.94
Clatskanie River Fall Run	1.24	2.01
Scappoose Creek Fall Run	0.99	1.73
Lower Columbia River Coho Salmon		
Youngs Bay	0.86	1.43
Big Creek	0.81	1.42
Clatskanie River	0.85	1.68
Scappoose Creek	1.11	1.88
Lower Columbia River Chum Salmon		
Youngs Bay	0.52	0.62
Big Creek	0.53	0.62
Clatskanie River	0.47	0.59
Scappoose River	0.48	0.58

The population persistence score is a composite score of the Viable Salmonid Population (VSP) parameters population attribute scores that rate the viability criteria originally described in the TRT's viability report. These VSP parameters are described by the TRT (2003) as follows:

"To obtain advice on technical issues related to recovery planning, NOAA Fisheries convened technical recovery teams (TRTs) in each recovery domain. The TRTs are composed of scientists from NOAA Fisheries; other federal, tribal, state and local agencies; academic institutions; and private consulting firms. A complete description of the TRT composition, tasks, relationship to ESA recovery planning, and operating principles can be found in the NMFS document Recovery Planning Guidance for Technical Recovery Teams (TRTs) (http://research.nwfsc.noaa.gov/cbd/trt/about.htm). The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) was established in May 2000. One of its first tasks was to provide technical information to support the development of delisting criteria."

The criteria, as described by the Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmon, are as follows:

Population & Abundance Criteria

In general, viable populations should demonstrate a combination of population growth rate, productivity, and abundance that produces an acceptable probability of population persistence. Various approaches for evaluating population productivity and abundance combinations may be acceptable, but must meet reasonable standards of statistical rigor.

Juvenile Out-migration

The abundance of naturally produced juvenile outmigrants should be stable or increasing as measured by observing a median annual growth rate or trend with an acceptable level of Confidence.

Diversity

Sufficient life-history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. The metrics and benchmarks for evaluating the diversity of a population should be evaluated over multiple generations and should include:

- a substantial proportion of the diversity of a life-history trait(s) that existed historically,
- gene flow and genetic diversity should be similar to historical (natural) levels and origins,
- successful utilization of habitats throughout the range,
- resilience and adaptation to environmental fluctuations.

Habitat Criteria

1. The spatial distribution and productive capacity of freshwater, estuarine, and marine habitats should be sufficient to maintain viable populations identified for recovery.
2. The diversity of habitats for recovered populations should resemble historical conditions given expected natural disturbance regimes (e.g., wildfire, flood, volcanic eruptions, etc.). Historical conditions represent a reasonable template for a viable population; the closer the habitat resembles the historical diversity, the greater the confidence in its ability to support viable populations.
3. At a large scale, habitats should be protected and restored, with a trend toward an appropriate range of attributes for salmonid viability. Freshwater, estuarine, and marine habitat attributes should be maintained in a nondeteriorating state.

Within Population Spatial Structure: The spatial structure of a population must support the population at the desired productivity, abundance, and diversity levels through short-term environmental perturbations, longer-term environmental oscillations, and natural patterns of disturbance regimes. The metrics and benchmarks for evaluating the adequacy of a population's spatial structure should specifically address:

1. Quantity: Spatial structure should be large enough to support growth and abundance, and diversity criteria.

2. Quality: Habitat underlying spatial structure should be within specified habitat quality limits for life-history activities (spawning, rearing, migration, or a combination) taking place within the patches.

3. Connectivity: Spatial structure should have permanent or appropriate seasonal connectivity to allow adequate migration between spawning, rearing, and migration patches.

4. Dynamics: The spatial structure should not deteriorate in its ability to support the population. The processes creating spatial structure are dynamic, so structure will be created and destroyed, but the rate of loss should not exceed the rate of creation over time.

5. Catastrophic Risk: The spatial structure should be geographically distributed in such a way as to minimize the probability of a significant portion of the structure being lost due to a single catastrophic event, either anthropogenic or natural.

In the remainder of this document, where applicable for characterizing the status of listed salmonids, the qualitative factors that contritibuted to the VSP category scoring are described.

2.2.4.4 Status and Charactorization of Listed Species

The ESA lists five potential factors for decline that must be considered in species listing decisions (ESA Section 4.2.1):

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. overutilization for commercial, recreational, scientific, or educational purposes;
3. disease or predation;
4. the inadequacy of existing regulatory mechanisms;
5. other natural or manmade factors affecting its continued existence.

The National Marine Fisheries Service (NMFS) identified all five factors as contributing to the endangerment of Pacific salmonids. In considering how viability criteria might inform population delisting requirements, the WLC-TRT (2003) also considered all five factors for decline. The WOTs subbarea of the Mainstem Lower Columbia River and Columbia River Estuary subbasin contains salmonids listed as threatened under the Endangered Species Act, as well as candidate species, and species proposed for listing.

On September 29, 2003, the National Marine Fisheries Service (NMFS) published in the Federal Register an Advanced Notice of Proposed Rulemaking (ANPR) regarding future critical habitat designations for 20 evolutionarily significant units of salmon and steelhead listed under the U.S. Endangered Species Act (ESA) in WA, OR, ID, and CA. As described in a recent court-approved schedule, NMFS intends to publish proposed designations in 2004 followed by final designations in 2005.

(http://www.nwr.noaa.gov/1salmon/salmesa/crithab/anprpg92903.htm).

Table 2-21 summarizes the status of these populations. The 2003 Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids (WLC-TRT,

2003) lists up to 14 populations within the Coast Range strata for Chum and Steelhead (Table 2-22). Additionally ODFW has identified at least 4 coho populations within this ecological zone

Table 2-21: Status of Salmonid Species and Their Critical Habitat

Species	ESU*	ESA Status	Date of Listing	Critial Habitat Status	Habitat Description	**Date of Listing**
Chinook	Lower Columbia River	Threatened	March 24, 1999	Pending	All accessible rivers, estuarine areas	March 9. 1998
Chum	Columbia River	Threatened	March 25, 1999	Pending	All accessible rivers, estuaring areas downstream of Bonneville Dam, but excluding Oregon tributarties upstream of Milton Creek	March 10, 1998
Coho	Lower Columbia River/Southwest Washington	Candidate	July 25, 1995	n/a	n/a	n/a
Steelhead	Lower Columbia River	Threatened	March 19, 1999	Pending	All accessible rivers, estuarine areas including Willamette River	February 6, 1999
Coastal Cutthroat	Southwestern Washington Columbia River	Proposed Threatened	April 5, 1999	None proposed	n/a	n/a

Table 2-22 Estimated number of populations in different strata in the Willamette/Lower Columbia domain (TRT, 2003, Meyers et. al. 2002)

ESU	Ecological Zone	Run Timing	Historical Populations
Lower Columbia chinook	Coast Range	Fall	7
	Cascade	Fall	9
		Late Fall	2
		Spring	7
	Columbia Gorge	Fall	4
		Spring	2
Lower Columbia steelhead	Cascade	Summer	4
		Winter	14
	Columbia Gorge	Summer	2
		Winter	3
Columbia chum	Coast Range	Fall	7
	Cascade	Fall	7
	Columbia Gorge	Fall	2
Upper Willamette chinook	Willamette	Spring	7
Upper Willamette steelhead	Willamette	Winter	4
Total			81

2.2.4.5 Chum

2.2.4.5.1 Population Delineation and Characterization

Chum salmon are native to rivers and creeks near the mouth of the Columbia River. There is little information on the size or distribution of chum salmon populations in specific river basins prior to the 1930s, and by that time chum abundance was already severely in decline.

Parkhurst et al. 1950 note that from 1936 to 1945, chum salmon were observed in the Chinook, Deep, and Grays Rivers, and Mill, Elochoman, Abernathy, and Germany Creeks (cited in the Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids, Meyers *et. al* 2003). The Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids (Meyers et. al, 2003) describes the the chum population in the coastal range stratum as follows:

"The Chinook River is relatively small, but geographically isolated from the Grays River basin. It may have represented an important transition between the Washington coast and Columbia River populations, but there is no historical information to establish its relationship with the other populations. It is tentatively identified as a DIP. The Grays River is the most important tributary remaining for chum salmon in this area. In 1936, survey crews observed over 6,200 chum adults in the Grays River (Parkhurst et al. 1950). WDF (1951) estimated that average chum escapement to the Grays River was 7,500, with an additional 1,200 fish spawning in nearby tributaries to the Columbia River. Spawning chum salmon were also observed in the

Elochoman River and Abernathy Creek during the 1936 survey. In general, spawning chum salmon were reported in most rivers and creeks in this area. WDF (1951) estimated average escapement for the Elochoman River and Abernathy Creek basins at 4,000 and 2,700 adults, respectively. Recent genetic analysis of samples from the Grays River were similar to other samples from the Columbia River (Hardy and Hamilton Creeks), but distinct from coastal and Puget Sound populations (Phelps et al. 1994b).

Parkhurst et al. (1950) reported that chum salmon were present in almost every watershed in this area, but no abundance estimates were presented, and the majority of the information was anecdotal. Records from Big Creek Hatchery show that between 1950 and 1960, an average of 607 chum salmon were intercepted at the hatchery rack annually, with a maximum of 2,430 chum salmon encountered in 1958 (Wallis 1963b). Chum salmon were also captured at the Klaskanine Hatchery rack. Although no adult numbers were recorded, a maximum of 1,481,294 eggs was obtained in 1940, for an estimated 530 females @ 2,800 eggs/female (Wallis 1963c). Additionally, Wallis (1963c) notes that chum salmon utilized the South Fork Klaskanine, but not the North Fork. Willis et al. (1960) reported that Milton Creek was the greatest producer of chum salmon (about 200 chum per year) in the area surrounding Scappoose Creek. ODFW identified 23 populations on the Oregon side of the Lower Columbia River, although this inventory was apparently based on incidental observations rather than set criteria for populations (Kostow 1995). "

The historical DIPs and sub-populations for chum in the coastal stratum of the Lower Columbia ESU are as follows.

1	Youngs Bay (RKm 15)
	Lewis and Clark River
	Youngs River
	Walluski River
	Klaskanine River
2	Grays River (RKm 35) SASSI
	Chinook River
	Deep River
	Grays River
3	Big Creek
	Big Creek
	Bear Creek
4	Elochoman River (RKm 60)
	Skamokawa Creek
	Elochoman River
5	Clatskanie River (RKm 85)
	Plympton Creek
	Clatskanie River
	Beaver Creek
6	Mill Creek (RKm 85)
	Mill Creek
	Abernathy Creek
	Germany Creek
	Coal Creek

7	Scappoose Creek (RKm 140)
	Tide Creek
	Goble Creek
	Milton Creek
	McNulty Creek
	Scappoose Creek
8	Cowlitz River fall run/summer run
9	Kalama fall run
10	Salmon Creek fall run
11	Lewis River fall run
12	Clackamas River fall run
13	Washougal River fall run
14	Sandy River fall run
15	Lower gorge tributaries fall run
	Mainstem Columbia River
	Bridal Veil Creek
	Wahkeena Creek
	Hardy Creek SASS

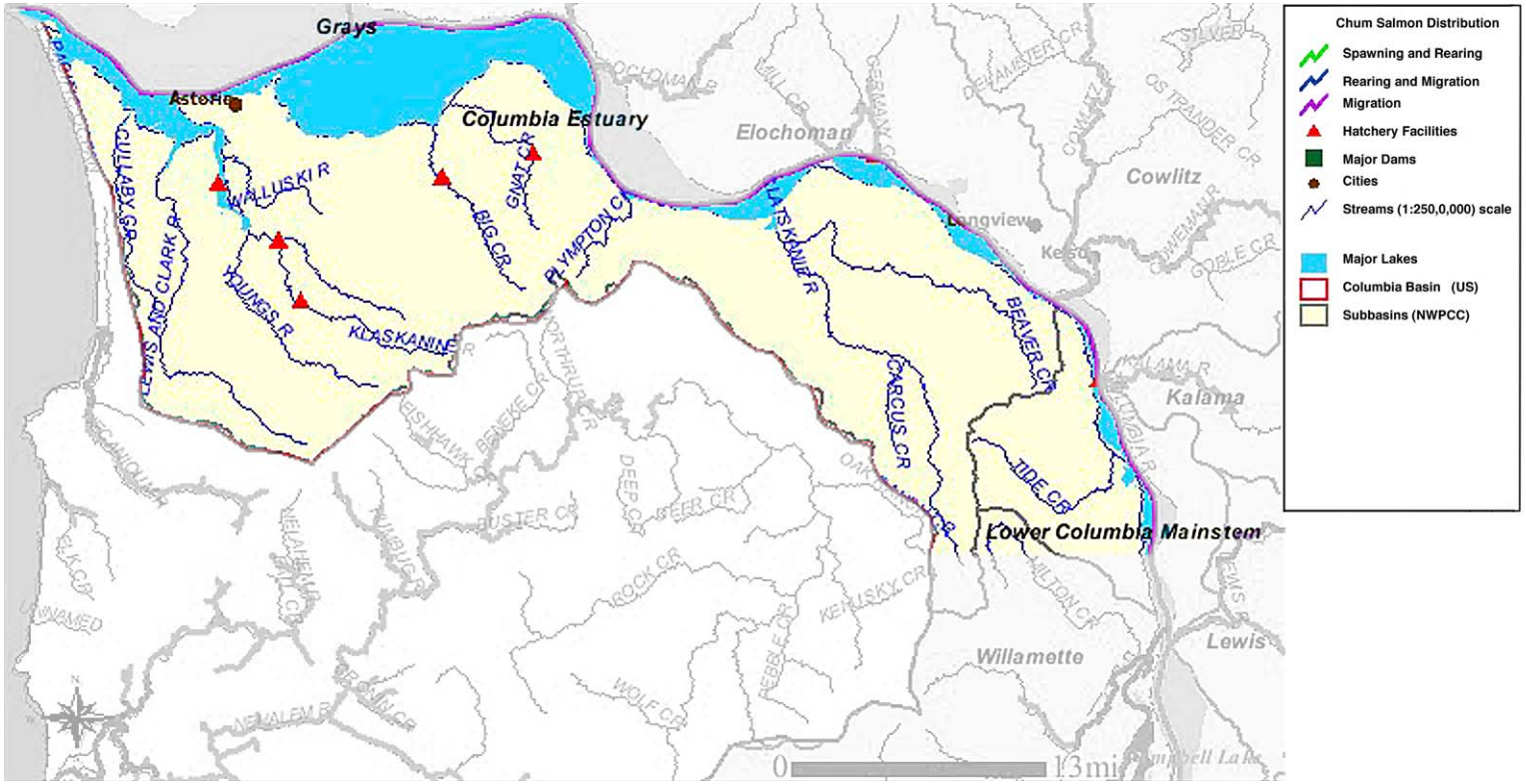


Figure 2-32: Chum distribution in the Western Oregon tributaries subarea (streamnet, 2004)

.2.2.4.5.1.1 Lower Columbia-Clatskanie Watershed Assessment

The Lower Columbia-Clatskanie Watershed Assessement notes that "historically, chum salmon spawned in the lower reaches of several streams within the Lower Columbia-Clatskanie Subbasin. The Oregon Fish Commission in 1951 reported runs of 100 chum salmon in the Clatskanie River annually and excellent runs in Tide Creek prior to the construction of a tide gate at the mouth of this stream. Goble Creek also had reports of chum salmon runs, although they were probably small runs. Two decades later, Lauman et al (1972) estimated the number of adult chum salmon spawning in the Clatskanie River to be 50 fish. The chum salmon is listed by ODFW as critical on the state's sensitive species list. Kostow (1995) has cited a dramatic decline in run sizes, noting that the 1992 commercial harvest landed about 700 fish whereas the harvest prior to the 1940s was 100,000 to 600,000 fish annually".

"The NMFS findings on the status of chum salmon in the lower Columbia River are similar to those by the ODFW. Beginning in the mid-1950s, commercial harvests declined drastically and now rarely exceed 2,000 fish per year (Johnson, 1997). The last significant harvest was in 1942, when over ½ million fish were caught. As of 1995, there has been no recreational or directed commercial harvests of chum salmon within the Columbia River (Johnson, 1997). Most of the production of chum salmon within the Lower Columbia River is from streams on the Washington side of the river. Since the collapse in the 1950's, chum salmon runs in the Columbia River have been relatively stable, with a run size that is probably 1% of historical levels. Despite the fact that Kostow (1995) identifies several populations of chum salmon in tributaries of the Lower Columbia-Clatskanie Subbasin, NMFS does not recognize any naturally spawning populations of chum salmon in Oregon (Johnson, 1997)".

"The following streams within the Lower Columbia-Clatskanie Subbasin are provisionally listed by Kostow (1995) as genuine wild populations of chum salmon: Clatskanie River, Beaver Creek, Green Creek, Nice Creek, Fox Creek, Tide Creek, McBride Creek, Plympton Creek, and Hunt Creek. However, Kostow (1995) gives no estimate of spawner abundance or population size for any of these streams. Because of a lack of data and problems with identification (the species has a very brief residence time in fresh water), very little is known about the potential for wild runs within the subbasin. Distribution of chum salmon is not included in Figure 9.2 because of the uncertainty of the status and distribution of the species. However, the provisionally listed streams for this species include the same range as the steelhead with the exception of areas above moderately steep sections of streams or above moderate instream obstacles such as low falls or beaver dams. Further research needs to be done to determine if there are actually any remaining naturally reproducing stocks of the species within the streams of the subbasin."

A VSP rating for Clatskenie River chum salmon exists (WLC-TRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: There was no information available for this population. Most WLC-TRT members utilized a default score.

JOM: Not rated.

Diversity: No information. Most members assumed that, if present, this population exists at a very low population abundance, making it susceptible to genetic bottlenecks or genetic introgression by stray adults.

Habitat: Conditions in the lower reaches of the tributaries to the Columbia River in this DIP are heavily impacted by agricultural land uses. Riparian conditions are severely impaired in these areas. Headwater areas are more impacted by timber harvest activities, although the degree of habitat degradation is moderate, relative to the lower reaches that would be more closely associated with spawning adult and juvenile chum salmon.

Spatial Structure: Dikes and tidal gates in lowland areas may have eliminated access to important side channels. Culverts may also limit access. Poor spatial structure was also related to low abundance.

.2.2.4.5.1.2 Scappoose Bay

According the the Scappoose Bay Watershed Association (DEA, 2000) Milton Creek was the largest producer of chum salmon in the watershed, with a total spawning run estimated to be about 200 fish per year according to Willis et al. (1960). However, the location of spawning grounds within Milton Creek is unknown.

A VSP rating for Scapoose River chum salmon exists (WLCTRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: The is no current abundance information available. The majority of WLC-TRT members utilized a default score.

JOM: Not rated.

Diversity: No information. TRT members assumed that small population size increases the risk for genetic diversity loss either through population bottlenecks or introgression by stray fish.

Habitat: Habitat conditions are severely or moderately impaired throughout the basin, agricultural land use in the lower reaches, in addition to residential and urban development, were factors identified in habitat degradation.

Spatial Structure: Historically, there were a number of small dams that presented migrational barriers. It was unclear how many of these structures still exist. Dikes and culverts have eliminated access to side channel habitat that is utilized by chum. Most importantly, the low population size was a severe limitation to spatial structure.

.2.2.4.5.1.3 Nicolai-Wickiup

Bishoff et al (2000b) notes that currently, chum salmon occur only in the lower portions of the Bear Creek subwatershed. Historically, the authors note that chum were found in almost

all of the subwatersheds in the Nicolai-Wickiup watershed including Marys, Bear, Ferris, Big, Fertile Valley, Gnat, and Hunt Creeks. However, many of these areas are considered poor chum habitats due to large numbers of hatchery coho and chinook and poor or inaccessible spawning areas (ODFW 1995).

A VSP rating for Big Creek chum salmon exists (WLCTRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: Chum have been occasionally observed at the hatchery weir, recent returns have been at or near zero.

JOM: Not rated.

Diversity: Small population size increases the risk for genetic diversity loss either through population bottlenecks or introgression by stray fish.

Habitat: Habitat conditions are moderately impaired throughout much of the basin, agricultural land use in the lower basin and timber harvest activities in the upper basin were factors identified in habitat degradation..

Spatial Structure: The Big Creek hatchery weir may prevent access to the upper Big Creek Basin. Dikes and agricultural diversions impair access to side channels and small tributaries.

.2.2.4.5.1.4 Youngs Bay

According to Bischoff et al (2000a), chum salmon do not currently occur in the Youngs Bay watershed. Historically, chum were found in almost all of the subwatersheds in the Youngs Bay watershed including the Lewis & Clark, Youngs, Klaskanine, and Wallooskee Rivers. However, many of these areas are considered poor chum habitats due to competition with large numbers of hatchery coho and chinook (ODFW 1995). Additionally, these areas have poor or inaccessible spawning areas (ODFW 1995). Annectodal evidence and discussion with local fisheries experts indicate that some spawning may be occurring in the lower reaches of the south fork of the Klatskanine River (unpublished QHA workshop results).

A VSP rating for Youngs River chum salmon exists (WLCTRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: Other than a few anecdotal reports, no chum salmon have been observed in the Youngs Bay area.

JOM: Not rated.

Diversity: No information is available, based on low escapement the potential for genetic loss is severe.

Habitat: Poor habitat conditions exist through the tributaries to Youngs Bay. Development and timber harvest were among the factors lists as sources of degradation.

Spatial Structure: There were no major blockages identified (although there was some discussion of the hatchery weir on the Klaskanine as a potential impediment). Numerous small blockages (tide gates, culverts) may influence access the smaller tributaries and side channels that are frequented by chum salmon.

2.2.4.5.2 Population and Listing Status

Chum salmon were listed as a threatened species on March 25, 1999. The ESU includes all naturally spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon (Source: http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm).

The following information is excerpted from ODFW, 1995 status report

"Oregon currently has 55 populations on its provisional list, including 23 in the Columbia Watershed and 32 in coastal watersheds. The species in Oregon requires typical low gradient, gravel-rich, barrier-free freshwater habitats and productive estuaries. In Oregon most chum mature at 3 to 4 years and weigh 10-15 pounds as adults".

"Chum salmon populations are very depressed to extinct in Oregon subwatersheds of the lower Columbia River. Small numbers of scattered adults are still observed and might providethe means for naturally recolonizing the area if conditions permitted. However, conditions on the Oregon side of the river are poorly suited to the natural production of chum. Spawning habitat is poor or inaccessible. Large numbers of hatchery coho and chinook are released into some of the potential juvenile chum rearing areas, such as the Youngs Bay area, where 3 to 5 million coho were released in 1992 and 1993. Gill-net fisheries can intercept adult chum salmon in October. The 1992 Columbia River commercial harvest landed about 700 chum salmon, most of which are thought to have come from Washington rivers (ODFW and WDF 1993). In comparison, Columbia River harvests prior to the 1940s landed 100,000 to 600,000 fish annually."

2.2.4.5.3 Description of Aqauatic Introductions

Bischoff (2000a) describes the chum hatchery program as follows:

"Oregon has never had a large chum salmon hatchery program, and there are currently no state hatchery programs for the species. The Klaskanine fish hatchery had a limited chum program that has been discontinued. One private hatchery has operated in the Nehalem estuary over the past few years. The objective at this hatchery has been to collect all returning hatchery adults; however some straying has occurred. Chum salmon are probably impacted by coho salmon hatchery programs that release large numbers of hatchery smolts into estuaries that are used by rearing juvenile chum. Coho salmon juveniles have been shown to be a major predator on chum juveniles in the Northwest (Hargreaves and LeBrasseur 1986). Juvenile chum salmon may also be affected by large releases of fall chinook salmon hatchery fish, particularly presmolts, since fall chinook juveniles also rear in estuaries and may compete with chum juveniles".

2.2.4.6 Steelhead

2.2.4.6.1 Population Delineation and Characterization

The following is excerpted from the Lower Columbia Watershed Assessment (LCWC, 2000a):

"Compared to coho and chinook salmon, there are few studies of the systematics and genetic similarities or differences in steelhead within the Oregon side of the lower Columbia River. Additionally, aside from the Clackamas, Sandy, and Hood Rivers, there are few estimates of population trends for tributaries of the lower Columbia River in Oregon. The lower Columbia River steelhead is not included on Oregon's lists for species of concern or threatened and endangered species. Observations of steelhead abundance from Washington to California indicate that all populations follow a similar cycle, and that factors common to these populations are influential to trends in abundance (Kostow, 1995). Ocean conditions have been identified as the cause for the recent decline in steelhead runs throughout the coastal range of the species. Ocean productivity is known to undergo long-term cycles of periods that are favorable or unfavorable to the survival of anadromous salmonids. The ocean productivity cycle appears to be unfavorable for steelhead currently and all steelhead population abundance trends are correspondingly low (Kostow, 1995)."

The Following is excerpted from the The Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids document produced by the Northwest Fisheries Science Center (Meyers, 2003):

"The Rivers in this region are larger than those found in the coastal region, with headwaters high in the Cascade Mountains. Many rivers are over 100 km long, with basins covering 1,000 km2 or more. Snowmelt and groundwater sources are substantial and maintain good year-round flows and cool water temperatures. River flows peak in December or January and sustain at least 50% of peak for 6 months or more. The lower reaches of these rivers are relatively low gradient, but high-gradient sections are common in the mid and upper reaches".

"This region extends from the Cowlitz River (RKm 106.2) to the Washougal River (RKm 194.9) on the Washington State side of the Columbia River and from the Willamette River (RKm 162.5) to the Sandy River (RKm 193.6) on the Oregon side. There appear to have been several major populations in this region, based on historical population abundance estimates and watershed size".

"In general, little life-history information is available to distinguish steelhead populations, other than traits associated with winter and summer run-timing. Historical references to steelhead rarely made any distinction between summer and winter runs. The majority of steelhead are believed to have emigrated to saltwater as 2-year-old fish and returned to spawn as 4-year-old adults (e.g., having spent 2 years in the ocean). The ability of steelhead to ascend waterfalls and cascades has given them a wide distribution in many basins that are not readily accessible to other anadromous salmonids. There is a considerable genetics database for Lower Columbia River steelhead. However, a number of the naturally spawning and hatchery populations have been strongly influenced by transfers of fish from Puget Sound hatcheries (Puget Sound ESU), the Big Creek Hatchery (Southwest Washington ESU), and the Skamania Hatchery (Phelps et al.,1997) Distribution Historically, there were at least 20,000 winter steelhead in the Cowlitz River (Hymer et al. 1992)".

"The Cowlitz River basin covers approximately 6,000 km^2 and drains the slopes of Mt. Rainier, Mount St. Helens, and Mt. Adams. . The construction of Mossyrock and Mayfield Dams eliminated approximately 50% of the historical spawning habitat. WDF and WDG (1946) estimated the steelhead spawning escapement above the Mayfield Dam site at 11,000 fish (including harvest, this represented a total run of 22,000 fish). The eruption of Mount St. Helens in 1980 dramatically altered habitat in the Toutle River basin. However, naturally spawning

populations still exist in the lower mainstem Cowlitz, Coweeman, and Toutle River basins. Based on the observed distribution of steelhead throughout the basin in the 1930s and 1940s it was concluded that suitable habitat was available and geographically arranged for a number of large independent populations of steelhead to have historically existed in the Cowlitz River basin".

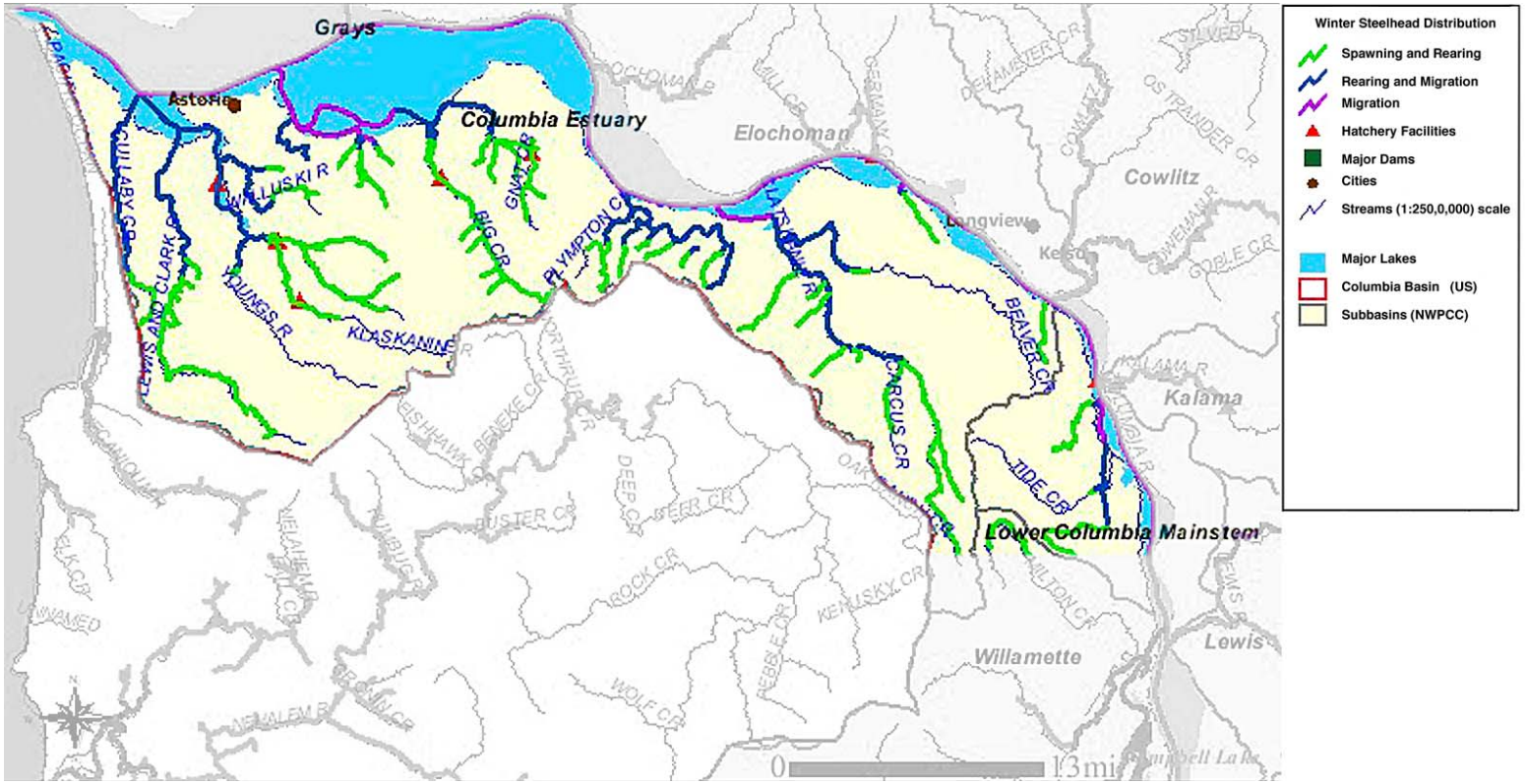


Figure 2-33 Steelhead Distribtution in the Western Oregon tributaries (Streamnet, 2004).

.2.2.4.6.1.1 Lower Columbia-Clatskanie

The following is excerpted from the Lower Columbia Clatskanie Watershed Assessment (PSU, 2000):

"The Lower Columbia-Clatskanie Subbasin is in the Southwest Washington ESU for west coast steelhead. The NMFS has listed the status of the steelhead in the lower Columbia River as having a moderate risk of extinction in smaller tributaries of the Columbia River but that the population as a whole is neither presently in danger of extinction nor likely to become endangered in the foreseeable future (Busby et al., 1996). Of the 12 monitored stocks for which there is adequate adult escapement information to compute trends, all but one has been declining since the mid-1980's. Since most of the data series used for trend calculations are short, the trends are believed to reflect climate conditions (Busby et al, 1996). The main threat to the native fish of this region is from hatchery introgression (Busby et al., 1996). Based on coded wire tag recoveries from naturally spawning hatchery fish, the Clatskanie River had the highest estimated proportion of hatchery fish (82%) per total number of spawning steelhead of any stream in the lower Columbia River".

"No comprehensive population surveys have been done for steelhead within the streams of the Lower Columbia-Clatskanie Subbasin. However, sport catch data exists for steelhead, coho, and chinook salmon within the Clatskanie River and Beaver Creek. LCWC (2000) identified a declining trend in steelhead populations of the Lower Columbia-Clatskanie Subbasin mirrors the steelhead trends for the lower Columbia River tributaries that are noted in reports by NMFS and ODFW (Kostow, 1995; Busby et al, 1996). Since this trend is based on sport catch data, these trends are only circumstantial. The numbers of steelhead caught in the Clatskanie River during the period of record are far greater than any other anadromous fish catches in either Beaver Creek or the Clatskanie River. Reports from the Oregon State Game Commission estimated about 1000 fish spawning in the Clatskanie River by 1951 and 2,000 fish by 1972 (Lauman et al, 1972; Oregon Fish Commission, 1951). Kostow (1995) cited observations of sport catch in Plympton Creek of about 300 adult steelhead, but Portland State University (PSU,2000) did not find any data on sport catch of steelhead in Plympton Creek".

.2.2.4.6.1.2 Scappoose Bay

According to local residents, winter steelhead was also abundant in the watershed until recent decades, with a drastic decline in recent years. In 1999, 33 adult steelhead were recorded at the adult fish trap installed at Bonnie Falls. Twenty-two of the 33 fish (66 percent) were estimated to be of hatchery origin based on presence of a clipped adipose fin. Ninety-five steelhead smolts were caught, with an estimated total out-migration of 409 smolts, based on an overall mark/recapture trap efficiency of 23 percent. Very litle is known about summer steelhead use of the watershed. ODFW's GIS shows summer steelhead occurring in the mainstem of Scappoose Creek (DEA, 2000).

.2.2.4.6.1.3 Nicolai-Wickiup

Winter steelhead occur in almost all of the subwatersheds in the Nicolai-Wickiup watershed. Winter steelhead occur in the Bear, Big, Fertile Valley, and Gnat Creek subwatersheds. Distribution is shown to extend beyond both the Big Creek and Gnat Creek fish

hatcheries. Populations above the fish hatcheries are most likely resident rainbow trout (E&S Environmenal Chemistry, 2000).

.2.2.4.6.1.4 Youngs Bay

Winter steelhead occurs in the Lewis & Clark and Klaskanine Rivers. Distribution in the Klaskanine River is shown to extend beyond the fish hatchery. ODFW is currently allowing adult steelhead to pass above the fish hatchery (Joe Sheahan, personal. communication, as cited in Birshoff 2000a.).

.2.2.4.6.1.5 Skipanon River

The following is excerpted from Birshoff, 2000b:

"ODFW mapped current steelhead distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. These data are available on ODFW's website (ftp://ftp.dfw.state.or.us/pub/gis). According to these data, no winter or summer steelhead reside in the Skipanon River watershed. However, spawning surveys conducted in Cullaby Creek by ODFW in 1991 and 1992 identified steelhead in Cullaby Creek suggesting steelhead are using Cullaby Creek for both spawning and rearing. Steelhead that may be present in the Skipanon River watershed are strays from hatchery programs adjacent to the watershed or from the Warrenton High School hatchery program."

2.2.4.6.2 Population and Listing Status

On March 19, 1998, NMFS determined that listing was not warranted for the Oregon Coast ESU. However, the ESU is designated as a candidate for listing due to concerns over specific risk factors. The ESU includes steelhead from Oregon coastal rivers between the Columbia River and Cape Blanco. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,604 sq. mi. in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill (Source: http://www.nwr. noaa.gov/1salmon/salmesa/index.htm).

Most of the winter steelhead populations in the lower Columbia Watershed are small. Observations of sport catch in the Lewis & Clark River, and the South Fork Klaskanine River indicate these populations have more than 300 adults each, although no comprehensive populations surveys have been done. Currently, ODFW is collecting adult spawning populations in the Lewis & Clark River (Joe Sheahan personal communication as cited in Bischoff,et al's Youngs Bay Watershed Assessment, 2000).

2.2.4.6.3 Description of Aqauatic Introductions

The following is excerpted from Birshoff (2000b):

"Most of the lower Columbia River watershed steelhead populations were planted with a winter steelhead broodstock founded from Big Creek in the lower Columbia River watershed. Releases of Big Creek stock were discontinued in the Lewis & Clark, South Fork Klaskanine and Hood Rivers, effective in 1993. Historical stocking of winter steelhead in the Klaskanine River included around 250,000 winter steelhead released in the NF Klaskanine and around 200,000

released in the lower portions of the watershed. More recently, the North Fork Klaskanine River was stocked with 50,000 to 60,000 winter steelhead annually between 1995 and 1999. Between 1982 and 1991, more than 380,000 winter steelhead were released in the Lewis & Clark River. However, stocking of winter steelhead has been discontinued in the Lewis & Clark River".

2.2.4.7 Coho

2.2.4.7.1 Population Delineation and Characterization

ODFW lists the lower Columbia River coho as in danger of extinction, citing a precipitous decline in returning spawners (Kostow, 1995). Streams within the subbasin are within two GCGs: the Lower Columbia and Willamette/Multnomah Channel. The Clatskanie River and Beaver Creek are listed in the Willamette/Multnomah Channel whereas Fox Creek, Nice Creek, Green Creek, Hunt Creek, and Plympton Creek are listed in the Lower Columbia GCG. This splitting of streams into two population segments is based largely on DNA analysis of scale samples from fish. The DNA analysis done by ODFW finds that anadromous salmonids in the Clatskanie River are most closely related to anadromous salmonids in the Clackamas River. (PSU, 2000).

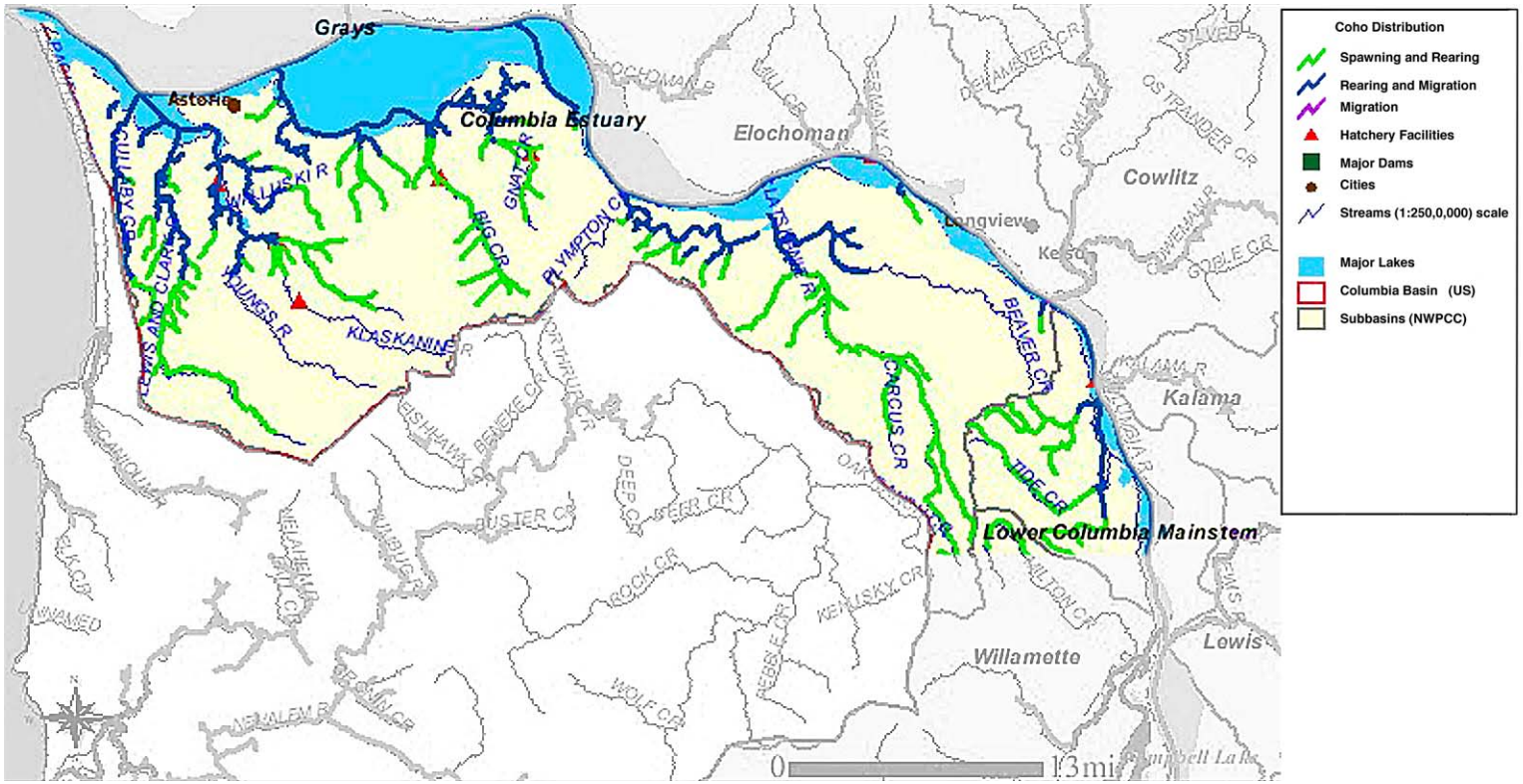


Figure 2 Coho in the Western Oregon tributaries subarea (Streamnet 2004)

At the time of the its writing, Oregon's recovery plan speculated that several of 6 historical populations identified in the plan had gone extinct (ODFW, 2004), however recent observations indicate that this judgement was premature; improvement in ocean conditions, and more rigorous spawning survey methodology indicate strong improvement.

Recent reports on the implementation the Lower Columbia River Coho Endangered Species Management Plan (ODFW, 2004) reports the following:

"The number of naturally produced coho that returned to the three downstream populations (Astoria, Clatskanie, and Scappoose) ranged from 292 to 808 fish (Table 2-23). Although the estimates for the Astoria and Scappoose populations in 2003 were somewhat less than that observed in 2002, substantial changes were observed for the Clatskanie population with nearly a ten-fold increase in 2003. It appears that viable populations of coho may be reestablishing themselves in these locations. This is an improvement over the late 1990s, when it was thought that coho had become extinct in these locations".

ODFW (2004) reports that while a large percentage of these naturally spawning fish are hatchery strays, the long term goal is to reduce this factor to less than 10% as populations are re-established.

Table 2-23: Coho spawning in Western Oregon tibutaries (ODFW, 2004)

	2003		**2002**	
Population	Natural Spawners	Hatchery Strays	Natural Spawners	Hatchery Strays
Astoria	383	80%	386	91%
Clatskanie	808	0%	94	60%
Scapoose	292	6%	458	0%

.2.2.4.7.1.1 Lower Columbia-Clatskanie

Coho salmon are reportedly excellent jumpers and are known to ascend streams to the upper reaches above the distribution of most anadromous fishes. Kostow (1995) has provisionally listed the following streams as genuine wild populations of coho salmon: Hunt Creek, Plympton Creek, Green Creek, Nice Creek, Fox Creek, Goble Creek, Tide Creek, and McBride Creek Graves (2001) includes tributaries of the Clatskanie River, Beaver Creek, and Westport Slough within the range of coho salmon Spawning surveys in the 1990's have found adult coho in Fox Creek, with 8 live adults reported on November 12th of 1994 (Whipple, 2001).

A VSP rating for Clatskenie River coho salmon exists (WLCTRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: Estimated escapement to this population is very low and most of the returning fish are of hatchery origin.

JOM: Not rated.

Diversity: Low effective spawning population size and the large number of hatchery introductions from other populations were mentioned by WLC-TRT members as factors influencing the low persistence probability scores.

Habitat: Agriculture land use, especially in the estuary areas, in combination with residential development and timber harvest all contributed to the degraded habitat condition.

Spatial Structure: There were no major blockages indicated within this DIP; however, dikes, water diversions, and tidal gates may all limit access to small tributaries and side channels.

.2.2.4.7.1.2 Scappoose Bay

Historically, coho was one of the most abundant anadromous fish species in the Scappoose Bay watershed. Coho has shown a drastic decline since the 1970s, with very few or no juvenile fish found in recent surveys (Morgan et al. 1998). In contrast, an electronic counter used at the fish ladder installed in 1951 at Bonnie Falls on North Scappoose Creek recorded 152 coho and 376 steelhead in the winter of 1956-57, and 432 coho and 264 steelhead in the winter of 1957-58 (Willis et al. 1960). In 1999, juvenile and adult fish trapping was initiated at Bonnie Falls: 706 coho smolts were caught between March 2 and June 21, with an estimated total migration of 1,317 individuals based on an overall mark/recapture trap efficiency of 54 percent.

A VSP rating for the Scappose River coho salmon exists (WLC-TRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: Recent improvements in escapement (up to the low 100s) follow a number of years of escapements of zero or near zero. Reliance on a single peak index count in many years introduces considerable uncertainty into the evaluation. Members also noted that there have been few direct hatchery introductions into this area in recent years.

JOM: Not rated.

Diversity: Small population size could have created a genetic bottleneck, or made the population susceptible to introgression by stray hatchery fish. Some WLC-TRT members focused on the absence of recent hatchery introductions.

Habitat: Conditions in this DIP are moderately to severely impaired. Agriculture and residential/urban development correlated strongly with severely impaired areas.

Spatial Structure: Numerous small blockages (tide gates, culverts) may influence access to smaller tributaries and side channels. Patches of poor habitat could also affect the distribution of coho salmon.

.2.2.4.7.1.3 Nicolai-Wickiup

Coho occurs in almost all of the subwatersheds in the Nicolai-Wickiup watershed.Coho occurs in the Bear Creek subwatershed and are limited from upstream reaches by the water control structure at the Bear Creek reservoir. Distribution is limited in both the Big Creek and Gnat Creek subwatersheds by artificial barriers at their respective fish hatcheries. Hunt Creek is

also used by Coho; however the falls located approximately 0.5 miles upstream from the mouth significantly limits the amount of the creek that can be used as habitat. All of these runs have been provisionally listed as genuine wild populations.

A VSP rating for Big Creek coho salmon exists (WLC-TRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: Abundance estimates suggest that total escapement is very small and the hatchery contribution is very large.

JOM: Not rated.

Diversity: Large numbers of fish have been released form the Big Creek Hatchery; however, there is evidence that the Big Creek Hatchery broodstock is representative of the population. Hatchery fish make up a large fraction of the total escapement and there may be little opportunity to maintain a high degree of local adaptation.

Habitat: Moderately impaired conditions exist throughout the basin. Much of the degradation is the result of timber harvest in the upper basin and agricultural/residential development in lower the basin.

Spatial Structure: The Big Creek hatchery weir may prevent access to the upper Big Creek Basin. Dikes and agricultural diversions impair access to side channels and small tributaries.

.2.2.4.7.1.4 Youngs Bay

Coho occur in the Lewis & Clark, Youngs, Klaskanine, and Wallooskee Rivers (Figure 2) The Lewis & Clark River is the river most heavily used by coho, with the distribution extending into the headwaters where a natural waterfall limits distribution. The lower portions of the South Fork Klaskanine are used by coho, extending to the 25 ft waterfall that limits upstream migration. Both the Wallooskee and Little Wallooskee Rivers are used by coho. It is generally believed that coho in the Youngs Bay watershed are hatchery returns.

A VSP rating for Youngs River coho salmon exists (WLC-TRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: WLC-TRT comments focused on the declining trend in abundance, the 91% hatchery contribution to escapement, and the very low overall abundance (especially during the 1990s).

JOM: Not rated.

Diversity: Large scale hatchery releases and the relatively poor contribution of NORs to escapement were the major negative factors considered by the WLC-TRT.

Habitat: Poor habitat conditions exist through the tributaries to Youngs Bay. Development and timber harvest were among the factors lists as sources of degradation.

Spatial Structure: There were no major blockages identified (although there was some discussion of the hatchery weir on the Klaskanine as a potential impediment). Numerous small blockages (tide gates, culverts) may influence access to smaller tributaries and side channels. Patches of poor habitat could also affect the distribution of coho salmon.

.2.2.4.7.1.5 Skipanon River

Coho occurs along the entire extent of the Skipanon River (Figure 2). It is unlikely that native populations exist in the watershed today. Cullaby Lake may have been a key rearing area both before and after its drainage was altered. Currently, the warm water fishery in Cullaby Lake precludes successful coho rearing. Spawning surveys were conducted in Cullaby Creek by ODFW in 1991 and 1992. Both juvenile and adult coho were found in Cullaby Creek as well as a few redds, suggesting coho is using Cullaby Creek for both spawning and rearing.

2.2.4.7.2 Population and Listing Status

On July 25, 1995, NMFS determined that listing was not warranted for the Lower Columbia Coho ESU. However, the ESU is designated as a candidate for listing due to concerns over specific risk factors. This ESU includes all naturally spawned populations of coho salmon from Columbia River tributaries below the Klickitat River on the Washington side and below the Deschutes River on the Oregon side (including the Willamette River as far upriver as Willamette Falls), as well as coastal drainages in southwest Washington between the Columbia River and Point Grenville. Major river watersheds containing spawning and rearing habitat for this ESU comprise approximately 10,418 sq. mi. in Oregon and Washington. The following counties lie partially or wholly within these watersheds: Oregon - Clackamas, Clatsop, Columbia, Hood River, Marion, Multnomah, Wasco, and Washington; Washington - Clark, Cowlitz, Grays Harbor, Jefferson, Klickitat, Lewis, Mason, Pacific, Skamania, Thurston, and Wahkiakum (Source: http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm).

Coastal watershed wild coho production has declined from approximately 1.5 million fish at the turn of the century to approximately 70,000 in the 1990s. Wild populations still occur in most coastal watersheds and in the Clackamas and Sandy Rivers in the Columbia River watershed, and may occur in some other tributaries of the lower Columbia River watershed. Remaining coho populations generally spawn and rear in small, low gradient (less than 3 percent) tributary streams, although rearing may also take place in lakes where available. Populations have been monitored by ODFW and data has been compiled in the StreamNet database. Three methodologies for estimating fish abundance have been used in the Youngs Bay watershed: peak or index live fish (# sampled from index locations), total live fish (live fish trapped at a location), and sport counts. Surveys in the Youngs River show a diminishing population of wild coho. It is important to note that this observation is based on a general trend in the data and not a result of rigorous statistical analysis. Statistics would need to be used to identify actual trends in fish populations, which is beyond the scope of this analysis.

2.2.4.7.3 Description of Aqauatic Introductions

Hatchery influences on coho populations in the WOTs subbarea are widespread. The Klaskanine Fish Hatchery (run by ODFW) located about 22 mi from Fort Stevens State Park, raises both coho and steelhead. Releases of coho salmon in the Youngs Bay watershed have been conducted by ODFW, the Clatsop Economic Development Council (CEDC), and the United

States Fish and Wildife Service (USFWS). In 1983, approximately 100,000 coho were released in the Lewis & Clark River (Genovese and Emmett 1997). No other information was found for coho releases in the Lewis & Clark River although it was suggested that heavy releases of presmolt coho occurred in more than one year (Walt Weber pers. Communication cited in Bischoff 2000b.). The Klaskanine River is the most heavily stocked river in the watershed. There are three historic release sites, including the upper reaches, a north fork site, and a lower site . Between 1982 and 1990, over 25 million coho yearlings were released in the Klaskanine River system, with 765,000 stocked in 1988 alone. More recently, the North Fork Klaskanine River received over 1 million coho and 800,000 coho in 1995 and 1996, respectively. In the early 1980s, over 2 million fish were stocked in Tucker Creek. Many releases occur in Youngs Bay itself as a result of net pen operations in the Youngs Bay estuary. Approximately 2 to 3 million coho were released from the net pens annually between 1992 and 1999.

Broodstocks for the hatchery raised fish were from varied locations with many of these coming from outside of the Youngs Bay watershed. The most common broodstock released in the Youngs Bay watershed is from the Big Creek hatchery, located just east of the watershed. Other early Columbia River stocks include Sandy, Tanner Creek, and Klaskanine stocks. The most varied broodstocks are released from the Youngs Bay net pen facilities. Coho broodstocks released from this site include Eagle Creek, Oxbow, Klaskanine, and Sandy broodstocks. Hatchery coho may have contributed to the decline of wild coho salmon. Hatchery programs supported historical harvest rates in mixed-stock fisheries that were excessive for sustained wild fish production.

Hatchery coho have also strayed to spawn with wild fish, which may have reduced the fitness and therefore survival of the wild populations through outbreeding depression (Hemmingsen et al 1986; Flemming and Gross 1989, 1993; ODFW 1995), and which lowered effective population sizes. Finally, hatcheries may have reduced survival of wild juveniles through increased competition for limited food in streams, bays, and the ocean in years of low ocean productivity; through attraction of predators during mass migrations; and through initiation or aggravation of disease problems (Nickelson et al. 1986).

The ODFW implementation update (2004) notes the following about ODFW hatcheries:

"In the recovery plan several streams, associated with ODFW operated hatcheries, were identified as having artificial barriers to migrating adult coho. These fish barriers had been erected to prevent potentially disease infected fish from spawning upstream of the water intake for the hatchery and transferring disease to fish being raised at the hatchery. One of the recovery plan strategies was to provide adult coho passage at several of these locations, consistent with the likelihood of gains in natural coho production and not unduly compromising the hatchery rearing environment in terms of disease. In 2003 adult coho were again passed upstream at the barriers associated with the North Fork Klaskanine and Big Creek hatcheries. Passage of adults at the Cedar Creek barrier associated with Sandy Hatchery was delayed pending construction of the necessary adult trap and juvenile migrant screening facility. However, in early 2004 NOAA Fisheries approved funding for a $350,000 project for engineering and design analysis for the water intake and potential fish passage facilities at the Cedar Creek location. NOAA Fisheries is also funding a $50,000 engineering and design analysis project at the Tanner Creek intake at Bonneville Hatchery that could also result in reduction of fish passage concerns."

2.2.4.8 Fall Chinook

2.2.4.8.1 Population Delineation and Characterization

Chinook salmon within the subbasin are defined as fall chinook within the Lower Columbia River ESU, and are listed as threatened under the ESA. This listing indicates that, in the opinion of biologists at NMFS, there is a significant risk of extinction for this ESU. Populations within this ESU and existing in the WOTs tributaries are those within the Coast Range Ecoregion. This region extends from the mouth of the Columbia River to Coal Creek (RKm 99.8) on the Washington State side of the Columbia River and Scappoose Creek (RKm 140) on the Oregon side. Chinook salmon spawning in this region was placed in seven population clusters, based on historical population abundance estimates and watershed size.

Meyers et al (2003) describe the coast range tributaries and their relationship to chinook as follows:

"Coast Range tributaries are all relatively short; less than 40 km. The lower reaches tend to be low-gradient, slow-moving systems that are under tidal influences. Many tributaries enter the Columbia River through a series of sloughs that offer little useable spawning habitat. The rivers and creeks drain low-elevation hills, with peaks less than 1,000 m. Rainfall averages 200–240 cm per year. In the absence of substantial snow pack or groundwater sources, the river flows are strongly correlated with rainfall (peak flows occurring in December and January), and summer flows can be very low (low flows occur in August). Presently, there are no naturally spawning, spring-run chinook salmon in this subregion, and given the relatively short length of these rivers and creeks and their rainfall-dominated hydrology, there is little suitable habitat for spring-run chinook salmon. It is unlikely that distinctive run times or geographically isolated populations could have developed in one of these systems. Furthermore, it is possible that during extended periods of poor ocean conditions or extremes in climate (floods or droughts) many of the smaller systems may experience short-term extirpations."

"The distribution of historical populations in this portion of the Lower Columbia River was initially derived using the geographic clustering of watersheds. In some cases it is unclear whether chinook salmon historically were present. For example, spawner surveys done in the 1930s and 1940s documented Chinook salmon in the Chinook River. However, a hatchery was established in the watershed in 1894 using adults captured in the mainstem mouth of the Columbia River, and the fish observed are most likely descendants of those hatchery fish."

The Washington Department of Fish and Game (WDFG 1916) suggested the Chinook River in Washington did not have an indigenous Chinook salmon population prior to establishment of the hatchery run. Marshall et al. (1995) suggest that many rivers in this region did not support Chinook salmon populations. However, Collins (1892), in his surveys of Pacific coast fisheries, specifically lists the Lewis and Clark River and Youngs River as supporting runs of Chinook salmon. Gilbert and Evermann (1895) note that, “Fish of the fall run enter the Columbia a short time only before they are ready to spawn. So far as we now know, the most of these turn directly into streams near the mouth of the river and spawn a short time after their entrance into the Columbia.” The absence of detailed historical documentation may be related to the emphasis on fisheries (and studies) targeting spring-run Chinook salmon. In contrast to the spring run, fall-run Chinook salmon entered freshwater at an advanced stage of maturation, and there was initially little demand for these poor quality fish. Spring-run Chinook salmon sold to salmon packers in 1894 were worth $.05 a pound, whereas fall-run Chinook salmon and chum salmon were worth $.03–.05 per fish (Smith 1895). The preference for springrun Chinook

salmon also influenced hatchery policies. “The opinion also prevails that the fish hatched from the eggs of the fall run will return to the river in the fall and be the undesirable fish, and the hope is general that no attempts will be made to propagate the late fish, but that the efforts will be centered on the spring and summer broods, which alone are suitable for canning” (Smith 1895)."

"Chinook salmon studies were conducted on Gnat Creek from 1956 to 1962 (Willis 1962). In 1955, construction of a weir on the lower portion of the creek enabled biologists to enumerate and measure returning adults, as well as sample emigrating juveniles, except during high flow periods. During the study, average chinook escapement was only 39 fish. Peak juvenile outmigration by subyearling juveniles was observed during February and March; no yearling migrants were observed. Genetic analysis was of limited utility due to the large numbers of hatchery-origin fish released into these basins from outside the specific watershed. Straying between these spawning aggregations was estimated using CWT recoveries from naturally spawning fish, fish returning to hatchery racks, or fishery recoveries from the tributaries. In general, it is believed that there was a high degree of exchange between all the populations in the smaller coastal tributaries of the Lower Columbia River, but less so between populations in this region and those in other regions within this ESU. For example, of the freshwater recoveries of marked fish released from the Grays River Hatchery, only 32.3% were recovered back in the Grays River basin, 10.3% in Skamokawa Creek, 23.0% in the Elochoman River, 33.0% in Big Creek, and less than 1.0% of recoveries were upstream of the Cowlitz River. Low levels of homing fidelity were also observed for fish released from Abernathy Creek Salmon Culture Technology Center (SCTC), and the Elochoman River and Big Creek hatcheries. In general, a significant proportion (>10%) of the freshwater recoveries occurred up to 50 km away from the release site. These rates may be substantially higher than historical levels due to (1) use of mixed-origin Lower Columbia River fish by most hatchery programs, (2) poor water quality or low attraction flows in many of the rivers or hatcheries, and (3) attraction of fish to assemblages of fish (i.e., fish in hatchery holding ponds). Additionally, fish that enter hatchery traps or are intercepted in terminal fisheries are considered strays, despite the fact that fish naturally often hold only temporarily in nonnatal streams or may test tributaries for homing cues. In general, fall-run Chinook salmon spawn in the lower reaches of the tributaries, just above the extent of tidal influence (Parkhurst et al. 1950, Merrell 1951). This may increase the likelihood of movement by spawning adults between basins."

"Willis et al. (1960) reported that 100 fall Chinook salmon was observed spawning in the lower two miles of Scappoose Creek. Ecologically, the tributaries on the Oregon side, which drain the Coast Range, are very different from the larger tributaries on the Washington side (e.g., Cowlitz and Kalama Rivers, etc.), which drain the Cascade Range".

"The seven Demographically Independent Populations (DIP) s proposed (see below) in this region are distinct based solely on geographic separation. In general, genetic information from recently collected fish is of limited value due to the high proportion of hatchery fish on the spawning grounds and the large numbers of nonnative hatchery fish introduced into the region Whether these clusters were historically reproductively isolated is difficult to establish, but to have maintained demographic independence, homing fidelity would have likely been substantially higher than is currently observed. Additionally, it is assumed that fish tend to orient along the riverbank, and in the Lower Columbia River a fish was more likely to stray to an adjacent system rather than across the river. It is fairly reasonable to assume that distinct independent populations did not exist on a scale smaller than the seven clusters. It may also be

reasonable to assume that because of geographic and ecological factors, these clusters did form at least one independent population relative to other populations in the ESU."

1	Youngs Bay fall run
	Lewis and Clark River
	Youngs River
	Walluski River
	Klaskanine River
2	Grays River fall run SASSI
	Deep River
	Grays River
3	Big Creek fall run
	John Day River
	Mill Creek (Oregon)
	Big Creek
	Bear Creek
4	Elochoman River fall run
	Skamokawa Creek SASSI
	Elochoman River SASSI
5	Clatskanie River fall run
	Plympton Creek
	Clatskanie River
	Beaver Creek
6	Mill Creek fall run
	Mill Creek SASSI
	Abernathy Creek SASSI
	Germany Creek SASSI
	Coal Creek
7	Scappoose Creek fall run
	Tide Creek
	Goble Creek
	Milton Creek
	McNulty Creek
	Scappoose Creek

The Lower Columbia River Watershed Assessment (2002) notes that since 1960, most natural fall run spawning on the Oregon side of the lower Columbia River has been attributed to hatchery strays (as cited in: BRT, 1997). Evidence from coded wire tag recoveries indicate that the majority of the returning fall chinook are strays from Big Creek hatchery as well as Rogue River fall-run chinook released into Big Creek and the Youngs Bay area (BRT, 1997; Kostow, 1995). Figure 3 shows known range of fall Chinook in the WOTs subbarea.

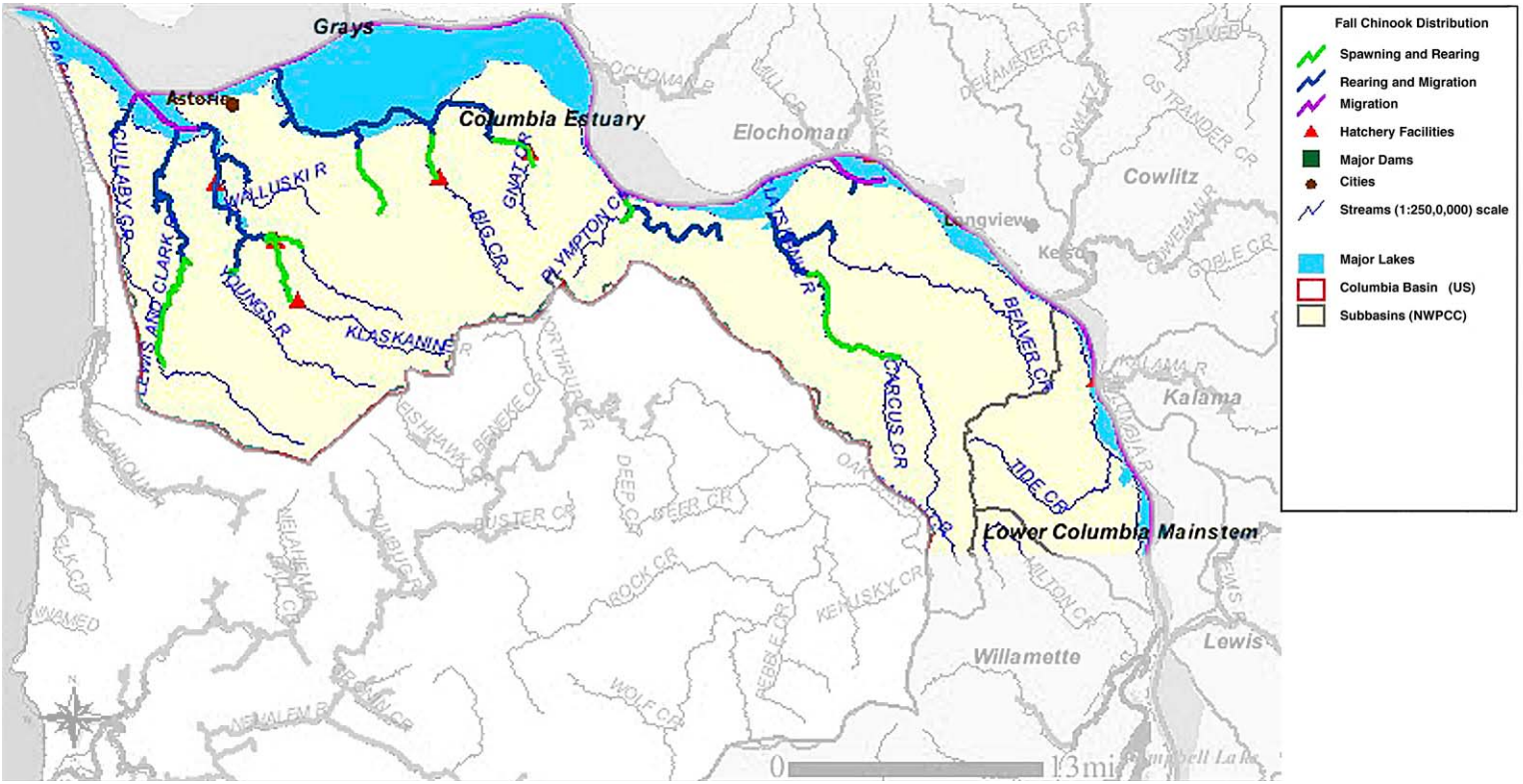


Figure 3. Fall Chinook in the Western Oregon Tributaries subbarea

2.2.4.8.2 Distribution

.2.2.4.8.2.1 Lower Columbia-Clatskanie

Long-term population trends for Plympton Creek and the Clatskanie River are positive, with an annual change of 1 to 5% (BRT, 1997). However, trends for most of the other tributaries of the lower Columbia River are negative. Distribution of fall chinook is limited to larger tributaries of the lower Columbia River. Kostow (1995) designates three of the streams of the Lower Columbia-Clatskanie Subbasin as containing habitat for spawning of fall chinook: Hunt Creek, Plympton Creek, and the Clatskanie River.

.2.2.4.8.2.2 Scappoose Bay

According to Willis et al. (1960), several hundred fall chinook spawned in the two-mile reach below the north and south forks of Scappoose Creek in the 1950s. Current status is unknown. Fall chinook have probably also occurred in small numbers in Milton Creek, although no data has been collected concerning them. According to residents, at least a few spring chinook also occur in the watershed. Spring chinook were observed spawning in lower North Scappoose Creek in 1997. An angler was observed catching a spring chinook in the mainstem of Scappoose Creek in 1998. Spring chinook may also be native to the watershed, although no historic references were found. The recent occurrences may be hatchery or native strays from the Willamette River stock.

Meyers et al. (2003) found that very little information is available for the cluster of populations from Tide Creek to Scappoose Creek, other than information indicating that fall-run chinook salmon were historically present in most of these systems. Fall-run chinook salmon were thought to be spawning in Milton Creek during the late 1950s (Willis et al. 1960). Scappoose Creek is the only basin that contains enough habitat to potentially sustain large numbers of fish (Table 1). Willis et al. (1960) reported that 100 fall chinook salmon were observed spawning in the lower two miles of Scappoose Creek. Ecologically, the tributaries on the Oregon side, which drain the Coast Range, are very different from the larger tributaries on the Washington side (e.g., Cowlitz and Kalama Rivers, etc.), which drain the Cascade Range.

A VSP rating for Clatskenie River Chinook salmon exists (WLCTRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: Aside from anecdotal reports of chinook salmon there was no information available for this population. Most WLC-TRT members utilized the “no data” default of 5,5,0,0,0.

JOM: Not rated.

Diversity: The only diversity information indicated that there had been very few hatchery fish released into this DIP.

Habitat: Conditions in this DIP was generally moderately degraded. Residential development along the Columbia River in combination with agricultural land uses has moderately to severely impaired many lower stream reaches.

Spatial Structure: There was some uncertainty concerning the number of existing barriers in the Scappoose and Milton Creeks. Poor habitat conditions were also suggested a limitation to distribution.

.2.2.4.8.2.3 Nicolai-Wickiup

The following is excerpted from the Nicolai-Wickiup Watershed Assessment (E&S Chemistry, 2000).

"Fall chinook occurs in almost all of the subwatersheds in the Nicolai-Wickiup watershed, including the Bear Creek subwatershed where they are limited from upstream reaches by the water control structure at the Bear Creek Reservoir. Distribution is limited in both the Big Creek and Gnat Creek subwatershed by their respective fish hatcheries. According to the Biennial Report on the Status of Wild Fish (ODFW 1995) Hunt Creek was historically used by chinook. However, there are no data available that definitely states whether or not there ever were any chinook in the Nicolai-Wickiup watershed (Walt Weber pers. communication in Birschoff 2000b). Currently, it is unlikely that there are any native chinook still in the Nicolai-Wickiup watershed."

A VSP rating for Big Creek Chinook salmon exists (WLCTRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows

Productivity and Abundance: Adult escapement to Big Creek is relatively good, although redd counts indicate that there is little natural reproduction in the basin and the majority of the fish return to the hatchery. The hatchery weir limits natural production to the less productive low reaches.

JOM: Not rated.

Diversity: Hatchery fish make up a substantial portion of escapement. Rogue River fall-run Chinook salmon were released from this site for a number of years and it was unclear if there had been any introgression between the tule and Rogue River populations. Genetically this population resembles fish from the Spring Creek National Fish Hatchery (NFH), which suggests that the native population was effectively lost years ago. In the absence of any natural reproduction, the potential for local adaptation was considered minimal.

Habitat: Conditions were moderately degraded through much of the basin. The effects of timber harvest may be significant in the upper reaches, while residential and agricultural land use was a factor among the lower reaches. Riparian conditions were considered highly degraded.

Spatial Structure: Most WLC-TRT members considered the hatchery weirs on Big and Gnat Creek to be significant factors in limiting fish distribution.

.2.2.4.8.2.4 Youngs Bay

Fall chinook occur in the Lewis & Clark, Youngs, Klaskanine, and Wallooskee Rivers These chinook are most likely hatchery strays or from direct hatchery releases. There may be some natural production from these hatchery fish. The Lewis & Clark River is the river most heavily by fall chinook, with the distribution extending midway up the river. The lower portions of the South Fork Klaskanine are used by fall chinook, extending to the 25 ft waterfall that limits upstream migration (Birshcoff et. al., 2000a).

A VSP rating for Young's Bay Chinook salmon exists (WLC--TRT, 2004), and can be found in Appendix B. A description of the qualitative parameters that led to the ratings is summarized as follows:

Productivity and Abundance: Most WLC-TRT members concluded that the extinction risk for this population was very high. Spawner surveys failed to find any returning adults in some years. Hatchery contribution to escapement in most years is probably very high.

JOM: Not rated.

Diversity: Hatchery fish make up a substantial portion of escapement. While many of the hatchery releases utilized within ESU tule fall-run hatchery stocks, the use of Rogue River fall run fish in Youngs Bay was of concern to the WLC-TRT.

Habitat: Conditions were moderately degraded through much of the basin. The effects of timber harvest may be significant in the upper reaches, while residential and agricultural land use was a factor among the lower reaches.

Spatial Structure: There was little information on fish distribution to use in evaluation. Dikes and tide gates have eliminated access to side channel spawning and rearing habitat. Two major barriers were also mentioned as restricting access. Some WLC-TRT members considered that the numerous tributaries entering Youngs Bays provided the *potential* for good fish distribution.

.2.2.4.8.2.5 Skipanon River

Currently, fall chinook salmon do not occur in the Skipanon River watershed and it is suggested that they did not inhabit this watershed historically either (Walt Weber pers. Comm. As cited in Birschoff et. al., 2000b.). Surveys conducted in Cullaby Creek by ODFW in 1991 and 1992 also did not identify any chinook in the watershed (Birschoff et al, 2000b).

2.2.4.8.3 Population and Listing Status

The following is excerpted from the Lower Columbia-Clatskanie Watershed Assessment (PSU, 2000):

"Chinook salmon was listed as a threatened species on March 24, 1999. The ESU includes all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River. It includes the Willamette River to Willamette Falls, Oregon, exclusive of spring-run chinook salmon in the Clackamas River (Source: http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm)".

"Lower Columbia Fall Chinook are chinook that enter the Columbia River as mature fish and spawn in small tributaries in the lower watershed. No wild populations have been sampled for allozyme (genetic) variation in this group, although Big Creek hatchery fish, founded from this group, were analyzed (Marshall 1993). The fish are distinctive from all other Columbia Watershed chinook in that they are mature upon river entry, have a short migration more similar to coastal populations, and spawn soon after arrival on the spawning grounds. Their ocean distribution is somewhat south of north coast populations extending along the coasts of Washington and British Columbia. Scattered naturally spawning fish are still observed in the lower Clackamas River and in small streams such as Plympton Creek, Gnat Creek, Big Creek, Clatskanie River, Hood River, and in the Youngs Bay and Columbia Gorge areas. Observations by ODFW district staff indicate that these fish generally spawn from September to early November".

"Most spawning has been observed in September, although fresh adults have been observed in late October and dead fish have been found in late November. Harvest management staff have concluded, based on expansions of coded-wire tag recoveries from these fish, that a huge proportion of the fish in these tributaries have been strays from Big Creek hatchery "tules" along with some strays of Rogue River "brights" released into Big Creek. The Plympton Creek "tules" were collected for hatchery broodstock in 1990, 1991 and 1994, with most of the females removed from the watershed in 1990. The information that is available indicates that the fall chinook populations in the lower Columbia Watershed are reduced from historical numbers, with much of the natural spawning dominated by hatchery fish from the 11 Oregon and Washington fall chinook hatcheries located in the lower Columbia."

2.2.4.8.4 Description of Aquatic Introductions

The following is excerpted from the Young's Bay Watershed Assessment (Birschoff (2000a):

"Releases of "tule" fall chinook from Oregon facilities included 13-14 million smolts below Bonneville Dam,10 million smolts in the Big Creek and Youngs Bay area, and 1-8 million smolts and fry in the lower Willamette in 1992 and 1993. Less than 5 percent of the fish are marked so the number of returning hatchery adults straying to natural spawning areas must be estimated from limited tag recoveries. Based on increases in coded-wire tags recovered in streams, most of the natural spawning can be attributed to hatchery strays. This straying pattern probably dates to the 1960s.

Fall chinook from the Rogue River were historically introduced into the lower Columbia River and were released into Big Creek and the Youngs Bay area. The purpose of this program was to provide a south migrating fall chinook for harvest along the Oregon coast and a "brighter" fall chinook in the lower river harvest. About 500,000 to 700,000 Rogue River smolts were released in 1992 and 1993. The fish are adapted to a long migration up the Rogue River and so enter the Columbia River "brighter" than the local populations. All Rogue River "brights" have been marked and straying is being monitored. There has been some straying into natural spawning areas and into lower Columbia hatcheries. Their spawning time does not overlap with the later part of the natural spawning distribution of the local "tules." And, based on their marks, they are removed from the hatchery tule spawning escapement.

The Klaskanine River is the most heavily stocked for fall chinook in the Youngs Bay watershed. Between 1974 and 1981, 2.9 million fall chinook were released in the lower reaches of the Klaskanine River (Figure 2.5). In the north fork Klaskanine River, 4.4 million fall chinook

were released from 1980 and 1988. Between 1996 and 1999, anywhere from 200,000 to 700,000 fall chinook were released in the Klaskanine River, and in the headwaters of the Klaskanine River, 17.7 million fall chinook were released between 1981 and 1990. There were also significant releases from the Youngs Bay net pen operations. From 1986 to 1994, almost 1 million fall chinook were released from the net pens. Currently, fall Chinook are heavily released from the net pen facilities. Anywhere from 56,000 to 1.5 million fall chinook were released annually from the net pen facilities for the period of 1992 to 1999.

Hatchery spring chinook from the Willamette River are also released into the Youngs Bay area to provide fish for sport and commercial harvest in the bay. About 400,000 smolts were released into the bay in 1992. Spring chinook releases range from 375,000 to about 450,000 spring chinook annually from the Youngs Bay net pen facilities. These fish enter the lower Columbia River in the spring, long before "tule" populations are present. Potential impacts of these fish are unknown, but they probably do not survive through the summer to spawn in the lower river tributaries near their release sites due to a lack of adult holding habitat in the lower Columbia River Watershed. They have not been found to stray into other areas".

2.2.5 *Assessment*

2.2.5.1 Qualitative Habitat Assessment

The scope of work for the Mainstem Lower Columbia River and Columbia River Estuary subbasin plan originally tasked the planning team to assess Youngs, Lewis & Clark River, Clatskanie River, and Klaskanine Rivers. At the November 5th , 2003 Planning Group Meeting, representatives from Oregon Department of Fish and Wildlife advocated for inclusion of Big Creek, since it is receiving a lot of attention as an area of potentially high productive value as fish passage issues get addressed.

Project staff attended the November 11th and December 10th meetings of the Lower Columbia-Clatskanie Watershed and the Nicolai-Wickiup Watershed Associations, respectively. At these meetings, general watershed issues were discussed and identified, and target streams for assessment confirmed. The Youngs Bay Watershed Association was briefed on the assessment approach by the Clatsop County Watershed Coordinator.

Mobrand Biometrics directed the establishment of reaches, the development of the QHA worksheets, created first draft species hypotheses, and facilitated the workshop in Astoria on January 14th, 15th, and 16th , 2004. In order to conserve budget and time, Project staff collected reach delineation information from ODFW's AIP program, and coordinated logistics.

Terrain Navigator, a PC based mapping program was used to display reaches.

The qualitative habitat workshop was held in Astoria for two and half days in January. Most participants were present for the full duration. Table 2-19 below identifies the workshop participants, their affiliation, and their role.

As mentioned in section 2.2.4.1 above, above, an important change to the focal species assessed was made by the workshop participants, who felt that evaluating Chum for these watersheds was a higher priority for evaluating changes of the watershed from historic conditions, since it was the group's belief that Chinook are a relatively recent introduction into these systems as a result of plantings in the 1970s.

Table 2-24: WOTS QHA workshop participants, January 14-16, 2004

Name	Organization	Role
Chip McConnaha	Morband Biometrics Inc.	Technical Staff
Finlay Anderson	Zenn Associates	Facilitator
Devlin Valence	Oregon Department of Fish & Wildlife	Participant
Joe Sheahan	Oregon Department of Fish & Wildlife	Participant
Rod Litton	Clatsop County Economic Development Commission	Participant
Todd Aslbury	Oregon Department of Fish & Wildlife	Participant
Bud Henderson	Hampton Affiliates	Participant
Walt Weber	Citizen (ODF&W, Retired)	Participant
Eric Ollerenshaw	Oregon Department of Fish & Wildlife	Participant
Cedric Cooney	Oregon Department of Fish & Wildlife	Participant
Troy Laws	Oregon Department of Fish & Wildlife	Participant
Margaret MaGruder	Columbia-Clatskanie Watershed Association	Participant
Gary Solderstrohm	Columbia-Clatskanie Watershed Association	Participant

.2.2.5.1.1.1 Reach Delineation

Project staff collected reach information from the AIP databases in mid-November and transcribed these reaches into Terrain Navigator. MBI, project staff, and ODFW met on December 5th to review the reaches, add or simplify where necessary, and discuss requirements for a productive workshop in January. At the January workshop, these reaches were once again reviewed and re-defined as appropriate for the level of knowledge represented. In all 63 reaches were evaluated and rated

Table 5 shows the reaches rated and provides a brief description of landmarks that distinguish them.

Table 2-25: Reach labels and descriptions evaluated in QHA workshop

Stream or River	Description	Reach Name
Big Creek	Mouth to hatchery outflow	3 Big-Mouth
Big Creek	Hatchery outflow to intake dam	11 ODFW-BIG-A1
Big Creek	Intake dam to valley broadening	12 ODFW-BIG-A2
Big Creek	Valley broadening to Mud Cr	13 ODFW-BIG-A3
Big Creek	Mud Cr to Elk incl Coon	14 ODFW-BIG-A4
Big Creek	Elk Creek	Big Elk-1
Big Creek	Elk Creek	Big Elk-2
Big Creek	Elk Creek	Big Elk-3
Big Creek	Elk Creek	Big Elk-4
Big Creek	Coon Creek	2 Big-Coon
Big Creek	Mud Creek	4 Big-Mud
Big Creek	Pigpen	5 Big-Pigpen
Claskenie	Mouth to Hazel Grove Rd.	6 CLA-A Mouth
Claskenie	Hazel Grove Rd to "Alder Grove School"	19 ODFW-CLA-A1
Claskenie	Alder Grove School to SwedeTown Rd	20 ODFW-CLA-A2
Claskenie	Swede Town Rd to Carcass Cr	21 ODFW-CLA-A3
Claskenie	Carcass Cr to end RM18	22 ODFW-CLA-A4
Claskenie	Mouth to RB trib	CLA Carcass-1
Claskenie	RB trib to West Fork	CLA Carcass-2
Claskenie	West Fork to Falls	CLA Carcass-3
Claskenie	Claskenie	6a-CLA-PAGE
Claskenie	Claskenie	6b-CLA-Miller
Claskenie	Claskenie	6c-CLA-Little Clatskenie
L&C	LC mouth in Youngs to RM8	LC-B0
L&C	RM8 (tidewater) to 400 Line	35 ODFW-LC-B1
L&C	400 Line to South Fork	36 ODFW-LC-B2
L&C	South Fork to Warrenton intake dam	37 ODFW-LC-B3
L&C	Intake dam to L&C Falls	38 ODFW-LC-B4
L&C	Heckard mouth to L&C Mainline	32 ODFW-LC-A2
L&C	Heckard L&C Mainline to Fletcher Spur	33 ODFW-LC-A3
L&C	Heckard Fletcher Spur to Swamp	34 ODFW-LC-A4
L&C	Stavebolt mouth to canyon narrows	39 ODFW-LC-C1
L&C	Stavebolt canyon section	40 ODFW-LC-C2
L&C	Hortill Creek	41 ODFW-LC-D1
L&C	Klickitat Creek	50 ODFW-LC-H2
L&C	Speelyai mouth to 150 Contour	42 ODFW-LC-E1
L&C	Speelyai 150 contour to end	43 ODFW-LC-E2
L&C	Loowit Creek	44 ODFW-LC-EF1
L&C	Shweeash Creek mouth to 400 Road	47 ODFW-LC-G1
L&C	Shweeash Creek 400 Road to top	48 ODFW-LC-G2
L&C	Camp C Creek mouth to reservoir	49 ODFW-LC-H1

Stream or River	Description	Reach Name
L&C	South Fork L&C to dam incl Little SF	30 LC-S Fork Reach
Youngs	Youngs Bay Mouth to confluence of Youngs R.	57 Youngs Bay Mouth
Youngs	Younds R. to Bridge (head of tide)	73 ODFW-YNG-A0
Youngs	Bridge to Falls	74 ODFW-YNG-A1
Youngs	MoosMoos	75 ODFW-YNG-A2
North Fork Klasks	Smileys Hole to State Hatchery dam	8 NKLA-A0
North Fork Klasks	Hatchery upstream to and incl Middle Fork	9 NKLA-A1
North Fork Klasks	North Fork of NFk	10 NKLA-NFK
Mainstem Klasks	Confluence to SouthFork (Smileys Hole)	63SKL-A0
South Fork Klasks	South Fork to 25' countour	64 ODFW-SKL-A1
South Fork Klasks	25' contour to CEDC Hatchery dam	65 ODFW-SKL-A2
South Fork Klasks	CEDC Hatchery Dam to first Falls	66 ODFW-SKL-A3
South Fork Klasks	first falls to bigfalls	67 ODFW-SKL-A4
South Fork Klasks	Big Falls to South Fk of South Fk	ODFW-SKL-A4.5
South Fork Klasks	South FK of South FK to End	68 ODFW-SKL-A5

.2.2.5.1.1.2 Species Hypotheses

In QHA the species hypothesis is a set of weights that are attached to the score for each Reach/Attribute cell to compute the final score. In other words, the hypothesis is the pair of "glasses" through which scores for each reach and attribute are judged.

Species hypotheses were developed by MBI, using models developed by Nickel son (1998) to provide the basic mechanism of life history requirements. The basic species hypothesis was then reviewed by workshop participants and refined where needed. The basic construction of the species hypothesis involves an interaction of two matrices as follows

- The first table provides (1) the relative importance of each life stage to fish productivity and sustainability and (2) for each life stage, the relative importance of each habitat characteristic.
- The second table is used to characterize how fish currently use each reach or small watershed and how they would use these areas in a reference condition, be it historical or potential.

Species hypotheses for the selected focal species are illustrated in Table 2-26 through Table 2-29 in the following pages.

Table 2-26: Chum Species Hypothesis

Species habitat range
Focal Species: Chum Salmon in WOTs
Weight Assigned to each attribute (0-2) relative to the reach's importance to the life stage

NPC= Not Present Currently
NPR = Not Present in Reference

			Current Range (0-2)				Reference Range (0-2)			
Description	Reach Name	NPC?	Spawn and incubation	Summer rearing	Winter rearing	Migration	Spawn and incubation	Summer rearing	Winter rearing	Migration
Mouth to hatchery outflow	3 Big-Mouth	NPC								
Hatchery outflow to intake dam	11 ODFW-BIG-A1	NPC								
Intake dam to valley broadening	12 ODFW-BIG-A2	NPC								
Valley broadening to Mud Cr	13 ODFW-BIG-A3	NPC								
Mud Cr to Elk incl Coon	14 ODFW-BIG-A4	NPC								
Elk Creek	Big Elk-1	NPC								
Elk Creek	Big Elk-2	NPC								
Elk Creek	Big Elk-3	NPC								
Elk Creek	Big Elk-4	NPC								
Coon Creek	2 Big-Coon	NPC								
Mud Creek	4 Big-Mud	NPC								
Pigpen	5 Big-Pigpen	NPC								
Mouth to Hazel Grove Rd.	6 CLA-A Mouth	NPC	0	0	0	0	0	2		2
Hazel Grove Rd to "Alder Grove School"	19 ODFW-CLA-A1	NPC	0	0	0	0	1			2
Alder Grove School to SwedeTown Rd	20 ODFW-CLA-A2	NPC	0	0	0	0	2			2
Swede Town Rd to Carcass Cr	21 ODFW-CLA-A3	NPC	0	0	0	0	2			2
Carcass Cr to end RM18	22 ODFW-CLA-A4	NPC	0	0	0	0	1			2
Mouth to RB trib	CLA Carcass-1	NPC	0	0	0	0	2			2
RB trib to West Fork	CLA Carcass-2	NPC								
West Fork to Falls	CLA Carcass-3	NPC								
Claskenie	6a-CLA-PAGE	NPC	0	0	0	0	1			2
Claskenie	6b-CLA-Miller	NPC	0	0	0	0	1			2
Claskenie	6c-CLA-Little Clats	NPC								
LC mouth in Youngs to RM8	LC-B0	NPC	0	0	0	0	0	0	2	2
RM8 (tidewater) to 400 Line	35 ODFW-LC-B1	NPC	0	0	0	0	2	0	2	2
400 Line to South Fork	36 ODFW-LC-B2	NPC	0	0	0	0	1.5	0	1.5	2
South Fork to Warrenton intake dam	37 ODFW-LC-B3	NPC	0	0	0	0	0	0	0	0
Intake dam to L&C Falls	38 ODFW-LC-B4	NPC	0	0	0	0	0	0	0	0
Heckard mouth to L&C Mainline	32 ODFW-LC-A2	NPC	0	0	0	0	1	0	1	2
Heckard L&C Mainline to Fletcher Spur	33 ODFW-LC-A3	NPC	0	0	0	0	0	0	0	0
Heckard Fletcher Spur to Swamp	34 ODFW-LC-A4	NPC	0	0	0	0	0	0	0	0
Stavebolt mouth to canyon narrows	39 ODFW-LC-C1	NPC	0	0	0	0	2	0	1	2
Stavebolt canyon section	40 ODFW-LC-C2	NPC	0	0	0	0	0	0	0	0
Hortill Creek	41 ODFW-LC-D1	NPC	0	0	0	0	2	0	1.5	2
Klickitat Creek	50 ODFW-LC-H2	NPC	0	0	0	0	1	0	1	2
Speelyai mouth to 150 Contour	42 ODFW-LC-E1	NPC	0	0	0	0	1	0	1	2
Speelyai 150 contour to end	43 ODFW-LC-E2	NPC	0	0	0	0	0	0	0	0
Loowit Creek	44 ODFW-LC-EF1	NPC	0	0	0	0	1	0	1	2
Shweeash Creek mouth to 400 Road	47 ODFW-LC-G1	NPC	0	0	0	0	1	0	1	2
Shweeash Creek 400 Road to top	48 ODFW-LC-G2	NPC	0	0	0	0	0	0	0	0
Camp C Creek mouth to reservoir	49 ODFW-LC-H1	NPC	0	0	0	0	0	0	0	0
South Fork L&C to dam incl Little SF	30 LC-S Fork Reach	NPC	0	0	0	0	0	0	0	0
Youngs Bay Mouth to confluence of Youngs R.	57 Youngs Bay Mouth	NPC	0	0	0	0	0	0	2	2
Younds R. to Bridge (head of tide)	73 ODFW-YNG-A0	NPC	0	0	0	0	0	0	2	2
Bridge to Falls	74 ODFW-YNG-A1	NPC	0	0	0	0	2	0	1	2
MoosMoos	75 ODFW-YNG-A2	NPC	0	0	0	0	2	0	1	2
Smileys Hole to State Hatchery dam	8 NKLA-A0	NPC	0	0	0	0	2	0	1	2
Hatchery upstream to and incl Middle Fork	9 NKLA-A1	NPC	0	0	0	0	1	0	1	2
North Fork of NFk	10 NKLA-NFK	NPC	0	0	0	0	1	0	1	2
Confluence to SouthFork (Smileys Hole)	63SKL-A0		0	0	0	2	2	0	1	2
South Fork to 25' countour	64 ODFW-SKL-A1		0	0	0	2	2	0	1	2
25' contour to CEDC Hatchery dam	65 ODFW-SKL-A2		1	0	1	2	2	0	1	2
CEDC Hatchery Dam to first Falls	66 ODFW-SKL-A3	NPC	0	0	0	0	0.5	0	1	2
first falls to bigfalls	67 ODFW-SKL-A4	NPC	0	0	0	0	0	0	0	0
Big Falls to South Fk of South Fk	ODFW-SKL-A4.5	NPC	0	0	0	0	0	0	0	0
South FK of South FK to End	68 ODFW-SKL-A5	NPC	0	0	0	0	0	0	0	0

Chum Species Hypothesis				
	Spawning/incubation	Summer Rearing	Winter Rearing	Migration
Life Stage Rank (1-4) *	4	0	3	1
Attribute Weight **				
Riparian Condition	0	2	1	0
Channel stability	1	1	2	2
Habitat Diversity	2	2	2	0
Fine sediment	2	0.5	0	0
High Flow	1.5	0	2	0
Low Flow	0	2	0	1
Oxygen	2	2	2	2
Low Temp	0	0	2	0
High Temp	0	2	0	0
Pollutants	2	2	2	0
Obstructions	0	0	0.5	2

* Life stage rank indicates a prioritization of habitat condition for use by a life stage. Stages are ranked
**Assign a weight to each attribute (0-2) relative to its importance to the life stage

Table 2-27: Steelhead Species Hypothesis

NPC= Not Present Currently
NPR = Not Present in Reference

Species habitat range
Focal Species: Steelhead in WOTs
Weight Assigned to each attribute (0-2) relative to the reach's importance to the life stage

			Current Range (0-2)				Reference Range (0-2)			
Description	Reach Name	NPC?	Spawn and incubation	Summer rearing	Winter rearing	Migration	Spawn and incubation	Summer rearing	Winter rearing	Migration
Mouth to hatchery outflow	3 Big-Mouth	NPC	1.5	0	0.5	2		1.5	2	2
Hatchery outflow to intake dam	11 ODFW-BIG-A1	NPC	1	2	2	0		2	2	2
Intake dam to valley broadening	12 ODFW-BIG-A2	NPC						2	2	2
Valley broadening to Mud Cr	13 ODFW-BIG-A3	NPC						2	2	2
Mud Cr to Elk incl Coon	14 ODFW-BIG-A4	NPC						2	2	2
Elk Creek	Big Elk-1	NPC						2	2	2
Elk Creek	Big Elk-2	NPC						2	2	2
Elk Creek	Big Elk-3	NPC						2	1	1
Elk Creek	Big Elk-4	NPC						1	1	1
Coon Creek	2 Big-Coon	NPC						2	2	2
Mud Creek	4 Big-Mud	NPC						2	2	2
Pigpen	5 Big-Pigpen	NPC						2	2	2
Mouth to Hazel Grove Rd.	6 CLA-A Mouth	NPC	0	0	1	2		0	1	2
Hazel Grove Rd to "Alder Grove School"	19 ODFW-CLA-A1	NPC	1	0	1	2		1	1	2
Alder Grove School to SwedeTown Rd	20 ODFW-CLA-A2	NPC	1	1	1	2		2	1	2
Swede Town Rd to Carcass Cr	21 ODFW-CLA-A3	NPC	2	2	2	2		2	2	2
Carcass Cr to end RM18	22 ODFW-CLA-A4	NPC	2	2	2	2		2	2	2
Mouth to RB trib	CLA Carcass-1	NPC	2	2	2	2		2	2	2
RB trib to West Fork	CLA Carcass-2	NPC	2	2	2	2		2	2	2
West Fork to Falls	CLA Carcass-3	NPC	2	2	2	2		2	2	2
Claskenie	6a-CLA-PAGE	NPC	2	2	2	2		2	2	2
Claskenie	6b-CLA-Miller	NPC	2	2	2	2		2	2	2
Claskenie	6c-CLA-Little Clats	NPC	2	2	2	2		2	2	2
LC mouth in Youngs to RM8	LC-B0	NPC	0	0	0	2		0	0	0
RM8 (tidewater) to 400 Line	35 ODFW-LC-B1	NPC	1	1	1	2		2	2	2
400 Line to South Fork	36 ODFW-LC-B2	NPC	2	2	1	2		2	2	2
South Fork to Warrenton intake dam	37 ODFW-LC-B3	NPC	1	2	2	2		1	2	2
Intake dam to L&C Falls	38 ODFW-LC-B4	NPC	2	2	2	2		2	2	2
Heckard mouth to L&C Mainline	32 ODFW-LC-A2	NPC	0	0	1	0		0	0	1
Heckard L&C Mainline to Fletcher Spur	33 ODFW-LC-A3	NPC	0	0	1	0		0	0	1
Heckard Fletcher Spur to Swamp	34 ODFW-LC-A4	NPC	0	0	0	0		0	0	0
Stavebolt mouth to canyon narrows	39 ODFW-LC-C1	NPC	0	0	1	2		0	0	1
Stavebolt canyon section	40 ODFW-LC-C2	NPC	0	0	0	0		0	0	0
Hortill Creek	41 ODFW-LC-D1	NPC	0	0	1	2		0	0	1
Klickitat Creek	50 ODFW-LC-H2	NPC	0.5	0.5	1	2		1	1	1
Speelyai mouth to 150 Contour	42 ODFW-LC-E1	NPC	0	0.5	1	2		1	1	1
Speelyai 150 contour to end	43 ODFW-LC-E2	NPC	1	1	1	2		1	1	1
Loowit Creek	44 ODFW-LC-EF1	NPC	1	1	1	2		1	1	1
Shweeash Creek mouth to 400 Road	47 ODFW-LC-G1	NPC	1	1	1	2		1	1	1
Shweeash Creek 400 Road to top	48 ODFW-LC-G2	NPC	0	0	0	0		0	0	0
Camp C Creek mouth to reservoir	49 ODFW-LC-H1	NPC	1	1	1	2		1.5	1	1
South Fork L&C to dam incl Little SF	30 LC-S Fork Reach	NPC	0.5	1	0.5	2		0.5	1	0.5
Youngs Bay Mouth to confluence of Youngs R.	57 Youngs Bay Mouth	NPC	0	0	0	2		0	0	0
Younds R. to Bridge (head of tide)	73 ODFW-YNG-A0	NPC	0	0.5	0.5	2		0	0.5	0.5
Bridge to Falls	74 ODFW-YNG-A1	NPC	2	2	2	2		2	2	2
MoosMoos	75 ODFW-YNG-A2	NPC	0	0	0	0		0	0	0
Smileys Hole to State Hatchery dam	8 NKLA-A0	NPC	2	2	2	2		1.5	1.5	2
Hatchery upstream to and incl Middle Fork	9 NKLA-A1	NPC	0	0	0	0		2	2	2
North Fork of NFk	10 NKLA-NFK	NPC	0	0	0	0		2	2	2
Confluence to SouthFork (Smileys Hole)	63SKL-A0		0	0.5	1	2		0	1	1
South Fork to 25' countour	64 ODFW-SKL-A1		0.5	0.5	1	2		1.5	2	2
25' contour to CEDC Hatchery dam	65 ODFW-SKL-A2		1.5	1	1	2		2	2	2
CEDC Hatchery Dam to first Falls	66 ODFW-SKL-A3	NPC	2	2	2	2		2	2	2
first falls to bigfalls	67 ODFW-SKL-A4	NPC	2	2	2	2		2	2	2
Big Falls to South Fk of South Fk	ODFW-SKL-A4.5	NPC	0	0	0	0		0	0	0
South FK of South FK to End	68 ODFW-SKL-A5	NPC	0	0	0	0		0	0	0

Steelhead Species Hypothesis				
	Spawning/incubation	Summer Rearing	Winter Rearing	Migration
Life Stage Rank (1-4) *	2	4	3	1
Attribute Weight **				
Riparian Condition	0	2	1	0
Channel stability	1	1	2	2
Habitat Diversity	2	2	2	0
Fine sediment	2	0.5	0	0
High Flow	1.5	0	2	0
Low Flow	0	2	0	1
Oxygen	2	2	2	2
Low Temp	0	0	2	0
High Temp	0	2	0	0
Pollutants	2	2	2	0
Obstructions	0	0	0.5	2

* Life stage rank indicates a prioritization of habitat condition for use by a life stage. Stages are ranked
**Assign a weight to each attribute (0-2) relative to its importance to the life stage

Table 2-28: Chinook Species Hypothesis

Species habitat range
Focal Species: Chinook in WOTs
Weight Assigned to each attribute (0-2) relative to the reach's importance to the life stage

NPC= Not Present Currently
NPR = Not Present in Reference

			Current Range (0-2)				Reference Range (0-2)			
Description	Reach Name	NPC?	Spawn and incubation	Summer rearing	Winter rearing	Migration	Spawn and incubation	Summer rearing	Winter rearing	Migration
Mouth to hatchery outflow	3 Big-Mouth	NPC	2	2		2		0	0	
Hatchery outflow to intake dam	11 ODFW-BIG-A1	NPC	0	0		0		0	0	
Intake dam to valley broadening	12 ODFW-BIG-A2	NPC	0	0		0		0	0	
Valley broadening to Mud Cr	13 ODFW-BIG-A3	NPC	0	0		0		0	0	
Mud Cr to Elk incl Coon	14 ODFW-BIG-A4	NPC	0	0		0		0	0	
Elk Creek	Big Elk-1	NPC	0	0		0		0	0	
Elk Creek	Big Elk-2	NPC	0	0		0		0	0	
Elk Creek	Big Elk-3	NPC	0	0		0		0	0	
Elk Creek	Big Elk-4	NPC	0	0		0		0	0	
Coon Creek	2 Big-Coon	NPC	0	0		0		0	0	
Mud Creek	4 Big-Mud	NPC	0	0	0	0				
Pigpen	5 Big-Pigpen	NPC	0	0	0	0				
Mouth to Hazel Grove Rd.	6 CLA-A Mouth	NPC	0	2		2		2	2	
Hazel Grove Rd to "Alder Grove School"	19 ODFW-CLA-A1	NPC	2	2		2		2	2	
Alder Grove School to SwedeTown Rd	20 ODFW-CLA-A2	NPC	2	2		2		2	2	
Swede Town Rd to Carcass Cr	21 ODFW-CLA-A3	NPC	2	2		2		2	2	
Carcass Cr to end RM18	22 ODFW-CLA-A4	NPC	0	0		0		0	0	
Mouth to RB trib	CLA Carcass-1	NPC	0	0		0		0	0	
RB trib to West Fork	CLA Carcass-2	NPC	0	0		0		0	0	
West Fork to Falls	CLA Carcass-3	NPC	0	0		0		0	0	
Claskenie	6a-CLA-PAGE	NPC	0	0		0		0	0	
Claskenie	6b-CLA-Miller	NPC	0	0		0		0	0	
Claskenie	6c-CLA-Little Clats	NPC	0	0		0		0	0	
LC mouth in Youngs to RM8	LC-B0	NPC		2		2			2	
RM8 (tidewater) to 400 Line	35 ODFW-LC-B1	NPC								
400 Line to South Fork	36 ODFW-LC-B2	NPC								
South Fork to Warrenton intake dam	37 ODFW-LC-B3	NPC								
Intake dam to L&C Falls	38 ODFW-LC-B4	NPC								
Heckard mouth to L&C Mainline	32 ODFW-LC-A2	NPC								
Heckard L&C Mainline to Fletcher Spur	33 ODFW-LC-A3	NPC								
Heckard Fletcher Spur to Swamp	34 ODFW-LC-A4	NPC								
Stavebolt mouth to canyon narrows	39 ODFW-LC-C1	NPC								
Stavebolt canyon section	40 ODFW-LC-C2	NPC								
Hortill Creek	41 ODFW-LC-D1	NPC								
Klickitat Creek	50 ODFW-LC-H2	NPC								
Speelyai mouth to 150 Contour	42 ODFW-LC-E1	NPC								
Speelyai 150 contour to end	43 ODFW-LC-E2	NPC								
Loowit Creek	44 ODFW-LC-EF1	NPC								
Shweeash Creek mouth to 400 Road	47 ODFW-LC-G1	NPC								
Shweeash Creek 400 Road to top	48 ODFW-LC-G2	NPC								
Camp C Creek mouth to reservoir	49 ODFW-LC-H1	NPC								
South Fork L&C to dam incl Little SF	30 LC-S Fork Reach	NPC								
Youngs Bay Mouth to confluence of Youngs R.	57 Youngs Bay Mouth	NPC								
Younds R. to Bridge (head of tide)	73 ODFW-YNG-A0	NPC								
Bridge to Falls	74 ODFW-YNG-A1	NPC								
MoosMoos	75 ODFW-YNG-A2	NPC								
Smileys Hole to State Hatchery dam	8 NKLA-A0	NPC								
Hatchery upstream to and incl Middle Fork	9 NKLA-A1	NPC								
North Fork of NFk	10 NKLA-NFK	NPC								
Confluence to SouthFork (Smileys Hole)	63SKL-A0									
South Fork to 25' countour	64 ODFW-SKL-A1									
25' contour to CEDC Hatchery dam	65 ODFW-SKL-A2									
CEDC Hatchery Dam to first Falls	66 ODFW-SKL-A3	NPC								
first falls to bigfalls	67 ODFW-SKL-A4	NPC								
Big Falls to South Fk of South Fk	ODFW-SKL-A4.5	NPC								
South FK of South FK to End	68 ODFW-SKL-A5	NPC								

Chinook Species Hypothesis				
	Spawning/incubation	Summer Rearing	Winter Rearing	Migration
Life Stage Rank (1-4) *	2	4	3	1
Attribute Weight **				
Riparian Condition	0	2	1	0
Channel stability	1	1	2	2
Habitat Diversity	2	2	2	0
Fine sediment	2	0.5	0	0
High Flow	1.5	0	2	0
Low Flow	0	2	0	1
Oxygen	2	2	2	2
Low Temp	0	0	2	0
High Temp	0	2	0	0
Pollutants	2	2	2	0
Obstructions	0	0	0.5	2

* Life stage rank indicates a prioritization of habitat condition for use by a life stage. Stages are ranked
**Assign a weight to each attribute (0-2) relative to its importance to the life stage

Table 2-29: Coho Species Hypothesis:

Species habitat range
Focal Species: Coho Salmon in WOTs
Weight Assigned to each attribute (0-2) relative to the reach's importance to the life stage

NPC= Not Present Currently
NPR = Not Present in Reference

			Current Range (0-2)				Reference Range (0-2)			
Description	Reach Name	NPC?	Spawn and incubation	Summer rearing	Winter rearing	Migration	Spawn and incubation	Summer rearing	Winter rearing	Migration
Mouth to hatchery outflow	3 Big-Mouth	NPC	1	0	0.5	2		1	2	2
Hatchery outflow to intake dam	11 ODFW-BIG-A1	NPC	0	0	0	0		2	2	2
Intake dam to valley broadening	12 ODFW-BIG-A2	NPC						2	2	2
Valley broadening to Mud Cr	13 ODFW-BIG-A3	NPC						2	2	2
Mud Cr to Elk incl Coon	14 ODFW-BIG-A4	NPC						2	2	2
Elk Creek	Big Elk-1	NPC						2	2	2
Elk Creek	Big Elk-2	NPC						2	2	2
Elk Creek	Big Elk-3	NPC						2	1	1
Elk Creek	Big Elk-4	NPC						1	1	1
Coon Creek	2 Big-Coon	NPC						2	2	2
Mud Creek	4 Big-Mud	NPC						2	2	2
Pigpen	5 Big-Pigpen	NPC						2	2	2
Mouth to Hazel Grove Rd.	6 CLA-A Mouth	NPC	0	0	1	2		0	1	2
Hazel Grove Rd to "Alder Grove School"	19 ODFW-CLA-A1	NPC	1	0	1	2		1	1	2
Alder Grove School to SwedeTown Rd	20 ODFW-CLA-A2	NPC	1	1	1	2		2	1	2
Swede Town Rd to Carcass Cr	21 ODFW-CLA-A3	NPC	2	2	2	2		1	2	2
Carcass Cr to end RM18	22 ODFW-CLA-A4	NPC	2	2	2	2		1	2	2
Mouth to RB trib	CLA Carcass-1	NPC	2	2	2	2		2	2	2
RB trib to West Fork	CLA Carcass-2	NPC	2	2	2	2		2	2	2
West Fork to Falls	CLA Carcass-3	NPC	2	2	2	2		2	2	2
Claskenie	6a-CLA-PAGE	NPC	2	2	2	2		2	2	2
Claskenie	6b-CLA-Miller	NPC	2	2	2	2		2	2	2
Claskenie	6c-CLA-Little Clats	NPC	2	2	2	2		2	2	2
LC mouth in Youngs to RM8	LC-B0	NPC	0	0.5	1	2		0	1	1.5
RM8 (tidewater) to 400 Line	35 ODFW-LC-B1	NPC	1	1	1	2		1.5	2	2
400 Line to South Fork	36 ODFW-LC-B2	NPC	2	2	2	2		2	2	2
South Fork to Warrenton intake dam	37 ODFW-LC-B3	NPC	0	0.5	1.5	2		0.5	2	1.5
Intake dam to L&C Falls	38 ODFW-LC-B4	NPC	1	1	1	1		2	2	2
Heckard mouth to L&C Mainline	32 ODFW-LC-A2	NPC	0.5	1	1	2		0.5	2	2
Heckard L&C Mainline to Fletcher Spur	33 ODFW-LC-A3	NPC	0	0	0	0		1	2	2
Heckard Fletcher Spur to Swamp	34 ODFW-LC-A4	NPC	0	0	0	0		2	2	2
Stavebolt mouth to canyon narrows	39 ODFW-LC-C1	NPC	0.5	0.5	1	2		1.5	2	2
Stavebolt canyon section	40 ODFW-LC-C2	NPC	0	0.5	1	2		0.5	1	1.5
Hortill Creek	41 ODFW-LC-D1	NPC	0.5	0.5	1	2		1.5	1	2
Klickitat Creek	50 ODFW-LC-H2	NPC	0.5	0.5	1	2		1.5	1	2
Speelyai mouth to 150 Contour	42 ODFW-LC-E1	NPC	0	0.5	1	2		1.5	1	2
Speelyai 150 contour to end	43 ODFW-LC-E2	NPC	1	1	1	2		2	2	2
Loowit Creek	44 ODFW-LC-EF1	NPC	1	1	1	2		2	2	2
Shweeash Creek mouth to 400 Road	47 ODFW-LC-G1	NPC	1	1	1	2		2	2	2
Shweeash Creek 400 Road to top	48 ODFW-LC-G2	NPC	0	0	0	0		1.5	1.5	1.5
Camp C Creek mouth to reservoir	49 ODFW-LC-H1	NPC	2	1	1	2		2	2	2
South Fork L&C to dam incl Little SF	30 LC-S Fork Reach	NPC	0.5	1	0.5	2		0.5	1	0.5
Youngs Bay Mouth to confluence of Youngs R.	57 Youngs Bay Mouth	NPC	0	1	1	2		0	1	1
Younds R. to Bridge (head of tide)	73 ODFW-YNG-A0	NPC	0	1	1	2		0	1	1
Bridge to Falls	74 ODFW-YNG-A1	NPC	2	2	2	2		2	2	2
MoosMoos	75 ODFW-YNG-A2	NPC	0	1	1	2		1	1	1
Smileys Hole to State Hatchery dam	8 NKLA-A0	NPC								
Hatchery upstream to and incl Middle Fork	9 NKLA-A1	NPC	2	2	2	2		1	2	2
North Fork of NFk	10 NKLA-NFK	NPC	0	0	0	0		2	2	2
Confluence to SouthFork (Smileys Hole)	63SKL-A0		0	0	0	0		2	2	1
South Fork to 25' countour	64 ODFW-SKL-A1		0	1	1.5	2		0	1	2
25' contour to CEDC Hatchery dam	65 ODFW-SKL-A2		0.5	1	1.5	2		0	1.5	2
CEDC Hatchery Dam to first Falls	66 ODFW-SKL-A3	NPC	2	2	2	2		2	2	2
first falls to bigfalls	67 ODFW-SKL-A4	NPC	2	2	2	2		2	2	2
Big Falls to South Fk of South Fk	ODFW-SKL-A4.5	NPC	0	0	0	0		0	0	0
South FK of South FK to End	68 ODFW-SKL-A5	NPC	0	0	0	0		0	0	0

Coho Species Hypothesis				
	Spawning/incubation	Summer Rearing	Winter Rearing	Migration
Life Stage Rank (1-4) *	2	4	3	1
Attribute Weight **				
Riparian Condition	0	2	1	0
Channel stability	1	1	2	2
Habitat Diversity	2	2	2	0
Fine sediment	2	0.5	0	0
High Flow	1.5	0	2	0
Low Flow	0	2	0	1
Oxygen	2	2	2	2
Low Temp	0	0	2	0
High Temp	0	2	0	0
Pollutants	2	2	2	0
Obstructions	0	0	0.5	2

* Life stage rank indicates a prioritization of habitat condition for use by a life stage. Stages are ranked
**Assign a weight to each attribute (0-2) relative to its importance to the life stage

.2.2.5.1.1.3 Reach Characterizations

A key task in QHA, is rating the defined reaches in terms of current and reference conditions. In the "current" conditions Table, planners rate the condition of the aquatic environment as it is today. In the "reference" conditions table, planers describe a "normative" condition for this subbasin that is used to contrast the current condition. This allows us to define "degradation " or "restoration potential." With respect to reference conditions, The MBI user guide for QHA (McConnaha, 2003) notes the following:

"In a subbasin with little cultural modification this reference condition might equate to 'historic' conditions, that is, the conditions that were in place at the time of European settlement. By contrast, in a subbasin where 'permanent' cultural modification has occurred (through urbanization, damming, channel modification, etc.) a more apt reference may be the 'potential' conditions, that is, the best conditions that could hope to be achieved through aggressive action while still maintaining these 'permanent' or 'long-term' cultural modifications. For example, if we were considering the lower Willamette in Portland, the reference condition might refer to a potential condition where all realistic restoration actions have been taken while still maintaining the urban fabric. Another example is a situation where a major dam exists or where a major highway has modified the river shoreline and where these modifications are expected to remain for the foreseeable future. In these cases the reference condition would be a theoretical state where these modifications remain but realistic actions had been taken to mitigate negative effects."

A variation that was employed in to evaluate the impact of fish passage barriers on Big Creek, was to conduct the exercise with two reference conditions – a true "historical" characterization and a "potential" characterization that recognizes the modifications. This is essentially a sensitivity analysis that helps us understand the differences between these two reference conditions and provides additional insights and a context for making decisions on habitat restoration and protection strategies with respect to the presence or absence of the passage barrier.

Habitat Characteristics. In both the reference and current condition tables we look at 11 habitat characteristics. These attributes are as follows:

Attribute	Definition
Riparian Condition	Condition of the stream-side vegetation, land form and subsurface water flow.
Channel Stability	The condition of the channel in regard to bed scour and artificial confinement. Measures how the channel can move laterally and vertically and to form a "normal" sequence of stream unit types.
Habitat diversity	Diversity and complexity of the channel including amount of large woody debris (LWD) and multiple channels
Key Habitat	The complex of habitat types formed by geomorphic processes (incl LWD) within the stream (e.g. pools, riffles, glides etc.).
Sediment Load	Amount of fine sediment within the stream, especially in spawning riffles
High Flow	Frequency and amount of high flow events.

Attribute	Definition
Low Flow	Frequency and amount of low flow events.
Oxygen	Dissolved oxygen in water column and stream substrate
Temperature	Duration and amount of high summer water temperature or low winter temperatures that can be limiting to fish survival
Pollutants	Introduction of toxic (acute and chronic) substances into the stream
Artificial obstructions	Presence of barrier that impedes or partially impedes stream usage

The QHA user guide notes describes these eleven attributes as the habitat characteristics (or attributes) that are generally thought to be the main "drivers" of fish production and sustainability.

Physical Habitat Score. The current and reference condition tables consider the relative condition of the physical environment by viewing each of the 11 habitat attributes through the eyes of salmonids species. The cell that forms the intersection between a reach/small watershed and a habitat characteristic is rated according to the following rating scheme:

0 = < 20% of optimum

1 = 20% to 40% of optimum

2 = 40% to 60% of optimum

3 = 60% to 80% of optimum

4 = 80% to 100% of optimum

Optimum is defined as the ideal condition of an attribute for salmonids. Note that historic conditions does not necessarily equate to optimum. For example, it is entirely possible that historic high summer temperature or channel structure limited productivity to a greater or lesser extent.

Table 2-30: Current conditions evaluation of key habitat attributes by reach in the WOTs subbarea

Note: color coding is intended to facilitate data review. For the current condition, values of 3-4 are yellow, values less than 3 are orange. Values outside the allowed range of 0-4 are white.

Scoring	
Confidence Rating	Attribute Rating
0 = Unknown	0 = 0% of
1 = Expert Opinion	1 = 25% of
2 = Well Documented	2 = 50% of
	normative
Definitions	4 = 100% of

Describe the natural physical condition of the stream

Stream Name: WOTs

Describe the current condition for this stream in regard to the **physical conditions** relative to the in this ecological province.

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Sequence	Subbasin	Description	Reach Name	Not Rated	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions	Reach Confidence	Documentation
			Attribute Confidence														
			Attribute Toggle		1	1	1	1	1	1	0	0	1	1	1		
1	Big Creek	Mouth to hatchery outflow	3 Big-Mouth		2.0	2.0	2.0	2.5	3.0	3.0	4.0		2.5	2.5	4.0		6,7,8,9
2	Big Creek	Hatchery outflow to intake dam	11 ODFW-BIG-A1		2.0	1.0	1.0	2.5	3.0	3.0	4.0		3.5	2.5	0.5		6
3	Big Creek	Intake dam to valley broadening	12 ODFW-BIG-A2		3.0	2.5	1.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		8
4	Big Creek	Valley broadening to Mud Cr	13 ODFW-BIG-A3		3.0	2.5	3.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		8
5	Big Creek	Mud Cr to Elk incl Coon	14 ODFW-BIG-A4		3.0	2.0	3.5	2.0	3.0	3.0	4.0		3.5	4.0	2.0		8,10
6	Big Creek	Elk Creek	Big Elk-1		3.0	2.0	2.0	2.0	3.0	3.0	4.0		3.5	4.0	4.0		11
7	Big Creek	Elk Creek	Big Elk-2		3.0	2.0	2.0	2.5	3.0	3.0	4.0		3.5	4.0	4.0		11
8	Big Creek	Elk Creek	Big Elk-3		3.0	2.5	2.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		8,10,11
9	Big Creek	Elk Creek	Big Elk-4		3.0	3.0	2.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		8,10,11
10	Big Creek	Coon Creek	2 Big-Coon		3.0	3.0	3.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		8
12	Big Creek	Mud Creek	4 Big-Mud		3.0	3.0	3.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		8
13	Big Creek	Pigpen	5 Big-Pigpen		3.0	3.0	3.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		8
14	Claskenie	Mouth to Hazel Grove Rd.	6 CLA-A Mouth		1.0	1.0	1.0	1.0	3.0	3.0	2.0		1.0	2.0	4.0		12,14
15	Claskenie	Hazel Grove Rd to "Alder Grove School"	19 ODFW-CLA-A1		1.5	2.0	2.5	2.5	3.0	2.0	2.0		2.0	4.0	4.0		12
16	Claskenie	Alder Grove School to SwedeTown Rd	20 ODFW-CLA-A2		3.0	3.0	2.5	3.0	3.0	3.0	4.0		3.0	4.0	4.0		
17	Claskenie	Swede Town Rd to Carcass Cr	21 ODFW-CLA-A3		3.0	3.0	2.5	3.0	3.0	3.0	4.0		3.0	4.0	4.0		
18	Claskenie	Carcass Cr to end RM18	22 ODFW-CLA-A4		3.0	2.5	2.5	3.0	3.0	3.0	4.0		3.0	4.0	4.0		
19	Claskenie	Mouth to RB trib	CLA Carcass-1		3.0	3.0	3.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		
20	Claskenie	RB trib to West Fork	CLA Carcass-2		3.0	3.0	3.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		
21	Claskenie	West Fork to Falls	CLA Carcass-3		3.0	3.0	3.0	3.0	3.0	3.0	4.0		3.5	4.0	4.0		
22	Claskenie	Claskenie	6a-CLA-PAGE		3.0	3.0	3.0	3.0	3.0	3.0	4.0		3.0	4.0	4.0		
23	Claskenie	Claskenie	6b-CLA-Miller		3.0	3.5	3.0	3.0	3.0	3.0	4.0		3.0	4.0	4.0		
24	Claskenie	Claskenie	6c-CLA-Little Clats		3.0	2.0	3.0	3.0	3.0	3.0	4.0		3.0	4.0	2.0		13
30	L&C	LC mouth in Youngs to RM8	LC-B0		1.5	0.5	0.5	0.5	4.0	4.0	3.0		3.0	2.5	4.0		15, 16
31	L&C	RM8 (tidewater) to 400 Line	35 ODFW-LC-B1		1.0	1.0	1.0	0.5	2.0	1.0	3.0		2.5	2.5	4.0		15, 16
32	L&C	400 Line to South Fork	36 ODFW-LC-B2		2.5	3.5	3.5	3.5	2.0	1.0	3.5		3.0	4.0	4.0		15, 16
33	L&C	South Fork to Warrenton intake dam	37 ODFW-LC-B3		2.5	4.0	4.0	3.5	2.0	0.5	4.0		3.0	4.0	0.0		15, 16
34	L&C	Intake dam to L&C Falls	38 ODFW-LC-B4		2.0	1.5	2.5	3.0	2.0	2.0	4.0		3.0	4.0	4.0		15, 16
35	L&C	Heckard mouth to L&C Mainline	32 ODFW-LC-A2		2.0	2.5	1.0	2.0	3.0	2.5	4.0		3.0	4.0	2.0		15, 16
36	L&C	Heckard L&C Mainline to Fletcher Spur	33 ODFW-LC-A3		2.0	4.0	2.0	2.5	3.0	2.5	4.0		3.0	4.0	4.0		15, 16
37	L&C	Heckard Fletcher Spur to Swamp	34 ODFW-LC-A4		2.0	4.0	2.5	3.0	3.0	2.5	4.0		3.0	4.0	4.0		15, 16
38	L&C	Stavebolt mouth to canyon narrows	39 ODFW-LC-C1		2.5	2.0	2.0	2.0	2.0	2.0	4.0		3.0	4.0	4.0		15, 16
39	L&C	Stavebolt canyon section	40 ODFW-LC-C2		1.0	4.0	3.0	3.0	2.0	2.0	4.0		3.0	4.0	4.0		15, 16
40	L&C	Hortill Creek	41 ODFW-LC-D1		1.5	4.0	1.5	1.5	2.0	2.0	4.0		3.0	4.0	0.0		15, 16
41	L&C	Klickitat Creek	50 ODFW-LC-H2		2.5	3.0	2.0	2.0	2.0	2.0	4.0		3.0	4.0	2.0		15, 16
42	L&C	Speelyai mouth to 150 Contour	42 ODFW-LC-E1		2.5	3.0	1.5	2.0	2.0	2.0	4.0		3.0	4.0	4.0		15, 16
43	L&C	Speelyai 150 contour to end	43 ODFW-LC-E2		1.5	4.0	2.5	3.0	2.0	2.0	4.0		3.0	4.0	2.0		15, 16
44	L&C	Loowit Creek	44 ODFW-LC-EF1		1.5	3.5	2.0	2.0	2.0	2.0	4.0		3.0	4.0	2.0		15, 16
45	L&C	Shweeash Creek mouth to 400 Road	47 ODFW-LC-G1		2.0	3.5	2.5	2.0	2.0	2.0	4.0		3.0	4.0	2.0		15, 16
46	L&C	Shweeash Creek 400 Road to top	48 ODFW-LC-G2		1.5	4.0	3.0	3.0	2.0	2.0	4.0		3.0	4.0	0.0		15, 16
47	L&C	Camp C Creek mouth to reservoir	49 ODFW-LC-H1		1.5	4.0	2.5	2.0	2.0	2.0	4.0		3.0	4.0	0.0		15, 16
48	L&C	South Fork L&C to dam incl Little SF	30 LC-S Fork Reach		2.0	4.0	3.0	4.0	2.0	2.0	4.0		3.0	4.0	0.0		15, 16
49	Youngs	Youngs Bay Mouth to confluence of Youngs R.	57 Youngs Bay Mouth		0.5	0.5	0.5	1.0	2.0	4.0	4.0		3.0	2.0	4.0		
50	Youngs	Younds R. to Bridge (head of tide)	73 ODFW-YNG-A0		0.5	0.5	0.5	2.0	2.5	4.0	4.0		3.0	3.0	4.0		
51	Youngs	Bridge to Falls	74 ODFW-YNG-A1		1.5	1.0	2.0	3.5	3.0	3.0	4.0		3.0	3.5	4.0		
52	Youngs	MoosMoos	75 ODFW-YNG-A2		2.5	2.5	2.5	2.0	3.0	3.0	4.0		2.5	3.5	2.0		
54	North Fork Klasks	Smileys Hole to State Hatchery dam	8 NKLA-A0		1.5	2.5	1.5	1.5	3.0	2.0	3.0		3.0	3.0	4.0		
55	North Fork Klasks	Hatchery upstream to and incl Middle Fork	9 NKLA-A1		3.0	2.5	3.0	2.5	3.0	3.0	4.0		3.0	3.5	0.0		
56	North Fork Klasks	North Fork of NFk	10 NKLA-NFK		2.5	3.0	3.0	2.5	3.0	3.0	4.0		3.0	4.0	4.0		
57	Mainstem Klasks	Confluence to SouthFork (Smileys Hole)	63SKL-A0		2.0	1.0	1.0	1.0	2.0	4.0	4.0		3.0	3.0	4.0		
58	South Fork Klasks	South Fork to 25' countour	64 ODFW-SKL-A1		1.0	1.0	1.0	1.0	3.0	3.0	4.0		3.0	3.0	4.0		
59	South Fork Klasks	25' contour to CEDC Hatchery dam	65 ODFW-SKL-A2		2.5	2.5	2.5	3.0	3.0	3.0	4.0		3.0	3.0	3.5		
60	South Fork Klasks	CEDC Hatchery Dam to first Falls	66 ODFW-SKL-A3		3.0	2.0	2.5	2.5	3.0	3.0	4.0		3.0	4.0	4.0		
61	South Fork Klasks	first falls to bigfalls	67 ODFW-SKL-A4		3.5	4.0	3.5	3.5	3.0	3.0	4.0		3.0	4.0	4.0		
62	South Fork Klasks	Big Falls to South Fk of South Fk	ODFW-SKL-A4.5	NR													
63	South Fork Klasks	South FK of South FK to End	68 ODFW-SKL-A5	NR													

Table 2-31: Reference conditions evaluation of key habitat attributes by reach in the WOTs subbarea

Note: color coding is intended to facilitate data review. For the reference condition, a value of 4 is dark green, values from 2-4 are lighter green and values less than 2 are orange. Values outside the allowed range are white.

Scoring	
Confidence Rating	Attribute Rating
	0 = 0% of normative
0 = Speculative	1 = 25% of normative
1 = Expert Opinion	2 = 50% of normative
2 = Well Documented	3 = 75% of normative
	4 = 100% of normative

Describe the natural physical condition of the stream

Stream Name: WOTs

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Describe the normative condition for this stream in regard to the physical conditions relative to an optimal condition for similar streams in this ecological province. The default rating for the reference condition is 4, however, ratings less than 4 inherent "limitations" of streams and reaches caused by geology, topography or other factors.

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Definitions

			Attribute Confidence														
			Attribute Toggle		1	1	1	1	1	1	0	0	1	1	1		
Sequence	Subbasin	Description	Reach Name	Not Rated	Riparian Condition	Channel Stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions	Reach Confidence	Documentation
1	Big Creek	Mouth to hatchery outflow	3 Big-Mouth	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
2	Big Creek	Hatchery outflow to intake dam	11 ODFW-BIG-A1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
3	Big Creek	Intake dam to valley broadening	12 ODFW-BIG-A2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
4	Big Creek	Valley broadening to Mud Cr	13 ODFW-BIG-A3	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
5	Big Creek	Mud Cr to Elk incl Coon	14 ODFW-BIG-A4	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
6	Big Creek	Elk Creek	Big Elk-1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
7	Big Creek	Elk Creek	Big Elk-2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
8	Big Creek	Elk Creek	Big Elk-3	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
9	Big Creek	Elk Creek	Big Elk-4	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
10	Big Creek	Coon Creek	2 Big-Coon	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
12	Big Creek	Mud Creek	4 Big-Mud	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
13	Big Creek	Pigpen	5 Big-Pigpen	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	0.0		
14	Claskenie	Mouth to Hazel Grove Rd.	6 CLA-A Mouth	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		2
15	Claskenie	Hazel Grove Rd to "Alder Grove School"	19 ODFW-CLA-A1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
16	Claskenie	Alder Grove School to SwedeTown Rd	20 ODFW-CLA-A2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
17	Claskenie	Swede Town Rd to Carcass Cr	21 ODFW-CLA-A3	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
18	Claskenie	Carcass Cr to end RM18	22 ODFW-CLA-A4	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
19	Claskenie	Mouth to RB trib	CLA Carcass-1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
20	Claskenie	RB trib to West Fork	CLA Carcass-2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
21	Claskenie	West Fork to Falls	CLA Carcass-3	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
22	Claskenie	Claskenie	6a-CLA-PAGE	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
23	Claskenie	Claskenie	6b-CLA-Miller	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
24	Claskenie	Claskenie	6c-CLA-Little Clats	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		1
30	L&C	LC mouth in Youngs to RM8	LC-B0	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		1
31	L&C	RM8 (tidewater) to 400 Line	35 ODFW-LC-B1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		1
32	L&C	400 Line to South Fork	36 ODFW-LC-B2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		1
33	L&C	South Fork to Warrenton intake dam	37 ODFW-LC-B3	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
34	L&C	Intake dam to L&C Falls	38 ODFW-LC-B4	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
35	L&C	Heckard mouth to L&C Mainline	32 ODFW-LC-A2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
36	L&C	Heckard L&C Mainline to Fletcher Spur	33 ODFW-LC-A3	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
37	L&C	Heckard Fletcher Spur to Swamp	34 ODFW-LC-A4	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
38	L&C	Stavebolt mouth to canyon narrows	39 ODFW-LC-C1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
39	L&C	Stavebolt canyon section	40 ODFW-LC-C2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
40	L&C	Hortill Creek	41 ODFW-LC-D1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	0.0		
41	L&C	Klickitat Creek	50 ODFW-LC-H2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.0		
42	L&C	Speelyai mouth to 150 Contour	42 ODFW-LC-E1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
43	L&C	Speelyai 150 contour to end	43 ODFW-LC-E2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
44	L&C	Loowit Creek	44 ODFW-LC-EF1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
45	L&C	Shweeash Creek mouth to 400 Road	47 ODFW-LC-G1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
46	L&C	Shweeash Creek 400 Road to top	48 ODFW-LC-G2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
47	L&C	Camp C Creek mouth to reservoir	49 ODFW-LC-H1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
48	L&C	South Fork L&C to dam incl Little SF	30 LC-S Fork Reach	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
49	Youngs	Youngs Bay Mouth to confluence of Youngs R.	57 Youngs Bay Mouth	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
50	Youngs	Younds R. to Bridge (head of tide)	73 ODFW-YNG-A0	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	0.0		
51	Youngs	Bridge to Falls	74 ODFW-YNG-A1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
52	Youngs	MoosMoos	75 ODFW-YNG-A2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
54	North Fork Klasks	Smileys Hole to State Hatchery dam	8 NKLA-A0	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
55	North Fork Klasks	Hatchery upstream to and incl Middle Fork	9 NKLA-A1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
56	North Fork Klasks	North Fork of NFk	10 NKLA-NFK	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
57	Mainstem Klasks	Confluence to SouthFork (Smileys Hole)	63SKL-A0	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
58	South Fork Klasks	South Fork to 25' countour	64 ODFW-SKL-A1	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
59	South Fork Klasks	25' contour to CEDC Hatchery dam	65 ODFW-SKL-A2	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
60	South Fork Klasks	CEDC Hatchery Dam to first Falls	66 ODFW-SKL-A3	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
61	South Fork Klasks	first falls to bigfalls	67 ODFW-SKL-A4	0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		3
62	South Fork Klasks	Big Falls to South Fk of South Fk	ODFW-SKL-A4.5	NR	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		
63	South Fork Klasks	South FK of South FK to End	68 ODFW-SKL-A5	NR	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0		

.2.2.5.1.1.4 Prioritization

.2.2.5.1.1.4.1 Restoration

QHA generates a table used for final reach and attributes scores are ranked for each focal species analyzed. The scores themselves have no inherent meaning and, for this reason, the focus is on the relative ranking of the scores between reaches and between attributes. The highest rank is given a 1 (and highlighted in red), followed by 2 and so on. The Table also identifies which reaches/small watersheds offer the highest restoration opportunity from a multiple habitat characteristic perspective (to the left of each row under the "reach score" column) and which habitat characteristics had the highest overall score (at the bottom of each column on the "attribute score" row). These scores adhere to the same 1, 2, 3 hierarchy.

This table was generated using information provided earlier in the current conditions table, the reference conditions table, and the hypothesis tables. The restoration Table summarizes physical and biological conclusions based how workshop participants described the habitat and their hypothesis about the focal species. The key question for QHA is what does this suggest about limiting factors and potential restoration actions?

.2.2.5.1.1.4.2 Protection

This table is the same as the restoration ranking table except that it identifies relative protection value rather than restoration value. The ranking is generated from an algorithm using information from the current conditions tables and the hypothesis tables, and therefore each Focal Species will generate an additional set of rankings.

Planners will want to use this table as a jumping off point to consider areas that warrant protection, starting by asking whether the table is an accurate depiction of the real situation. If so, planners can proceed to identify major implications for management. Later in this guide we identify a list the questions that planners may want to consider when analyzing this table.

Table 2-32 Coho Restoration and Protection Priorites

OUTPUT ONLY

Protection Habitat Ranking

NPC= Not present currently

Subbasin	Reach Name	Reach Rank	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Big Creek	3 Big-Mouth	1	8	2	5	6	3	7	9	9	9	4	1
Big Creek	11 ODFW-BIG-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	12 ODFW-BIG-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	13 ODFW-BIG-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	14 ODFW-BIG-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	Big Elk-1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	Big Elk-2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	Big Elk-3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	Big Elk-4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	2 Big-Coon	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	4 Big-Mud	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	5 Big-Pigpen	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Claskenie	6 CLA-A Mouth	11	7	4	6	8	2	5	8	8	8	3	1
Claskenie	19 ODFW-CLA-A1	10	7	4	3	6	2	8	9	9	9	1	5
Claskenie	20 ODFW-CLA-A2	9	4	2	3	9	6	5	10	10	7	1	8
Claskenie	21 ODFW-CLA-A3	6	4	3	2	8	5	5	10	10	7	1	9
Claskenie	22 ODFW-CLA-A4	7	4	3	2	8	5	5	10	10	7	1	9
Claskenie	CLA Carcass-1	2	4	3	2	8	6	6	10	10	5	1	9
Claskenie	CLA Carcass-2	2	4	3	2	8	6	6	10	10	5	1	9
Claskenie	CLA Carcass-3	2	4	3	2	8	6	6	10	10	5	1	9
Claskenie	6a-CLA-PAGE	5	4	3	2	8	5	5	10	10	7	1	9
Claskenie	6b-CLA-Miller	1	4	3	2	8	5	5	10	10	7	1	9
Claskenie	6c-CLA-Little Clats	8	3	4	2	8	5	5	10	10	7	1	9
L&C	LC-B0	16	6	7	8	9	2	2	10	10	5	1	4
L&C	35 ODFW-LC-B1	15	7	6	4	9	4	8	10	10	3	1	2
L&C	36 ODFW-LC-B2	1	4	3	2	6	7	9	10	10	5	1	8
L&C	37 ODFW-LC-B3	9	4	1	2	7	5	8	9	9	6	2	9
L&C	38 ODFW-LC-B4	6	4	5	2	8	6	6	10	10	3	1	9
L&C	32 ODFW-LC-A2	7	6	2	7	9	5	3	10	10	4	1	8
L&C	33 ODFW-LC-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	34 ODFW-LC-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	39 ODFW-LC-C1	12	5	2	3	9	6	8	10	10	7	1	4
L&C	40 ODFW-LC-C2	10	8	1	3	9	6	6	10	10	5	2	4
L&C	41 ODFW-LC-D1	13	7	1	3	8	4	6	9	9	5	2	9
L&C	50 ODFW-LC-H2	11	4	2	3	9	5	7	10	10	6	1	8
L&C	42 ODFW-LC-E1	14	4	2	5	9	7	7	10	10	6	1	3
L&C	43 ODFW-LC-E2	3	8	2	3	7	6	5	10	10	4	1	9
L&C	44 ODFW-LC-EF1	5	7	2	3	8	6	5	10	10	4	1	9
L&C	47 ODFW-LC-G1	4	5	2	3	8	7	6	10	10	4	1	9
L&C	48 ODFW-LC-G2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	49 ODFW-LC-H1	2	8	2	3	6	5	6	9	9	4	1	9
L&C	30 LC-S Fork Reach	8	6	2	3	7	8	5	9	9	4	1	9
Youngs	57 Youngs Bay Mouth	4	8	6	6	9	5	1	10	10	3	2	4
Youngs	73 ODFW-YNG-A0	3	8	6	6	9	5	2	10	10	3	1	4
Youngs	74 ODFW-YNG-A1	1	7	8	2	6	3	3	10	10	5	1	8
Youngs	75 ODFW-YNG-A2	2	5	2	2	9	7	4	10	10	6	1	8
North Fork Kla	8 NKLA-A0	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
North Fork Kla	9 NKLA-A1	3	4	3	2	8	5	5	9	9	7	1	9
North Fork Kla	10 NKLA-NFK	6	1	1	1	1	1	1	1	1	1	1	1
Mainstem Klask	63SKL-A0	6	1	1	1	1	1	1	1	1	1	1	1
South Fork Kla	64 ODFW-SKL-A1	5	8	6	6	9	3	2	10	10	5	1	4
South Fork Kla	65 ODFW-SKL-A2	4	5	3	2	9	4	6	10	10	7	1	8
South Fork Kla	66 ODFW-SKL-A3	2	3	4	2	8	5	5	10	10	7	1	9
South Fork Kla	67 ODFW-SKL-A4	1	4	3	2	8	5	5	10	10	7	1	9
South Fork Kla	ODFW-SKL-A4.5	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
South Fork Kla	68 ODFW-SKL-A5	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
0													
0													

Restoration Habitat Ranking

NPR = Not present in reference condition

Reach Rank	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions	<==Note Scroll Lock
2	4	2	1	8	7	6	9	9	5	3	9	5
1	4	2	1	8	6	6	10	10	9	3	5	2
3	3	2	1	6	4	4	8	8	7	8	8	13
7	3	1	2	6	4	4	8	8	7	8	8	36
6	3	1	4	2	4	4	9	9	8	9	7	25
4	4	2	1	3	5	5	8	8	7	8	8	15
5	3	2	1	6	4	4	8	8	7	8	8	17
10	4	2	1	5	3	5	8	8	7	8	8	48
12	3	2	1	6	5	4	8	8	7	8	8	51
8	3	2	1	6	4	4	8	8	7	8	8	40
8	3	2	1	6	4	4	8	8	7	8	8	40
11	3	2	1	6	4	4	8	8	7	8	11	49
1	3	1	1	8	6	7	9	9	5	4	9	9
3	3	1	2	7	6	4	8	8	5	8	8	28
11	4	2	1	5	3	5	8	8	7	8	8	47
5	3	2	1	7	6	4	8	8	5	8	8	37
4	3	2	1	7	6	4	8	8	5	8	8	34
7	3	2	1	6	4	4	8	8	7	8	8	40
7	3	2	1	6	4	4	8	8	7	8	8	40
7	3	2	1	6	4	4	8	8	7	8	8	40
5	3	2	1	7	4	4	8	8	6	8	8	37
10	2	6	1	7	3	3	8	8	5	8	8	45
2	3	1	2	8	4	4	9	9	6	9	7	20
9	3	1	1	6	7	7	7	7	5	4	7	21
1	3	2	1	6	7	4	9	9	8	5	9	1
13	3	6	4	7	2	1	8	8	5	8	8	27
17	2	7	7	6	4	1	7	7	5	7	3	35
2	3	1	2	7	4	4	8	8	6	8	8	6
5	2	3	1	8	7	4	9	9	5	9	6	9
12	2	7	1	6	5	3	7	7	4	7	7	25
15	2	7	1	6	4	3	7	7	5	7	7	30
4	4	2	1	6	5	3	8	8	7	8	8	8
18	1	7	4	6	2	3	7	7	5	7	7	50
11	2	7	1	4	3	4	7	7	6	7	7	24
14	4	3	1	6	2	5	8	8	7	8	8	29
10	4	3	1	6	2	5	8	8	7	8	8	23
8	1	8	2	7	3	3	8	8	5	8	6	14
3	2	7	1	5	3	3	9	9	6	9	7	7
7	2	7	1	5	3	3	9	9	6	9	7	12
16	1	8	3	7	3	2	8	8	6	8	5	31
6	1	8	2	6	3	3	8	8	7	8	5	11
19	2	7	4	7	5	1	7	7	6	7	2	52
2	3	1	1	7	5	8	8	8	6	4	8	22
3	3	1	1	7	5	8	8	8	6	4	11	39
1	3	1	2	8	4	4	9	9	7	4	9	4
4	3	2	1	5	8	7	10	10	4	8	6	46
NPR	NPR		NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
4	4	1	2	9	8	5	10	10	6	6	3	19
5	2	3	1	6	4	4	8	8	7	8	8	32
1	3	2	1	4	6	8	8	8	7	5	8	3
2	3	1	1	8	5	6	9	9	7	4	9	15
6	3	2	1	9	6	5	10	10	6	4	8	33
3	3	1	2	6	4	4	8	8	7	8	8	18
7	5	7	1	6	1	1	7	7	4	7	7	53
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR

Table 2-33: Chum Protection and Restoration Priorities

OUTPUT ONLY

		Protection Habitat Ranking (NPC= Not present currently)												Restoration Habitat Ranking (NPR = Not present in reference condition)												
Subbasin	Reach Name	Reach Rank	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions	Reach Rank	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions	System restoration rank
Big Creek	3 Big-Mouth	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	11 ODFW-BIG-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	12 ODFW-BIG-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	13 ODFW-BIG-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	14 ODFW-BIG-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	Big Elk-1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	Big Elk-2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	Big Elk-3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	Big Elk-4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	2 Big-Coon	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	4 Big-Mud	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Big Creek	5 Big-Pigpen	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Claskenie	6 CLA-A Mouth	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	8	3	1	3	3	3	2	3	3	3	3	3	29
Claskenie	19 ODFW-CLA-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	4	6	1	2	2	4	5	6	6	6	6	6	25
Claskenie	20 ODFW-CLA-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	1	6	3	1	2	3	5	6	6	6	6	6	20
Claskenie	21 ODFW-CLA-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	1	6	3	1	2	3	5	6	6	6	6	6	20
Claskenie	22 ODFW-CLA-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	5	6	1	1	3	4	5	6	6	6	6	6	26
Claskenie	CLA Carcass-1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	3	6	3	1	1	3	5	6	6	6	6	6	24
Claskenie	CLA Carcass-2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Claskenie	CLA Carcass-3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Claskenie	6a-CLA-PAGE	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	6	6	1	1	1	4	5	6	6	6	6	6	27
Claskenie	6b-CLA-Miller	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	7	6	4	1	1	3	5	6	6	6	6	6	28
Claskenie	6c-CLA-Little Clats	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	LC-B0	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	4	4	1	2	5	5	5	5	5	5	3	5	10
L&C	35 ODFW-LC-B1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	1	6	2	1	3	4	7	8	8	8	5	8	1
L&C	36 ODFW-LC-B2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	10	4	3	2	5	1	5	7	7	7	7	7	19
L&C	37 ODFW-LC-B3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	38 ODFW-LC-B4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	32 ODFW-LC-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	5	6	2	1	3	4	7	8	8	8	8	5	13
L&C	33 ODFW-LC-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	34 ODFW-LC-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	39 ODFW-LC-C1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	3	5	2	1	4	2	6	7	7	7	7	7	7
L&C	40 ODFW-LC-C2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	41 ODFW-LC-D1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	2	4	6	1	3	2	5	6	6	6	6	6	6
L&C	50 ODFW-LC-H2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	8	5	4	1	3	2	6	7	7	7	7	7	17
L&C	42 ODFW-LC-E1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	6	5	4	1	3	2	6	7	7	7	7	7	14
L&C	43 ODFW-LC-E2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	44 ODFW-LC-EF1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	6	5	6	1	3	2	7	8	8	8	8	4	14
L&C	47 ODFW-LC-G1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	9	6	5	2	3	1	7	8	8	8	8	4	18
L&C	48 ODFW-LC-G2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	49 ODFW-LC-H1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	30 LC-S Fork Reach	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
Youngs	57 Youngs Bay Mouth	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	1	5	1	2	6	3	6	6	6	6	3	6	5
Youngs	73 ODFW-YNG-A0	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	4	3	1	2	6	4	6	6	6	6	5	11	12
Youngs	74 ODFW-YNG-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	2	6	1	2	5	3	7	8	8	8	4	8	8
Youngs	75 ODFW-YNG-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	3	7	3	1	2	4	8	9	9	9	5	5	9
North Fork Kla	8 NKLA-A0	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	3	6	3	1	2	5	7	8	8	8	4	8	4
North Fork Kla	9 NKLA-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	5	7	2	3	4	4	8	9	9	9	6	1	16
North Fork Kla	10 NKLA-NFK	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	7	5	1	1	3	3	6	7	7	7	7	7	23
Mainstem Klash	63SKL-A0	2	4	3	4	4	4	2	4	4	4	4	1	1	6	2	1	3	4	7	7	7	7	5	7	2
South Fork Kla	64 ODFW-SKL-A1	3	4	3	4	4	4	2	4	4	4	4	1	2	6	2	1	3	5	7	8	8	8	4	8	3
South Fork Kla	65 ODFW-SKL-A2	1	7	3	3	5	2	8	9	9	9	1	6	4	6	2	1	5	4	8	9	9	9	3	7	11
South Fork Kla	66 ODFW-SKL-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	6	5	1	2	4	3	6	7	7	7	7	7	22
South Fork Kla	67 ODFW-SKL-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
South Fork Kla	ODFW-SKL-A4.5	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
South Fork Kla	68 ODFW-SKL-A5	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR

Table 2-34: Steelhead Protection and Restoration Priorities

OUTPUT ONLY

		Protection Habitat Ranking (NPC= Not present currently)												Restoration Habitat Ranking (NPR = Not present in reference condition)												
Subbasin	Reach Name	Reach Rank	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions	Reach Rank	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions	<==Note Scroll Lock
Big Creek	3 Big-Mouth	2	8	3	5	6	1	7	9	9	9	1	4	2	4	2	1	8	7	6	9	9	5	3	9	4
Big Creek	11 ODFW-BIG-A1	1	5	7	6	8	4	3	10	10	2	1	9	1	4	2	1	8	6	6	10	10	9	3	5	2
Big Creek	12 ODFW-BIG-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	3	3	2	1	6	4	4	8	8	7	8	8	10
Big Creek	13 ODFW-BIG-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	7	3	1	2	6	4	4	8	8	7	8	8	23
Big Creek	14 ODFW-BIG-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	6	3	1	4	2	4	4	9	9	8	9	7	17
Big Creek	Big Elk-1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	4	4	2	1	3	5	5	8	8	7	8	8	11
Big Creek	Big Elk-2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	5	3	2	1	6	4	4	8	8	7	8	8	13
Big Creek	Big Elk-3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	10	4	2	1	5	3	5	8	8	7	8	8	38
Big Creek	Big Elk-4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	12	3	2	1	6	5	4	8	8	7	8	8	41
Big Creek	2 Big-Coon	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	8	3	2	1	6	4	4	8	8	7	8	8	27
Big Creek	4 Big-Mud	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	8	3	2	1	6	4	4	8	8	7	8	8	27
Big Creek	5 Big-Pigpen	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	11	3	2	1	6	4	4	8	8	7	8	11	40
Claskenie	6 CLA-A Mouth	11	7	4	6	8	2	5	8	8	8	3	1	1	3	1	1	8	6	7	9	9	5	4	9	8
Claskenie	19 ODFW-CLA-A1	10	7	4	3	6	2	8	9	9	9	1	5	4	3	1	2	7	6	4	8	8	5	8	8	19
Claskenie	20 ODFW-CLA-A2	9	4	2	3	9	6	5	10	10	7	1	8	11	4	2	1	5	3	5	8	8	7	8	8	36
Claskenie	21 ODFW-CLA-A3	6	4	3	2	8	5	5	10	10	7	1	9	5	3	2	1	7	4	4	8	8	6	8	8	21
Claskenie	22 ODFW-CLA-A4	7	4	3	2	8	5	5	10	10	7	1	9	3	3	2	1	7	4	4	8	8	6	8	8	16
Claskenie	CLA Carcass-1	2	4	3	2	8	6	6	10	10	5	1	9	7	3	2	1	6	4	4	8	8	7	8	8	27
Claskenie	CLA Carcass-2	2	4	3	2	8	6	6	10	10	5	1	9	7	3	2	1	6	4	4	8	8	7	8	8	27
Claskenie	CLA Carcass-3	2	4	3	2	8	6	6	10	10	5	1	9	7	3	2	1	6	4	4	8	8	7	8	8	27
Claskenie	6a-CLA-PAGE	5	4	3	2	8	5	5	10	10	7	1	9	6	3	2	1	7	4	4	8	8	6	8	8	24
Claskenie	6b-CLA-Miller	1	4	3	2	8	5	5	10	10	7	1	9	10	2	6	1	7	3	3	8	8	5	8	8	33
Claskenie	6c-CLA-Little Clats	8	3	4	2	8	5	5	10	10	7	1	9	2	3	1	2	8	4	4	9	9	6	9	7	15
L&C	LC-B0	16	4	3	4	4	4	2	4	4	4	4	1	16	2	1	2	2	2	2	2	2	2	2	2	49
L&C	35 ODFW-LC-B1	11	7	6	4	9	4	8	10	10	3	1	2	1	3	2	1	6	7	4	9	9	8	4	9	1
L&C	36 ODFW-LC-B2	3	5	3	2	6	7	9	10	10	4	1	8	3	3	6	4	7	2	1	8	8	5	8	8	18
L&C	37 ODFW-LC-B3	1	4	3	1	7	6	8	9	9	5	1	9	4	2	7	7	6	3	1	7	7	5	7	4	20
L&C	38 ODFW-LC-B4	2	4	5	2	8	6	6	10	10	3	1	9	2	3	1	2	7	4	4	8	8	6	8	8	6
L&C	32 ODFW-LC-A2	15	4	3	4	7	2	7	7	7	7	1	6	13	3	2	1	6	3	6	6	6	6	6	5	46
L&C	33 ODFW-LC-A3	14	5	1	4	7	3	7	7	7	7	1	5	15	2	4	1	4	2	4	4	4	4	4	4	48
L&C	34 ODFW-LC-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	39 ODFW-LC-C1	12	6	3	4	8	4	7	8	8	8	1	2	12	4	1	2	6	2	5	6	6	6	6	6	45
L&C	40 ODFW-LC-C2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	41 ODFW-LC-D1	13	5	1	4	7	3	6	7	7	7	2	7	14	3	5	1	5	2	4	5	5	5	5	5	47
L&C	50 ODFW-LC-H2	9	4	2	3	9	5	7	10	10	6	1	8	8	4	5	1	6	3	2	8	8	7	8	8	35
L&C	42 ODFW-LC-E1	10	4	2	5	9	7	7	10	10	6	1	3	7	4	5	1	6	3	2	8	8	7	8	8	34
L&C	43 ODFW-LC-E2	4	8	2	3	7	6	5	10	10	4	1	9	10	1	8	2	7	4	3	8	8	6	8	5	39
L&C	44 ODFW-LC-EF1	7	7	2	3	8	6	5	10	10	4	1	9	6	2	7	1	5	4	3	9	9	7	9	6	32
L&C	47 ODFW-LC-G1	5	5	2	3	8	7	6	10	10	4	1	9	9	2	7	1	5	4	3	9	9	7	9	6	36
L&C	48 ODFW-LC-G2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
L&C	49 ODFW-LC-H1	6	7	2	3	8	6	5	9	9	4	1	9	5	2	8	1	6	4	5	8	8	7	8	3	26
L&C	30 LC-S Fork Reach	8	6	2	3	7	8	5	9	9	4	1	9	11	2	7	4	7	5	1	7	7	6	7	2	42
Youngs	57 Youngs Bay Mouth	3	4	3	4	4	4	2	4	4	4	4	1	3	2	1	2	2	2	2	2	2	2	2	2	49
Youngs	73 ODFW-YNG-A0	2	8	6	7	9	5	1	10	10	4	2	3	2	3	1	2	7	5	8	8	8	6	4	11	44
Youngs	74 ODFW-YNG-A1	1	7	8	2	6	3	3	10	10	5	1	8	1	3	1	2	8	4	4	9	9	7	4	9	5
Youngs	75 ODFW-YNG-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
North Fork Kla	8 NKLA-A0	3	7	2	3	9	3	6	10	10	5	1	8	2	2	3	1	6	7	5	9	9	8	4	9	7
North Fork Kla	9 NKLA-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	4	4	1	2	8	5	5	10	10	9	5	3	12
North Fork Kla	10 NKLA-NFK	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	6	2	3	1	6	4	4	8	8	7	8	8	22
Mainstem Klask	63SKL-A0	6	4	6	8	9	6	2	10	10	5	1	3	7	3	1	1	7	5	8	8	8	6	4	8	25
South Fork Kla	64 ODFW-SKL-A1	5	8	5	7	9	2	4	10	10	6	1	3	1	3	2	1	5	7	6	9	9	8	4	9	3
South Fork Kla	65 ODFW-SKL-A2	4	6	3	2	7	4	5	10	10	7	1	9	3	4	2	1	8	5	5	10	10	7	3	9	9
South Fork Kla	66 ODFW-SKL-A3	2	3	4	2	8	5	5	10	10	7	1	9	5	3	1	2	6	4	4	8	8	7	8	8	14
South Fork Kla	67 ODFW-SKL-A4	1	4	3	2	8	5	5	10	10	7	1	9	8	5	7	1	6	1	1	7	7	4	7	7	43
South Fork Kla	ODFW-SKL-A4.5	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
South Fork Kla	68 ODFW-SKL-A5	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR

Table 2-35: Fall Chinook Restoration and Protection Priorities

OUTPUT ONLY

Protection Habitat Ranking

NPC= Not present currently

Subbasin	Reach Name	Reach Rank	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
Big Creek	3 Big-Mouth	1	5	5	3	7	8	2	10	10	4	1	9
Big Creek	11 ODFW-BIG-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	12 ODFW-BIG-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	13 ODFW-BIG-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	14 ODFW-BIG-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	Big Elk-1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	Big Elk-2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	Big Elk-3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	Big Elk-4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	2 Big-Coon	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	4 Big-Mud	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Big Creek	5 Big-Pigpen	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Claskenie	6 CLA-A Mouth	4	3	7	3	8	9	1	9	9	3	2	3
Claskenie	19 ODFW-CLA-A1	3	7	4	2	6	8	3	10	10	4	1	9
Claskenie	20 ODFW-CLA-A2	1	4	4	2	7	8	3	10	10	4	1	9
Claskenie	21 ODFW-CLA-A3	1	4	4	2	7	8	3	10	10	4	1	9
Claskenie	22 ODFW-CLA-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Claskenie	CLA Carcass-1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Claskenie	CLA Carcass-2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Claskenie	CLA Carcass-3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Claskenie	6a-CLA-PAGE	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Claskenie	6b-CLA-Miller	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Claskenie	6c-CLA-Little Clats	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	LC-B0	1	4	7	6	8	9	1	9	9	2	3	5
L&C	35 ODFW-LC-B1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	36 ODFW-LC-B2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	37 ODFW-LC-B3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	38 ODFW-LC-B4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	32 ODFW-LC-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	33 ODFW-LC-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	34 ODFW-LC-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	39 ODFW-LC-C1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	40 ODFW-LC-C2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	41 ODFW-LC-D1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	50 ODFW-LC-H2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	42 ODFW-LC-E1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	43 ODFW-LC-E2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	44 ODFW-LC-EF1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	47 ODFW-LC-G1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	48 ODFW-LC-G2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	49 ODFW-LC-H1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
L&C	30 LC-S Fork Reach	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Youngs	57 Youngs Bay Mouth	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Youngs	73 ODFW-YNG-A0	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Youngs	74 ODFW-YNG-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Youngs	75 ODFW-YNG-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
North Fork Kla	8 NKLA-A0	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
North Fork Kla	9 NKLA-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
North Fork Kla	10 NKLA-NFK	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
Mainstem Klash	63SKL-A0	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
South Fork Kla	64 ODFW-SKL-A1	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
South Fork Kla	65 ODFW-SKL-A2	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
South Fork Kla	66 ODFW-SKL-A3	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
South Fork Kla	67 ODFW-SKL-A4	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
South Fork Kla	ODFW-SKL-A4.5	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC
South Fork Kla	68 ODFW-SKL-A5	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC	NPC

Restoration Habitat Ranking

NPR = Not present in reference condition

Reach Rank	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR
NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR	NPR

2.2.5.2 Reach Rankings

The QHA workshop generated a significant amount of information on relative rankings of reaches for restoration and protection potential. Rankings were provided by species and by watershed, as illustrated in Table 2-36.

For purposes of summarizing broad themes and for generating basin wide and tributary specific hypotheses, an aggregated table of restoration priorities and protection priorities is provided in below.

Table 2-36: Restoration and protection priorities, limiting factors by watershed

Species	Watershed	Designation	Priority Value	Description of Reach	Type of Measure	Key Attributes to Restore or Protect	Life Stage Addressed
Coho	Big Creek	11 ODFW-BIG-A1	0.26	Hatchery outflow to intake dam	Restoration	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing
Steelhead	Big Creek	11 ODFW-BIG-A1	0.26	Hatchery outflow to intake dam	Restoration	Chabitat Diversity	Spawning/Incubation, (Summer Rearing Winter Rearing Migration)
Steelhead	Big Creek	11 ODFW-BIG-A1	0.24	Hatchery outflow to intake dam	Protection	High Temp	Spawning/Incubation, (Summer Rearing Winter Rearing Migration)
Steelhead	Big Creek	3 Big-Mouth	0.20	Mouth to hatchery outflow	Restoration	Channel Stabilty	(Spawning/Incubation), Summer Rearing Winter Rearing (Migration)
Coho	Big Creek	3 Big-Mouth	0.19	Mouth to hatchery outflow	Restoration	Habitat Diversity	Summer Rearing, Winter Rearing
Steelhead	Big Creek	3 Big-Mouth	0.09	Mouth to hatchery outflow	Protection	Water Quality	(Spawning/Incubation), Summer Rearing Winter Rearing (Migration)
Coho	Big Creek	3 Big-Mouth	0.04	Mouth to hatchery outflow	Protection	Water Quality	Summer Rearing, Winter Rearing

Species	Watershed	Designation	Priority Value	Description of Reach	Type of Measure	Key Attributes to Restore or Protect	Life Stage Addressed
Coho	Claskenie	6b-CLA-Miller	0.44	Claskenie	Protection	Water Quality & Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Coho	Claskenie	CLA Carcass-1	0.44	Mouth to RB trib	Protection	Water Quality & Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Coho	Claskenie	CLA Carcass-2	0.44	RB trib to West Fork	Protection	Water Quality & Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Coho	Claskenie	CLA Carcass-3	0.44	West Fork to Falls	Protection	Water Quality & Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Claskenie	CLA Carcass-1	0.44	Mouth to RB trib	Protection	Water Quality	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Claskenie	6b-CLA-Miller	0.44	Claskenie	Restoration	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Claskenie	CLA Carcass-3	0.44	West Fork to Falls	Protection	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration

Species	Watershed	Designation	Priority Value	Description of Reach	Type of Measure	Key Attributes to Restore or Protect	Life Stage Addressed
Coho	Claskenie	6c-CLA-Little Clats	0.40	Claskenie	Protection	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Claskenie	6c-CLA-Little Clats	0.40	Claskenie	Protection	Channel Stability	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Coho	Claskenie	6 CLA-A Mouth	0.18	Mouth to Hazel Grove Rd.	Restoration	Habitat Diversity & Channel Stability	Summer Rearing, Winter Rearing
Steelhead	Claskenie	6 CLA-A Mouth	0.18	Mouth to Hazel Grove Rd.	Restoration	Channel Stability & Habitat Diversity	Summer Rearing, Winter Rearing, (Migration)
Steelhead	Claskenie	CLA Carcass-1	0.10	Mouth to RB trib	Restoration	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Claskenie	CLA Carcass-3	0.10	West Fork to Falls	Restoration	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Chum	Claskenie	20 ODFW-CLA-A2	0.08	Alder Grove School to Swede Town Rd	Restoration	Habitat Diversity	Spawning/Incubation
Chum	Claskenie	21 ODFW-CLA-A3	0.08	Swede Town Rd to Carcass Cr	Restoration	Habitat Diversity	Spawning/Incubation

Species	Watershed	Designation	Priority Value	Description of Reach	Type of Measure	Key Attributes to Restore or Protect	Life Stage Addressed
Chum	Klaskanine-Mainstem	63 SKL-A0	0.27	Mouth of Klaskenine to Hatchery	Restoration	Habitat Diversity	Spawning/Incubation
Coho	Klaskanine-Mainstem	63 SKL-A0	0.21	Confluence to South Fork (Smileys Hole)	Restoration	Channel Stability	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Klaskanine-North Fork	8 NKLA-A0	0.31	Smileys Hole to State Hatchery dam	Restoration	Habitat Diversity	Spawning/Incubation, Summer RearingWinter RearingMigration
Coho	Klaskanine-South Fork	67 ODFW-SKL-A4	0.48	first falls to bigfalls	Protection	Water Quality & Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Klaskanine-South Fork	67 ODFW-SKL-A4	0.48	first falls to bigfalls	Restoration	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Coho	Klaskanine-South Fork	66 ODFW-SKL-A3	0.40	CEDC Hatchery Dam to first Falls	Protection	Water Quality & Habitat Diversity	Summer Rearing, Winter Rearing
Steelhead	Klaskanine-South Fork	66 ODFW-SKL-A3	0.40	CEDC Hatchery Dam to first Falls	Protection	Channel stability	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Chum	Klaskanine-South Fork	64 ODFW-SKL-A1	0.25	South Fork to 25' contour	Restoration	Habitat Diversity	Spawning/Incubation, Winter Rearing

Species	Watershed	Designation	Priority Value	Description of Reach	Type of Measure	Key Attributes to Restore or Protect	Life Stage Addressed
Steelhead	Klaskanine-South Fork	64 ODFW-SKL-A1	0.25	South Fork to 25' contour	Restoration	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Chum	Klaskanine-South Fork	65 ODFW-SKL-A2	0.24	25' contour to CEDC Hatchery dam	Protection	Pollutants	Spawning/Incubation, Winter Rearing
Coho	Klaskanine-South Fork	64 ODFW-SKL-A1	0.15	South Fork to 25' contour	Restoration	Habitat Diversity & Channel Stability	Winter Rearing
Steelhead	Klaskanine-South Fork	66 ODFW-SKL-A3	0.14	CEDC Hatchery Dam to first Falls	Restoration	Water Quality	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Coho	Lewis and Clark	36 ODFW-LC-B2	0.41	400 Line to South Fork	Protection	Water Quality & Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Chum	Lewis and Clark	35 ODFW-LC-B1	0.38	RM8 (tidewater) to 400 Line	Restoration	Habitat Diversity	Spawning/Incubation, Winter Rearing
Steelhead	Lewis and Clark	37 ODFW-LC-B3	0.37	South Fork to Warrenton intake dam	Protection	Habitat diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Lewis and Clark	38 ODFW-LC-B4	0.35	Intake dam to L&C Falls	Protection	Water Quality	Spawning/Incubation, Summer Rearing Winter Rearing Migration

Species	Watershed	Designation	Priority Value	Description of Reach	Type of Measure	Key Attributes to Restore or Protect	Life Stage Addressed
Steelhead	Lewis and Clark	35 ODFW-LC-B1	0.33	RM8 (tidewater) to 400 Line	Restoration	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing (Migration)
Coho	Lewis and Clark	35 ODFW-LC-B1	0.31	RM8 (tidewater) to 400 Line	Restoration	Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing
Coho	Lewis and Clark	49 ODFW-LC-H1	0.22	Camp C Creek mouth to reservoir	Protection	Water Quality & Channel Stability	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Coho	Lewis and Clark	38 ODFW-LC-B4	0.19	Intake dam to L&C Falls	Restoration	Channel Stability	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Lewis and Clark	38 ODFW-LC-B4	0.19	Intake dam to L&C Falls	Restoration	Channel Stabilty	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Coho	Youngs	74 ODFW-YNG-A1	0.34	Bridge to Falls	Protection	Habitat Diversity & Channel Stability	Spawning/Incubation, Summer Rearing Winter Rearing
Steelhead	Youngs	74 ODFW-YNG-A1	0.34	Bridge to Falls	Protection	Protect WQ Restore Channel Stabilty	Spawning/Incubation, Summer Rearing Winter Rearing Migration

Species	Watershed	Designation	Priority Value	Description of Reach	Type of Measure	Key Attributes to Restore or Protect	Life Stage Addressed
Chum	Youngs	57 Youngs Bay Mouth	0.22	Mouth to Confluence of Klask.	Restoration	Channel Stability	Winter Rearing
Coho	Youngs	74 ODFW-YNG-A1	0.20	Bridge to Falls	Protection	Water Quality & Habitat Diversity	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Steelhead	Youngs	74 ODFW-YNG-A1	0.20	Bridge to Falls	Restoration	Channel Stabilty Habitat Diversity Riparian Conditions	Spawning/Incubation, Summer Rearing Winter Rearing Migration
Chum	Youngs	74 ODFW-YNG-A1	0.17	Bridge to Falls	Restoration	Habitat Diversity	Spawning/Incubation, Winter Rearing
Coho	Youngs	75 ODFW-YNG-A2	0.16	MoosMoos	Protection	Water Quality & Channel Stability	Summer Rearing, Winter Rearing
Coho	Youngs	57 Youngs Bay Mouth	0.13	Youngs Bay Mouth to confluence of Youngs R.	Restoration	Channel Stability	Summer Rearing, Winter Rearing
Steelhead	Youngs	73 ODFW-YNG-A0	0.07	Youngs R. to Bridge (head of tide)	Protection	Low-Flow	Summer Rearing, Winter Rearing, Migration
Steelhead	Youngs	73 ODFW-YNG-A0	0.05	Youngs R. to Bridge (head of tide)	Restoration	Channel stability	Summer Rearing, Winter Rearing, Migration

2.2.5.3 Limiting Factors and Working Hypothesis

The subbasin planning process for the Mainstem Lower Columbia River and Columbia River Estuary relies on the development of working hypotheses that provide a framework for relating the assessment data to proposed management objectives. The working hypotheses are a set of key assumptions that are based on assessment data and analysis; the hypotheses describe a scientific understanding of the subbarea and contains key assumptions relating to species-habitat relationships and/or the effectiveness of strategies to modify elements of the environment

The Estuary and Mainstem Assessment (EMA) also proposes hypotheses that serve as assumptions for the development of biological and physical objectives for the subbasin. The Western Oregon tributaries (WOTs) assessment provides an opportunity to add assumptions that were not part of EMA. In section 2.2.5.4, the applicability of these assumptions to the WOTs subbarea are noted.

W.H1. General

If habitat diversity and channel stability in high-priority reaches of the Western Oregon tributaries subarea are protected and restored, salmonids production and abundance will increase.

The WLC-TRT (2004) commonly noted that habitat conditions are moderately degraded through much of the basin. The effects of timber harvest may be significant in the upper reaches, while residential and agricultural land use was a factor among the lower reaches. Riparian conditions were considered by the WLC-TRT to be highly degraded.

Lower reaches are challenged by channelization, and modifications to the historic flow regimes. For example, flows in the estuary and a lack of spring freshets resulting from hydropower operation have modified conditions in the lower reaches of these tributaries in important ways. Turbidity has been reduced at critical times for out-migrating juveniles, resulting in increased predation. Additionally, the lack of large woody debris and channelization has simplified habitat, reducing refugia and resting areas. Tide gates, culverts, and other passage barriers have created challenges for salmonids which require off channel areas for spawning and rearing. The WLC-TRT population persistence ratings also identify such barriers as problematic for resolving the DIPs spatial structure needs.

QHA workshop participants noted that in areas where timber practices have been previously addressed, watersheds appear to be more ready to receive fish, particularly in the upper reaches. Examples of watersheds where improved timber practices have positively impacted habitat include the Clatskanie and Big Creek, although development pressure and land-use practices continue to provide challenges to the habitat in these areas. Members of the Mainstem Lower Columbia River and Columbia River Estuary subbasin planning team noted that while regulations governing Washington forest practices are "ESA approved", a determination of the benefits of the Oregon Forest Practices Act on the ESA listed species has not been reached. However, emphasis on the lower reaches of the Willamette subbasin has been endorsed as a priority by in subbasin planning under the premise that upland timber areas are generally improving while the lower reaches are suffering from cumulative effects of agriculture and urbanization.

W.H2. General

If n-type coho are promoted and restored to the Western Oregon tributaries subarea, then population diversity in the coastal range emographically independent populations (DIPs) will improve.

Hatchery practices have promulgated s-Type coho which has an "early run" life history type, which is not ideally suited to the environmental and physical characteristics of tributaries in the coastal range ecological stratum (Meyers, pers. communication). Consequently, these hatchery practices, combined with harvest policies and other out-of-basin effects have contributed to the virtual extirpation of the n-type life history, which has a later run-type coho. The WLC-TRT (2003) identifies population diversity as an important goal for population recovery of salmonids in the Lower Columbia River/Willamette ESU, and matching population characteristics with watersheds environmental and physical characteristics could be an important step in re-establishing these stocks.

Current Coho runs have improved and are arguably stable and self sustaining (ODFW, 2004), as compared to other salmonids populations in the WOTs subbarea, however the Technical Review Team (WLC-TRT, 2004) has been especially concerned about declining trends in abundance and increasing hatchery contributions to escapement. QHA workshop participants commented that runs have somewhat adapted to current conditions, but the watersheds analyzed would likely support a late run Coho stock if it were introduced, and since the late run Coho would be outside of the current impactful harvest season, these fish would be very viable in the opinion of fisheries experts on the QHA panel.

Opportunities exist for improving chum spawning and rearing habitat, especially in the Young's Bay watershed—however better information on current distribution and use is needed. For example while QHA participants were quite confident that Chum is present, WLC-TRT evaluators do not identify this as a reliable source of production.

W.H3. Lewis and Clark River

If habitat diversity is restored in the lower reaches of the Lewis and Clark River, spawning and rearing of all salmonid populations will improve.

Limiting factors for all focal species in this watershed are habitat diversity and channel stability throughout the watershed, reflecting a long term decrease in large woody debris (LWD) and channelization due to land management practices which include timber operations and agricultural usage. Flows, particularly in the lower reaches appear to be problematic.

Restoring habitat diversity to the lower reaches (tidewater to 400 line) will benefit both spawning/incubation and winter rearing lifestages of Chum salmon populations; restoring flows below the South Fork should improve rearing habitat. Rearing opportunities for other salmonids would also be improved. In some instances, the absence of high flows, particularly from the 400 line to the South Fork of the Lewis and Clark have limited chum rearing potential, and present a potential restoration opportunity.

W.H4. Youngs

If geomorphic behavior of channels in the lower reaches of the Youngs River is restored, and connectivity to the floodplains and estuary is enhanced, spawning and rearing of salmonids will improve.

Limiting factors for all focal species in this watershed are channel stability and habitat diversity throughout the watershed, reflecting channelization and a long term decrease in large woody debris (LWD) due to land management practices which include timber operations and agricultural usage. Both QHA participants as well as the WLC-TRT evaluators noted that dikes and tide gates have eliminated access to side channel habitat, which would be otherwise be used by salmonids for spawning and rearing.

Chum salmon would benefit from restoring the historic geomorphic behavior of channels in the lower reaches (mouth of Youngs Bay to the end of tidewater) will be most beneficial to spawning/incubation and winter rearing lifestages

W.H5. Big Creek

If access to productive habitat above the Big Creek hatchery is improved and if concerns about disease transmittal at the hatchery can be addressed., the spatial structure of salmonid populations in the coastal DIPs will improve and productivity of coho, steelhead, and Chinook populations will increase.

An obstruction to upstream passage posed by the Big Creek Hatchery limits this watershed from being utilized to its full potential. A sensitivity analysis examining how protection values in Big Creek are impacted by the passage barrier at the hatchery illustrates that providing passage by this obstruction would provide additional habitat for Coho and Steelhead, and significantly increase the protection value throughout the watershed and especially for the upper tributaries to Big Creek. Without improving passage at the hatchery, reaches throughout the watershed would benefit from restoration activities that address channel stability and habitat diversity. Projecting how salmonids would use the watershed if the passage at the barrier was addressed suggest that in this case, the watershed is ready to receive protecting key attributes from degradations would be a higher priority than restoring reaches.

Table 2-37: Sensitivity analysis of QHA restoration and Protection values relative to passage at the big creek hatchery

	Cumulative Restoration Score	Cumulative Protection Score
Big Creek (no change in passage at hatchery)	1.56	0.07
Big Creek (improved passage at hatchery)	1.56	3.52

ODFW (2004) notes that in the Coho recovery plan several streams, associated with ODFW operated hatcheries, were identified as having artificial barriers to migrating adult coho. These fish barriers had been erected to prevent potentially disease infected fish from spawning upstream of the water intake for the hatchery and transferring disease to fish being raised at the

hatchery. One of the recovery plan strategies was to provide adult coho passage at several of these locations, consistent with the likelihood of gains in natural coho production and not unduly compromising the hatchery rearing environment in terms of disease. In 2003 adult coho were again passed upstream at the barriers associated with the North Fork Klaskanine and Big Creek hatcheries. Removing or mitigating the barrier has implications for hatchery practices, and there is concern that disease from the hatchery may spread as habitat upstream is made available.

Once available, spawning and rearing life stages of both species of this habitat could be enhanced by addressing habitat stability just above the hatchery, and habitat diversity in the upper reaches and in the tributaries

W.H6. Klaskanine

If habitat diversity and channel stability are restored in the lower reaches of the Klaskanine River, chum spawning and summer rearing opportunities for Steelhead will improve.

The lower reaches of the Klaskanine are degraded and channelized. Low habitat diversity was noted by WLC-TRT evaluators, the QHA workshop and in the Youngs Bay Watershed Assessment. Historically, this area has supported chum production and provided rearing habitat for a number of salmonids species. WLC-TRT evaluators and the QHA panel also identified the hatchery weir as partial impediment to Coho salmon.

W.H7. Clatskanie

If protection measures are applied to key reaches of the Clatskanie River and if channelization, habitat diversity, and water quality attributes are mitigated in its lower reaches, the population and abundance of salmonids, including chum, coho and winter steelhead, will improve.

Comparison of QHA workshop results with **WLC-**TRT evaluations resulted in conflicting information on this watershed. The QHA participants, who included members of the local watershed council assert that this is a well functioning watershed, with the potential to support stable populations of salmonids, including Chum, Coho and winter steelhead.

Absence of spawning behavior and redds in the watershed were attributed to depressed populations and out of basin effects. The WLC-TRT evaluators were less positive; agriculture, timber and residential development has, in their opinion, contributed to degradation habitat, and this apparent degradation may be responsible for the low productivity and low Chinook escapement from this DIP. WLC-TRT evaluators also noted that the lower reaches of the tributaries in this watershed have been degraded riparian conditions that negatively impact chum spawning in this DIP.

Ratings from the QHA demonstrate high protection values throughout the watershed. The primary rationale for high protection values in the Clatskenie are lack of human population and development, particularly in the upper reaches. This watershed has a long history of protection and upland forest reform.

Areas demonstrated as having a relatively high restoration potential in the Clatskenie include the mouth reach, which is currently limited by channel stability and habitat diversity. Improvements in the mouth reach would provide summer and winter rearing habitat for Coho

and steelhead. Highest restoration values in the watershed are found in Miller creek, which is also limited by habitat diversity.

Water quality parameters for E. Coli and dissolved oxygen do not meet the state standards in the Clatskanie River; and the Clatskanie is on the state 303d list. Impacts of this water quality limitation on salmonids are quantifiable, however are generally regarded as detrimental to egg incubation and juvenile rearing.

W.H8. Scappoose

Habitat conditions in Scappoose Bay are impaired throughout the watershed, and significant impacts in the lower reaches have been observed due to channelization and diking. Protection of the south end of Scappoose Bay should be a priority, as it is one of the few remaining relatively intact portions of the lowland floodplain portion of the watershed; restoration opportunities in Jackson Creek and Joy Creek are possible means of improving habitat conditions; Artficial and natural barriers to fish passage limit access to potentially productive habitat.

The Scappoose watershed was not incorporated into the QHA workshops, however attribute scoring from the WLC-TRT population evaluation workshop scored habitat conditions as severely or moderately impaired throughout the basin. Agricultural land use in the lower reaches, in addition to residential and urban development, were factors identified as contributing to habitat degradation (TRT 2004; DEA 2000). There are potential barriers in Scappoose and Milton Creeks that may create access problems influence spatial structure of the of Chinook and Coho populations; for example numerous small blockages (tide gates, culverts) may influence access to smaller tributaries and side channels. Hatchery practices have tended to make coho populations in the Scappoose DIP susceptible to genetic introgression, however Chinook stocks have been kept relatively distinct.

2.2.5.4 Integration with Mainstem Lower Columbia River and Columbia River Estuary Assessment

2.2.5.4.1 Working Hypothesis

The Estuary and Lower Mainstem subbasins have historically been viewed as a distinct geographic subbasin, with the Western Ooregon tributaries subbarea given little consideration but generally aggregated with the estuary. Hypothesis statements generated from the Mainstem Lower Columbia River and Columbia River Estuary basin assessments articulated in chapter 2.1.7 above of the Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan, reflect the working assumptions regarding the functions and processes that govern the estuary and mainstem. Many of these hypotheses also apply and modify the Western Oregon tributaries (WOTs) hypotheses described in section 2.2.5.4.1 above.

Limiting factors, biological and physical objectives, and strategies for the focal species assessed here, were developed in response to working hypothesis in both EMA and the Western Oregon tributaries assessment and are discussed in Chapter 4. However, its important to note that while the working hypothesis developed for the WOTs subarea are considered to be specific to these tributaries, many of the working hypotheses in EMA also are relevant to WOTs, and provide additional foundation for biological objectives and strategies. Table 2-38 below summarizes the Mainstem Lower Columbia River and Columbia River Estuary basin-wide hypotheses used as the technical foundation for the setting of biological and physical objectives

in the subbasin. Where these hypotheses are inadequate for describing key processes and needs for the Western Oregon tributaries, the WOTs specific hypothesis are used to guide identifiy the need for additional strategies and measures.

Table 2-38. Estuary and lower mainstem subbasins working hypotheses.

Working Hypotheses – Estuary & Lower Columbia Mainstem		Application to Western Oregon tributaries
E.H1.	Complex and dynamic interactions between physical river and oceanographic processes, as modulated by climate and human activities, affect the general features of fish and wildlife habitat in the Columbia River estuary and lower mainstem.	Yes
E.H2.	Human activities have altered how the natural processes interact, changing habitat conditions in the Columbia River estuary and lower mainstem.	Yes
E.H3.	Rates of obvious physical habitat change in the Columbia River estuary and lower mainstem have slowed in recent years; current physical and biological processes are likely still changing such that habitat conditions represent a degraded state	No
E.H4.	Our current understanding of the interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem is not robust and introduces substantial uncertainty in decisions intended to benefit recovery and sustainability of natural resources.	Yes
E.H5.	Exotic species are capitalizing on the Columbia River estuary and lower mainstem habitats and they have impacted ecosystem processes and relationships.	No
E.H6.	Of all fish and wildlife species utilizing the Columbia River estuary and lower mainstem habitat, salmonids appear the most distressed.	Yes
E.H7.	The Columbia River estuary and lower mainstem ecosystem is critical to the expression of salmonid life history diversity and spatial structure which support population resilience and production.	Yes
E.H8.	Changes in the Columbia River estuary and lower mainstem habitat have decreased the productivity of the ecosystem and contributed to the imperiled status of salmon and steelhead.	Partially
E.H9.	Construction and operation of the Columbia River hydropower system has contributed to changes in Columbia River estuary and lower mainstem habitat conditions that have reduced salmonid population resilience and inhibited recovery.	Partially
E.H10.	Predation has always been a significant source of juvenile salmonid mortality in the lower Columbia River mainstem and estuary but habitat changes resulting from human activities have substantially altered predator concentration and distribution, particularly Caspian terns and northern pikeminnow.	Yes
E.H11.	Density dependent factors might affect salmonid productivity in the Columbia River estuary and lower mainstem under some conditions, but their current significance is unclear.	Partially

2.2.5.4.2 Biological Objectives and Limiting Factors

Development of biological objectives and limiting factors included as part of the Management Plan (Chapter 5) In general, the limiting factors and objectives needed to guide the development of strategies and measures in the Western Oregon tributaries are consistent with those stemming from the Estuary and and Mainstem Assessment; however, some of the needs identified through this assessment are distinct. Apart from EMA, the WOTs assessment's contributions to the Mainstem Lower Columbia River and Columbia River Estuary management plan address the following need and opportunities:

- Emphasis on restoring life history diversity by supporting or re-establishing historical Coho populations that includes an n-type life history run timing (late run).
- Providing access to new and productive habitat by addressing barriers in the tributaries, including hatchery wiers, tide gates, and culverts
- Recognizing priorities for restoration and protection of habitat diversity and channel stability in the WOTs subbarea that impact salmonids spawning and rearing opportunities

2.2.6 *References*

Bischoff, J.M., R B. Raymond, K.U. Snyder, L. Heigh, and S.K. Binder. 2000a. Youngs Bay Watershed Assessment. E&S Environmental Chemistry, Inc. and Youngs Bay Watershed Council. Corvallis, OR.

Bischoff, J.M., R B. Raymond, K.U. Snyder, L. Heigh, and S.K. Binder. 2000b. Skipanon River Watershed Assessment. E&S Environmental Chemistry, Inc. and the Skipanon River Watershed Council. Corvallis, OR.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dept. of Commer., NOAA Tech. Memo. NMFS-NWFSC-27.

Collins, J. W. 1892. Report on the fisheries of the Pacific coast of the United States. In Report of the Commissioner for 1888. U.S. Commission of Fish and Fisheries, Washington, D.C. p. 3–269.

David Evans and Associates, Inc. (DEA). 2000. Scappoose Bay Watershed Assessment.Prepared for the Scappoose Bay Watershed Council. Portland, Oregon.

E&S Environmental Chemistry, Inc. Nicolai-Wickiup Bay Watershed Assessment. 2000

Flemming, I.A. and M.R. Gross. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*) in competition. Ecol. Applic. 3:230-245.

Genovese, P.V. and R.L. Emmett. 1997. Desktop geographic information system for salmonids resources in the Columbia River basin. U.S. Dept. of Commerce, NOAA Technical Memo

Gilbert, C. H., and B. W. Evermann. 1895. A report upon investigations in the Columbia River Basin, with descriptions of four new species of fishes. Bull. U.S. Fish. Comm. for 1894. 14: 169–205.

Graves, J. K., J. A. Christy, P. J. Clinton and P. L. Britz. 1995. Historic habitats of the lower Columbia River. Astoria, OR, Columbia River Estuary Study Taskforce: 14.

Hargreaves, N.B. and R.J. LeBrasseur. 1986. Size selectivity of coho (Oncorhynchus kisutch) preying on juvenile chum salmon (O. keta). Can. J. Fish. Aquat. Sci. 43:581-586.

Hemmingsen, A.R., R.A. Holt, and R.D. Ewing. 1986. Susceptibility of progeny from crosses among three stocks of coho salmon to infection by *Ceratomyxa shasta*. Transactions of the American Fish. Soc. 115:492-495.

http://www.pacifier.com/~wauna/Assessment/index.htm

Johnson, O. W., W. S. Grant, R. G. Kope, K. Neely, F. W. Waknitz, and R. S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Dept. of Commer., NOAA Tech Memo NMFS-NWFSC-32.

Kostow, K. 1995. Biennial Report on the Status of Wild Fish in Oregon. Oregon Department of Fish and Wildlife.

Lestelle, L.C., L.E. Mobrand, J.A. Lichatowich, and T.S. Vogel. 1996. Applied ecosystem analysis - a primer, EDT: the ecosystem diagnosis and treatment method. Project number 9404600. Bonneville Power Administration, Portland, Oregon.

Lichatowich, J., L. E. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems. Fisheries 20(1): 10-18.

Lichatowich, J.A. and L.E. Mobrand. 1995. Analysis of chinook salmon in the Columbia River from an ecosystem perspective. Project number 92-18; Contract No. DE-AM79-92BP25105. Final Report. Bonneville Power Administration, Portland, Oregon.

Lower Columbia River Watershed Council (LCWC). (Date unknown). Lower Columbia-Clatskanie Watershed Assessment.

Marshall, A. R., C. Smith, R. Brix, W. Dammers, J. Hymer, and L. LaVoy. 1995. Genetic diversity units and major ancestral lineages for chinook salmon in Washington. In C. Busack and J. B. Shaklee (eds.), Genetic diversity units and major ancestral lineages of salmonid fishes in Washington. Tech. Rep. RAD 95-02., Wash. Dept. of Fish. And Wildl., Olympia, Wash. p. 111–173.

McConnaha, C. (2003) Qualitative Habitat Assessment (QHA) User's Guide Version 1.2.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. of Commer. NMFS-NWFSC-42.

Merrell, T. R. 1951. Stream improvement as conducted in Oregon on the Clatskanie River and its tributaries. Ore. Fish Comm. Res. Briefs 3:41–47.

Meyers, J., C. Busack, D. Rawlings, and A. Marshall (2003) Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids. National Marine Fisheries Service, Northwest Fisheries Science Center.

Mobrand Biometrics Inc. 1996. Ecosystem Diagnosis and Treatment (EDT). Applied ecosystem analysis. Bonneville Power Administration, Portland, Ore. 297 p.

Mobrand, L. E., J. A. Lichaowich, L. C. Lestelle, and T. S. Vogel. 1997. An approach to describing ecosystem performance "through the eyes of salmon". Canadian Journal of Fisheries and Aquatic Sciences 54: 2964-2973.

Mobrand, Lars, Lestelle, Larry, and Blair, Greg. 1998. Recovery of a Columbia River watershed from an ecosystem perspective: a case study using the EDT method. Contract #94AM33243. Final report to Bonneville Power Administration. Mobrand Biometrics, Inc., Vashon, Washington.

Morgan, B., J. Whisler, and J. Fulop. 1998. 1997 Oregon lower Columbia River coho spawning ground surveys and 1998 coho juvenile survey results. Oregon Department of Fish and Wildlife, Columbia River Management.

Myers, J. M., C. Busack, D. Rawding, and A. R. Marshall. 2002. Identifying historical chum salmon, chinook salmon, and steelhead within the Lower Columbia River and Upper Willamette River Evolutionary Significant Planning Units. Unpublished.

Myers, J. M., C. Busack, D. Rawding, and A. R. Marshall. 2003. Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids. National Marine Fisheries Service, Northwest Fisheries Science Center.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Leirheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon and California. U.S. Dept. of Commer.,

NMFS. 65 Fed. Reg. 7764-7787 (Feb. 16, 2000).

Oregon Department of Fish & Wildlife, 2004. Implementation of the Lower Columbia River Coho Endangered Species Management Plan, April 2004 Progress Report

Oregon Department of Fish and Wildlife. 1995. Biennial Report on the Status of Wild fish in Oregon. Oregon Dept. of Fish and Wildlife, Portland, OR.

Oregon Fish Commission. 1951. Lower Columbia River Fisheries Development Program: Reports on the Clatskanie River & Scappoose Creek Area. State of Oregon Fish Commission.

Oregon Plan for Salmon and Watersheds, 1999. Governor's Natural Resources Office, Salem, Oregon.

Parkhurst, Z. E., F. G. Bryant, and R. S. Nielson. 1950. Survey of the Columbia River and its tributaries. Part 3. USFWS Special Scientific Report–Fisheries, No. 36, 103 p.

Phelps, S. R., S. A. Leider, P. L. Hulett, B. M. Baker, and T. Johnson. 1997. Genetic analyses of Washington steelhead: Preliminary results incorporating 36 new collections from 1995 and 1996. Progress Report. Wash. Dept. Fish and Wildl., Olympia, Wash. 30 p.

Phelps, S., J. Uehara, D. Hendrick, A. Blakley and R. Brix. 1995. Genetic diversity units and major ancestral lineages for chum salmon in Washington. In C. Busack and J. B. Shaklee (eds.), Genetic diversity units and major ancestral lineages of salmonid fishes in Washington. WDFW Technical Report #RAD 95-02, Olympia, Wash. 55 p.

Smith, H. M. 1895. Notes on a reconnoissance [sic] of the fisheries of the Pacific coast of the United States in 1894. Bull. U.S. Fish Comm. Vol. XIV(1894):223–288.

Wallis, J. 1963b. An evaluation of the Big Creek Salmon Hatchery. Res. Lab. Rept., Ore. Fish Comm., Clackamas, Ore. 64 p.

Wallis, J. 1963c. An evaluation of the Klaskanine Salmon Hatchery. Res. Lab. Rept., Ore. Fish Comm., Clackamas, Ore. 83 p.

Washington Department of Fisheries (WDF). 1951. Planning reports. Lower Columbia River Fisheries Development Program. Washington. Preliminary Draft of August 1951. 205 p. + app.

Washington Department of Fisheries and Game (WDFG). 1916. Twenty-fourth and twenty-fifth annual reports of the State Fish Commission to the Governor of the State of Washington from April 1, 1913 to March 31, 1915. Dept. Fish and Game, State of Washington. 171 p.

Washington Department of Fisheries. 1993. Review draft, fisheries resources in southwest Washington. Prepared for Washington Dept. of Ecology, Olympia.

West Coast Chinook Salmon Biological Review Team (BRT). 1997. Review of the Status of Chinook Salmon (Oncorhynchus tshawytscha) from Washington, Oregon, California, and Idaho under the U.S. Endangered Species Act. Prepared for the National Marine Fisheries Service.

Willamette/Lower Columbia Technical Recovery Team (WLC-TRT). 2003. Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids. http://research.nwfsc.noaa.gov/trt/viability_report.htm

Willamette/Lower Columbia Technical Recovery Team (WLC-TRT). 2004. Memorandum to NOAA Fisheries, Oregon Department of Fish & Wildlife, and Willamette Restoration Initiative: Population Evaluation for Oregon State Tributary Population of Lower Columbia River and Upper Willamette River Chinook Salmon, Chum Salmon, Coho Salmon, and Steelhead

Willis, R. A. 1962. Gnat Creek weir studies. Research Division, Fish Commission of Oregon. Final Report. 71 p.

Willis, R. A., M. D. Collins, and R. E. Sams. 1960. Environmental survey report pertaining to salmon and steelhead in certain rivers of eastern Oregon and the Willamette River and its tributaries, part II survey reports of the Willamette River and its tributaries. Fish Commission of Oregon. Clackamas, Oregon.

3. INVENTORY

3.1 Overview

The inventory for the Mainstem Lower Columbia and Columbia River Estuary subbasins is structured in two sections. The first—Agencies and Authorities—provides details on the many interests in the two-subbasin area. The second section—Programs, Plans and Projects—provides additional details on key activities that have or are occurring in the subbasins.

The Lower Columbia Fish Recovery Board, a partner in this subbasin planning effort, also has compiled an inventory for its 11 subbasins, which includes information on the Lower Columbia River mainstem and estuary. This information is included LCFRB's Lower Columbia Salmon and Steelhead Recovery and Subbasin Plan Technical Foundation, Volume 4: Programs and Projects Directory.

3.2 Agencies and Authorities

Numerous government agencies and nongovernmental bodies have authority over and/or engage in activities that impact the Lower Columbia River mainstem and estuary subbasins. Federal, state, regional, county, local and tribal governments all have functions that affect the subbasins. In addition, many nongovernmental agencies have active roles within the Lower Columbia River basin.

Amended from the Lower Columbia River Estuary Partnership Comprehensive and Management Plan (June 1999), this section summarizes authorities of 19 federal, 20 state (12 Oregon, eight Washington), 13 regional and more than 40 local agencies. Four tribes also have interests in specific portions of the subbasins. Additionally, at least 46 nongovernmental agencies in Washington and Oregon are active in the Lower Columbia mainstem and estuary.

These agencies and groups are listed along with reference pages in the table 3-1.

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3.2.1.1 U.S. Department of Agriculture: Cooperative State Research, Education, And Extension Service

The Cooperative State Research, Education, and Extension Service is one of the United States Department of Agriculture's (USDA) organizations designed to address soil conservation and agricultural impacts on water quality. The agency's two focal areas that are relevant to water quality are agriculture and natural resources, and community and rural development. Conservation work is provided through a cooperative effort among this federal agency, state extension services, and county extension agents. This service emphasizes the use of Best Management Practices (BMP's) through field demonstrations, public education, and outreach programs. The Extension Service has two general program areas that relate to the estuary study area:

3.2.1.1.1 Plant Production and Protection Programs:

- Administers the National Biological Impact Assessment Program which addresses safe and appropriate applications of biotechnology to agriculture
- Conducts Integrated Pest Management (IPM) programs and activities
- Manages the National Agricultural Pesticide Impact Assessment Program

3.2.1.1.2 Research Programs:

- Manages the National Research Initiative, which supports research aimed at solving key agricultural and environmental problems
- Addresses issues concerning plant and animal genomes, water quality, human nutrition, food safety, and animal and plant systems
- Coordinates educational programs based on findings of research

3.2.1.1.3 U.S. Department of Agriculture: Farm Service Agency (Fsa)

The Farm Service Agency (FSA) is one of USDA's organizations designed to address soil conservation and agricultural impacts on water quality. FSA administers the Soil Conservation Domestic Allocation Act, the "Swampbuster" and "Sodbuster" provisions of the 1985 Food Security Act, and the following environmental conservation programs:

3.2.1.1.4 Conservation Reserve Program:

- Conserves and improves soil and water quality by reducing soil erosion and sedimentation
- Encourages farmers to discontinue growing crops on highly erodible lands
- Identifies wildlife habitat to be set aside for preservation purposes
- Removes highly erodible croplands and wetlands from production by financially
- reimbursing program participants

3.2.1.1.5 Emergency Conservation Program:

- Allows farmers to rehabilitate farmland destroyed by wind erosion, floods or other natural disasters
- Enables farmers to perform emergency conservation measures to prevent damage to lands

3.2.1.1.6 Farm Debt Cancellation-Conservation Easement Program:

- Protects marginal and sensitive lands by purchasing easements for conservation, recreation, and wildlife habitat
- Allows debt cancellation for program participants in exchange for conservation easements

3.2.1.1.7 Water Bank Program:

- Protects important waterfowl habitat by authorizing payments for preventing wetland loss and preserving inland freshwater
- Conserves surface waters, reduces runoff and erosion, provides flood control assistance, enhances natural beauty of the landscape
- Provides funds for small flood control projects to protect agricultural lands

3.2.1.2 U.S. Department of Agriculture: Forest Service

3.2.1.3 U.S. Department of Agriculture: Natural Resources Conservation Service (NRCS)

Formerly the Soil Conservation Service, The Natural Resources Conservation Service (NRCS) is one of USDA's technical agencies designed to address soil conservation and agricultural impacts on water quality. NRCS focuses its assistance on non-federal lands, and works primarily with private land owners in implementing water and soil erosion-reducing programs to protect water quality. The main NRCS activities are:

3.2.1.3.1 Farmland Protection Program:

- Protects prime and unique farmland from conversion to non-agricultural uses

3.2.1.3.2 Forestry Incentives Program:

- FIP is a cost-share program designed to increase forest production by increasing tree planting; timber stand improvement, and other related practices on non-industrial private forest lands

3.2.1.3.3 Reduction of Runoff and Erosion Control:

- offers grants and training to farmers regarding best management practices to reduce runoff and control erosion

3.2.1.3.4 Resource Conservation and Development Program:

- Encourages the capability of state and local government agencies and nonprofit organizations in rural areas to develop programs for resource conservation and community sustainability
- Provides water supply forecasting services

3.2.1.3.5 Watershed Protection and Flood Prevention:

- Provides financial and technical assistance to state and local governments in watershed protection
- Develops watershed restoration plans focusing on ways to improve salmon habitat 6) Wetland Identification and Protection Program:
- Assists private landowners and others in protecting and restoring wetlands, and developing wildlife habitats

3.2.1.3.6 Wetland Reserve Program:

- offers agricultural landowners an opportunity to receive payments for restoring and protecting wetlands
- Provides cost share funds for restoration and the purchase of conservation easements

3.2.1.3.7 Technical Assistance Programs:

Provides planning assistance to landowners, groups, federal, state, and local governments to inventory natural resources and apply conservation practices needed to protect and enhance those resources

- offers irrigation water management technical assistance
- Provides private landowners with technical and financial assistance in conservation planning and implementation (integrated crop and pest management, confined-animal feeding operations)
- Provides technical assistance for the Governor's Watershed Enhancement Board program

3.2.1.3.8 Urban Resources Partnership:

- Sets up partnerships with government agencies, nonprofit organizations, and community groups to implement natural resource projects in urban areas

3.2.1.3.9 Wildlife Habitat Incentives Program:

- Provides technical and financial assistance to landowners to improve wildlife habitat

3.2.1.4 U.S. Department of Commerce: National Oceanic And Atmospheric Administration

National Oceanic and Atmospheric Administration (NOAA) is the principal federal agency that develops and distributes scientific information related to estuaries and coastal ocean waters. The agency's main responsibilities involve research, data collection and assessment, and management. NOAA has developed an array of programs to address coastal issues. Some of these programs include:

3.2.1.4.1 Coastal Zone Management Program:

- Assists federally approved coastal states in effectively managing the nation's coastal zone by balancing competing demands
- Provides oversight for state Coastal Zone Management Act (CZMA) programs 2) Marine Sanctuary Program:

3.2.1.4.2 Marine Sanctuary Program

- Identifies sensitive marine environments and provides authority for coordinated conservation and management of these areas
- Supports scientific research and public education programs concerning marine environments

3.2.1.4.3 National Estuaries Research Reserve System:

- Manages a national system of reserves which represents different coastal regions and estuarine types

3.2.1.4.4 U.S. Department of Commerce: National Oceanic And Atmospheric Administration's National Marine Fisheries Service

The National Marine Fisheries Service (NMFS) is an agency of the National Oceanic and Atmospheric Administration (NOAA). NMFS is responsible for the assessment and management of marine resources through the regulation of fisheries. NMFS fishery managers and scientists participate in international treaties and agreements, and create national partnerships to conserve living marine resources. NMFS emphasizes preservation of habitat as an essential way to protect species. NMFS works in numerous areas that directly impact the nation's water resources. These include:

3.2.1.4.5 Fishery Management:

- Works with Fishery Management Councils to develop and coordinate Fishery Management Plans for all species under federal jurisdiction
- Monitors fishery landings and fishing efforts by compiling and analyzing relevant statistics of U.S. territorial seas
- Analyzes federal projects, permits, and license proposals
- Provides recommendations to protect, mitigate, and enhance anadromous fish resources
- Participates in fish management planning actions sponsored by the Northwest Power Planning Council

3.2.1.4.6 Habitat Conservation and Species Management:

- Monitors and protects the health of the nation's estuarine marshes, coral reefs, seagrass beds, and mangroves by reviewing permits, legislation, and future activities that will affect fish and wildlife habitat
- Conducts research on the ecological importance of estuaries, and provides recommendations for reduced impact through the Habitat Conservation Program
- Shares management of NOAA's Damage Assessment and Restoration Program
- Works to recover resources that impact the health of endangered/threatened species

3.2.1.4.7 Seafood Safety and Inspection:

- Inspects hundreds of seafood distributor plants to ensure that their products are safe for human consumption
- Works cooperatively with other nations to guarantee seafood safety

3.2.1.4.8 Technical Assistance:

- Provides technical assistance to state and federal agencies regarding the effects of water quality parameters on resources of concern
- Performs damage assessments for chemical spills that affect relevant resources
- Administers coastal zone planning, permit, and hydroelectric project reviews

3.2.1.4.9 Water Management:

- Provides recommendations to the Army Corps of Engineers on dredge and fill permits
- Reviews instream flow studies associated with federally permitted actions

3.2.1.5 U.S. Department of Commerce: National Oceanic and Atmospheric Administration's National Ocean Service

The National Ocean Service (NOS) also is managed under the auspices of NOAA. NOS is primarily interested in estuarine and coastal water navigation. Most of the National Ocean Service's authority is derived from the following two laws:

3.2.1.5.1 Coastal Zone Management Act of 1972:

- Provides financial support, policy guidance, and technical assistance to coastal states in an effort to promote the protection of water resources and coastal land
- Establishes a state-federal partnership in managing coastal resources
- Works with coastal states to develop and maintain coastal zone management programs

3.2.1.5.2 Coastal Zone Act Reauthorization Amendments:

- Requires states to develop coastal nonpoint programs which must be approved by NOAA and EPA

  Assures consistency between state and federal coastal zone management and water quality programs
- NOS also has a role in tidal current prediction and in nautical charting. NOS has a number of programs related to coastal management. These programs have been grouped into the following two areas:

3.1.1.1.1 Estuarine Assessment:

- Produces inventories of multiple uses related to pollution discharge, coastal wetlands, and estuaries under Strategic Environmental Assessments Division (SEA)
- Develops geographical information systems under SEA
- Creates strategic environmental assessments which aim to balance conservation needs with use demands under SEA

3.1.1.1.2 office of Ocean and Coastal Resources Management:

- Administers the federal Coastal Zone Management Program and the Coastal Nonpoint Pollution Control Program

- Promotes low-impact use of the U.S. coastal zone, provides funding to coordinate management planning, and manages and supports estuarine reserves

3.1.1.2 U.S. Department of Defense: U.S. Army Corps of Engineers

The Army Corps of Engineers provides engineering and planning services and construction support for a wide variety of military and civilian projects. The Corps' primary role is to develop and manage the country's waterways and wetlands. Its projects reduce flood damage, improve harbors and navigation channels, protect stream banks and shorelines, restore ecosystems, and other activities aimed at protecting watersheds and the environment. The following is a list ofprograms and activities relevant to the Lower Columbia River estuary:

3.1.1.2.1 Resource Management Programs:

- Conducts fish, wildlife, environmental, and cultural studies and project resource management
- Administers natural resources/master planning
- Assists with fish passage research, mitigation, funding, and coordination
- Provides habitat inventory and analysis
- ESA compliance
- Works on water quality and water supply issues

3.1.1.2.2 Flood Damage Reduction Control Programs:

- Conducts flood damage reduction, flood plain management and preparedness planning, and shoreline protection
- Implements flood damage reduction projects and operates reservoirs
- Provides emergency preparedness assistance and response for floods and other natural disasters
- Conducts hydrologic and hydraulic analyses
- Provides flood control works inspection and flood damage rehabilitation

3.1.1.2.3 Navigation and Dredging Programs:

- Regulates activities involving, and permits structures and work in, navigable waters of the U.S.
- Constructs navigation improvement projects
- Regulates (under Section 404 of the Clean Water Act) activities involving the discharge of dredged material into all waters of the U.S.
- Maintains harbor entrances and navigation channels and structures
- Prepares and implements dredge material management plans
- Evaluates sediments in the federal channel to ensure management practices comply with the Clean Water Act
- Participates in oceanographic and jetty construction studies

3.1.1.2.4 Research and Technical Assistance:

- Conducts comprehensive planning, watershed and environmental restoration studies
- Provides planning assistance to states
- Provides work for others on a cost-reimbursement basis

3.1.1.3 U.S. Department of Energy: Bonneville Power Administration

Bonneville Power Administration (BPA) is an agency of the U.S. Department of Energy responsible for wholesaling electric power generated at 29 federal dams located in the Columbia-Snake River Basin. BPA is a federal utility and one of the five power marketing agencies. Its principal service territory includes the states of Oregon, Washington, Idaho, parts of Montana and small portions of adjacent states. The Pacific Northwest Electric Power Planning and Conservation Act of 1980 extended BPA's responsibilities to include improvements of fish and wildlife resources and development of conservation resources. The following is a list of BPA's programs that relate to the LCREP:

3.1.1.3.1 Fish and Wildlife Protection Programs:

- Implements the Northwest Power Planning Council's Fish and Wildlife Program for impacts associated with the Federal Columbia River Power System (includes consideration of oceanic and estuarine impacts)
- Implements Endangered Species Act activities associated with the national Marine Fisheries Service and the U.S. Fish and Wildife Services biological opinion's, including estuary, near shore, and ocean salmonid survival
- Engages in hatchery programs and genetics and disease assessments
- Pursues acquisition of water rights needed to support fish hatcheries
- Funds programs to restore fish habitat through the use of water storage and transfers
- Funds the Coordinated Information System and the Northwest Hydropower Data Base to provide standard methods for assessing fish and wildlife data

3.1.1.3.2 Water Management Activities:

- Runs an industrial energy conservation program which funds water system retrofits
- Participates in protection of groundwater related to pesticide use
- Works with the Northwest Power Planning Council to compile hydroelectric power supply curves
- Prepares internal Pollution Abatement Clearances (PAC) for any proposed construction activity or major modification to existing facilities

3.1.1.3.3 U. S Department of Health And Human Services: U.S. Food And Drug Administration

The U.S. Food and Drug Administration (FDA) develops methods for detecting, quantifying, and identifying contaminants in shellfish and estuarine waters. It is the national regulatory authority for public health protection and seafood regulation. It is responsible for establishing and enforcing safe levels for harmful substances in accordance with the Federal Food, Drug and Cosmetic Act. The following is a list of the programs relevant to the estuary study area:

.3.1.1.3.3.1 Low-Acid Canned Food Program:

- Focuses on thermally processed, commercially sterile foods, including seafood and canned salmon and tuna
- National Shellfish Sanitation Program:
- Provides for the harvest and production of fresh and frozen molluscan shellfish
- offers technical assistance to states in studying specific pollution problems
- Provides data to establish closure levels for shellfish harvesting
- Conducts applied research in various contaminants to assist in developing standards and criteria
- Evaluates the effectiveness of state shellfish sanitary control programs

.3.1.1.3.3.2 Salmon Control Plan:

- Provides control over plant sanitation and processing activities
- Addresses concerns involving decomposition in the salmon canning industry

.3.1.1.3.3.3 Seafood Regulatory Program:

- Operates an oversight compliance program for fishery products
- Sets tolerances in foods for natural and human-made contaminants (except for pesticides that are under EPA jurisdiction)
- Provides financial support to state regulatory agencies for the inspection of food plants
- Conducts research regarding the health risks posed by unsafe processing practices

3.1.1.3.4 U.S. Department of the Interior: Bureau of Land Management

The mission of the Bureau of Land Management (BLM) is to sustain the health, diversity and productivity of the public domain lands for the use and enjoyment of present and future generations. One focus of the agency involves assisting states with the development of non-point source pollution plans, and identifying threatened bodies of water. BLM has a number of projectsand activities related to land management and its effects on water quality:

.3.1.1.3.4.1 Land Management Activities:

- Manages federal range and forest lands with respect to water quality and quantity, riparian and watershed restoration, water source development, and water rights
- Prepares, adopts, and implements Wild and Scenic River Management Plans
- Administers the Oregon and California Lands Sustained Yield Act of 1937
- Manages 19 million acres of subsurface minerals in Oregon
- Administers the Federal Land Policy and Management Act of 1976

3.1.1.3.5 Technical Assistance:

- Provides technical assistance on watershed and riparian management issues
- Administers rangeland management research

- Evaluates effects of resource management activities on water management

3.1.1.4 U.S. Department of the Interior: Bureau of Reclamation

The Bureau of Reclamation has traditionally administered federal programs for water resource development and use. In 1987, the Bureau decided to redirect its mission to focus more on the efficient operation of existing projects and resource management issues, and less on water resource development. The Bureau's activities include: hydroelectric power generation; irrigation service; groundwater management; flood control; fish and wildlife enhancement; river regulation and control; water quality and quantity issues; and industrial and municipal water supply. The Bureau also owns and operates the Grand Coulee Dam and many other dams in the Northwest.Some other programs and projects significant to the the staury and mainstem stdy areas are:

3.1.1.4.1 Departmental Irrigation Drainage Program:

- Serves to protect and restore fish and wildlife resources that have been adversely impacted by irrigation systems
- Works to improve the operating efficiencies of irrigation facilities

3.1.1.4.2 Federal Water Projects:

- Coordinates resource management planning
- Monitors water quality relevant to projects
- Provides technical assistance for best management practices (BMP's)
- Implements structural and nonstructural water quality management programs

3.1.1.4.3 Water Supply and Management Studies and Planning Activities:

- Conducts river basin conservation planning, including impact analyses
- Performs recharge studies, conjunctive use studies, and water supply studies
- Conducts planning investigations under the Federal Bureau of Reclamation Project Program
- Performs hydrologic analyses
- Identifies potential watershed and riparian zone enhancement projects through planning studies

3.1.1.5 U.S. Department of the Interior: National Park Service

The National Park Service (NPS) conducts management, enforcement, and research on public lands subject to its jurisdiction. The National Park Service is the steward of some of the nation's most significant natural and cultural resources. The mission of the NPS is to preserve and protect these resources, attributes, and processes within areas of its jurisdiction for future generations to be able to study, learn and enjoy. NPS directs programs to assist other federal agencies, state and local governments, and individuals in the protection of natural, cultural, and archeological resources. Some of these programs include:

3.1.1.5.1 Fort Clatsop National Memorial

- Produces and implements a Resources Management Plan, Water Resources Scoping Report/Plan, and numerous baseline inventories and mapping projects

3.1.1.5.2 Land and Water Conservation Fund:

- Creates and maintains high-quality recreation facilities through grant assistance

3.1.1.5.3 Rivers, Trails, and Conservation Programs:

- Manages instream resources within the national parks to protect the recreational and scenic resources
- Evaluates natural resources values for FERC hydroelectric license applications
- Provides planning expertise to state and local governments in order to conserve rivers and establish trails
- Develops a Master Plan and Land Protection Plan that address protection of park resource values, including significant wetlands, watershed issues, and habitat fragmentation

3.1.1.5.4 Wild and Scenic River Act Projects:

- Maintains the National Rivers Inventory as required by the Act
- Provides technical assistance for Wild and Scenic River eligibility and suitability studies

3.1.1.6 U.S. Department of the Interior: U.S Fish and Wildife Service

The responsibilities of the United States Fish and Wildife Service (USFWS) include protecting and conserving fish and wildlife and their habitats for the benefit of the species. Its major responsibilities include: migratory birds; certain marine mammals; freshwater and anadromous fish; endangered species; wetlands; the National Wildlife Refuge System; and environmental contaminants. Although the agency has no direct regulatory control concerning discharges of pollutants into waters of the United States or discharge of dredge and fill materials, the agency plays a direct advisory role in these regulatory practices. USFWS manages living resources under several statutes, two of which are described below:

3.1.1.6.1 Endangered Species Act of 1973 (ESA):

- Provides for the listing of threatened or endangered plant and animal species
- Designates critical habitat for these species to be protected
- Coordinate actions to restore threatened and endangered species to full reproductive capacity
- Enables USFWS and the National Marine Fisheries Service to protect and conserve the species and their habitats

3.1.1.6.2 The Fish and Wildlife Coordination Act of 1958:

USFWS has a number of programs and projects responsible for enhancing and protecting fish and wildlife. Many of these programs also involve coastal and marine habitat and protection. These include:

- Allows USFWS and the National Marine Fisheries Service to consider and comment on the impacts of water resource/use interests on fish and wildlife species for federal projects in navigable waters

- Guarantees consideration of impacts on fish and wildlife habitats for federal water use projects

3.1.1.6.3 Environmental Contaminants Program

- Estimates damage to natural resources that may occur as a result of oil spills and other contaminants
- Participates in cleanup of contaminants which harm freshwater and anadromous fish and migratory bird species
- Assesses the impacts of point and non-point source pollution on fish and wildlife
- Provides recommendations on best management practices (BMP's) to control nonpoint source pollution
- Repairs damage to living resources in and around Superfund sites
- Conducts research on marine debris effects on seabirds

3.1.1.6.4 Fish Protection and Management:

- Initiates tissue analysis of invertebrates and fish taken from contaminated waters
- Participates in fish management planning actions sponsored by the Northwest Power Planning Council
- Administers Fish and Wildlife Coordination Act
- Provides tax and general funds to state agencies for fish restoration and management

3.1.1.6.5 Wetlands Research:

- Administers the Service's National Wetlands Inventory Program
- Reviews and comments on Section 10/404 permits for projects affecting wetlands
- Funds the restoration and enhancement of private wetlands
- Administers the Small Wetlands Acquisition Program

3.1.1.6.6 Wildlife Protection and Wildlife Refuge System:

- Manages wildlife refuges in Oregon and Washington
- Acquires coastal land to protect significant migratory bird and endangered species habitat, and recreation and wilderness areas
- Administers the National Wildlife Refuge System Technical Assistance Program
- Works with other agencies to ensure the protection of many species of coastal migratory birds and waterfowl

3.1.1.7 U.S. Department of the Interior: U.S. Geological Survey

The mission of the USGS is to provide geologic, topographic, and hydrologic information that contributes to the wise management of the nation's natural resources and that promotes the health, safety, and well-being of the people. USGS's Water Resources Division provides the information and understanding needed to fully address the nation's water resources. Seven relevant USGS programs and studies are:

3.1.1.7.1 Federal State Cooperative Program:

- Conducts water resource investigations for the USGS and state and local agencies
- National Marine and Coastal Geology Program
- Investigates critical geologic issues affecting the nation's coastal and marine realms
- Provides objective scientific information to managers and planners working in coastal and offshore regions
- Co-directs the Southwest Washington Coastal Erosion Study with the Department of Ecology's Shorelands and Water Resources Program

3.1.1.7.2 National Water Quality Assessment Program:

- Provides a nationally consistent description of current water quality conditions of the nation's water resources
- Characterizes trends (or lack of trends) in the quality of the nation's groundwater and surface water
- Studies the natural and human factors that affect water quality

3.1.1.7.3 National Stream Quality Accounting Network:

- Characterizes the concentration and flux of sediment and chemicals in the nation's largest river basins
- Determines regional source areas for chemicals in transport
- Assesses the effect of human influences on observed concentrations and flux

3.1.1.7.4 Toxic Substances Hydrology Program:

- Provides unbiased earth science information on the behavior of toxic substances in water systems
- Conducts intensive field and regional investigations

.3.1.1.7.4.1.1 Water Information Coordination Program:

- Ensures the availability of water information required for effective decision making in natural resource management and environmental protection
- Strives for continual coordination of water information programs
- Publishes approximately 3,000 new or updated reports and maps yearly

.3.1.1.7.4.1.2 Water Quality Studies:

- Evaluates instream flow for areas that can support fish spawning
- Conducts urban hydrology studies to predict changes in runoff
- Studies the effects of impoundments on water quality

3.1.1.7.5 U.S. Department of the Interior: U.S. Geological Survey Biological Resources Division

The National Biological Service (NBS) was created in 1993 by consolidating the biological science programs of seven federal agencies into one entity. It served as the biological research division of the Department of Interior until October 1996, when it became the Biological Resources Division (BRD) of the US Geological Survey. The mission of the division is to work with other agencies to provide the scientific understanding and technologies needed to manage the nation's biological resources. The BRD has two main programs:

.3.1.1.7.5.1 Information and Technological Services:

- Provides access to, and shares, biological resources data and information
- Establishes a National Biological Information Infrastructure that will consist of a network of databases and information sources on biological resources
- Contains two components: Information Management; Information and Technology Transfer

.3.1.1.7.5.2 Inventory and Monitoring:

- Inventories and monitors the nation's biological resources to determine their health and status, and reports the findings to the public
- Publishes a biennial Status and Trends Report to identify existing resources
- Contains three components: Ecosystem Inventory and Assessment; Population Inventory and Monitoring; Inventory Standards and Protocol Development

3.1.1.8 U.S. Department of Transportation: Federal Highway Administration

The Federal Highway Administration is responsible for working with other federal agencies to design and build principal roads in national forests, parks, and Indian reservations. While conducting business in an efficient manner, the agency also strives to have the least impact possible on the natural environment. One of the agency's activities that affects the Columbia mainstem and estuary is:

3.1.1.8.1 Highway Planning and Construction

- Assists state highway agencies in the development of an interconnected transportation system
- Administers provisions for areawide planning, which include wetland activities and highway runoff water quality measures
- Provides funds to mitigate damage to ecosystems

3.1.1.9 U.S. Department of Transportation: U.S. Coast Guard

The United States Coast Guard is one of the five armed forces branches of the federal government. It operates under the Department of Transportation during peacetime. The Coast Guard enforces applicable federal laws and international treaties upon the high seas and under state jurisdiction concerning water safety, water pollution, and spills. The agency also acts as a port safety regulatory agency. The Coast Guard has a role in two areas of importance to the mainstem and estuary study area:

3.1.1.9.1 Marine Waste Management:

- Enforces the provisions of the Marine Pollution Research and Control Act (MARPOL) establishing regulations for vessel waste disposal
- Establishes regulations regarding performance standards for marine sanitation devices, in cooperation with EPA
- • Issues certificates to terminals and ports to properly dispose of solid waste from ships
- Oil Spill Prevention and Response:
- Develops management plans for oil and hazardous spills
- Is involved in prevention activities, research for advancing response techniques, and technical assistance to oil and hazardous substance responses

3.1.1.10 U.S. Environmental Protection Agency

The Environmental Protection Agency (EPA), established on December 2, 1970, protects the nation's rivers, streams, and lakes from pollution by administering federal environmental protection laws. The majority of these laws and programs contribute to water quality protection in the maistem Lower Columbia River and estuary. These include:

3.1.1.10.1 Clean Water Act of 1972 (CWA) as amended:

- Establishes criteria for water quality
- Defines categories of pollutants
- Creates a national permit system
- Controls point source pollution by regulating industrial and municipal wastewater discharges
- Controls some non-point source pollution by regulating confined animal feeding operation discharges and urban stormwater runoff
- Regulates the discharge of dredge and fill material for wetland protection purposes
- Establishes the National Estuary Program

3.1.1.10.2 Clean Air Act of 1970 and 1972 (CAA):

- Establishes maximum acceptable levels of outdoor air pollutants
- Develops standards for new stationary and motor vehicle emissions
- Limits the release of hazardous substances

3.1.1.10.3 Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA):

- Requires EPA to respond immediately to chemical spills and/or releases of any toxic substances which pose potential human or environmental health risks

3.1.1.10.4 Emergency Planning and Community Right-To-Know Act of 1986 (EPCRA):

- Requires states to establish Local Emergency Planning Communities and State Emergency Response Commissions which collect data on hazardous chemicals and prepare procedures for emergency action plans

- Section 313 requires owners of manufacturing plants to report their releases of toxicchemicals in order to establish the Toxic Release Inventory

3.1.1.10.5 Environmental Monitoring and Assessment Program (EMAP):

- Evaluates the effectiveness of national pollution control efforts through interagency monitoring activities
- Federal Insecticide, Fungicide, and Rodenticide Act of 1982 (FIFRA):
- Regulates the licensing of pesticide programs and the disposal of banned pesticides
- Administers pesticide testing to determine adverse effects on humans, wildlife, fish, and plants
- Registers pesticides and often restricts certain uses
- Develops integrated pest management programs
- Regulates pesticidal contamination of drinking water

3.1.1.10.6 National Environmental Policy Act of 1969 (NEPA):

- Requires an Environmental Impact Statement (EIS) to be completed for any proposed legislation and/or activity that could alter the quality of the human environment
- Mandates that alternatives to minimize potential impacts be considered, and possibly adopted

3.1.1.10.7 Pollution Prevention Act of 1990 (PPA):

- Proposes voluntary compliance in toxics reduction
- Recommends increased efficiencies in the use of energy, water, raw materials, and other resources through conservation efforts

3.1.1.10.8 Resource Conservation and Recovery Act of 1976 (RCRA):

- Requires the EPA to regulate the treatment, storage, disposal, and transportation of hazardous and solid waste in the U.S.

3.1.1.10.9 Toxic Substances Control Act of 1976 (TSCA):

- Authorizes EPA to regulate chemical substances that present a serious human health risk or potential harm to the natural environment
- Requires EPA to investigate chemical substances that pose imminent hazards

3.1.1.10.10 Marine Protection, Research and Sanctuaries Act (MPRSA):

- Regulates the dumping of industrial waste or sewage sludge into the ocean

3.1.1.10.11 National Environmental Education Act of 1990 (NEEA):

- Develops environmental education and training materials in order to increase public knowledge of the natural environment

3.1.1.10.12 Protection of Wetlands-Executive Order 11990:

- Regulates new construction in wetlands by requiring actions to be taken that will preserve the natural values and minimize destruction and modification of these delicate areas

3.1.1.10.13 Water Management Programs:

Administer programs in the areas of:

- Coastal and Ocean Protection
- Ecosystem Protection
- Effluent Trading
- Fish Consumption Advisories
- National Estuary Program
- Nonpoint Source Pollution Control
- Point Source Control
- Water Quality Standards, Criteria, and Methods
- Wetlands/Aquatic Resources Protection
- Watershed Approach

3.1.2 *State of Oregon Government Agencies*

3.1.2.1 Oregon Department of Agriculture

The Oregon Department of Agriculture provides service, leadership, and regulatory functions for the agricultural industry. It regulates commercial shellfish areas, administers the pesticide control program, and assists with implementing programs that address agriculturally related non-point source pollution impacts on water quality. The Department is divided into eight major program divisions. One division that is of particular importance to the mainstem Lower Columbia River and estuary is the Natural Resources Division. This division develops agricultural water quality management plans, and provides support to 45 Soil and Water Conservation Districts throughout the state. The other significant division is the Food Safety Division, which is responsible for shellfish safety.

3.1.2.1.1 Conservation Projects:

- Coordinates programs for the conservation districts
- Provides administrative grant assistance to districts
- Reviews all projects, practices, budgets, contracts, or regulations of districts

3.1.2.1.2 Ocean Resources:

- Administers the commercial oyster plat leasing program
- Administers the state's shellfish sanitation program

3.1.2.1.3 Water Planning Coordination:

- Coordinates basin program development with local Soil and Water Conservation Districts

3.1.2.1.4 Water Quality:

- Provides assistance to farmers through Soil and Water Conservation Districts on ways to protect water quality
- Works with Oregon's Department of Environmental Quality on agriculturally related non-point source pollution programs
- Administers Senate Bill 1010 in assisting producers in addressing those agricultural activities in watersheds known to have the most problems with water quality, to prevent pollution problems where possible, and to manage existing problems

3.1.2.1.5 Watershed and Riparian Management:

- Provides technical assistance to the Governor's Watershed Enhancement Board
- Provides funding for landowner workshops on watershed issues

3.1.2.2 Oregon Department of Environmental Quality

The mission of Oregon's Department of Environmental Quality (DEQ) is to be an active force torestore, enhance, and maintain the quality of Oregon's air, water, and land. DEQ is a regulatory agency that strives to protect the state's environment. Specific to water quality, the agencypreserves and restores Oregon's waters to ensure that they are drinkable, swimmable, and fishable. It also regulates discharge permits and investigates stormwater runoff pollution in order to maintain clean water. Many of the agency's programs are relevant to the management of the Lower Columbia River Estuary:

3.1.2.2.1 Coastal Non-point Control Program:

- Exercises joint responsibility with Oregon Department of Land Conservation and Development to implement coastal non-point program
- Develops and implements non-point source pollution programs needed for comprehensive program approval: Construction Site Erosion Control Program, Sewage Disposal Systems Inspection and Education Program, and Road and Bridge Construction and Maintenance Program

3.1.2.2.2 Dams, Reservoirs, and Hydroelectric Power Activities:

- Analyzes requests for 401 certificates associated with FERC applications
- Issues certificates when appropriate
- Reviews proposals for dredge and fill activities and hydroelectric water storage to assure water quality standards are met

3.1.2.2.3 Ocean Resources:

- Participates in the development of an ocean policy and maintenance of the Territorial Sea Management Plan

3.1.2.2.4 Permit Responsibilities:

- Issues National Pollution Discharge Elimination System (NPDES) and Waste Pollution Control Facility permits

- Inspects permitted facilities to affirm compliance and enforces actions needed against non-compliant facilities

3.1.2.2.5 Wastewater Activities:

- Develops pretreatment requirements to be met by municipal sewerage facilities
- Insures the safe disposal of wastewater treatment plant sludge
- Regulates the siting, installation, and operation of on-site sewage disposal systems
- Certifies the qualifications of operators of wastewater treatment plants

3.1.2.2.6 Water Planning Coordination:

- Ensures rules and actions are consistent with local comprehensive land use plans
- Coordinates program development activities with other state natural resource management agencies

3.1.2.2.7 Water Quality:

- Monitors and analyzes the quality of the state's surface and groundwater
- Reviews and establishes water quality standards for the state
- Establishes total daily maximum loads for streams that are not in compliance with water quality standards
- Develops individual control strategies for non-complaint water bodies
- Reviews and approves plans for pollution control facilities

3.1.2.2.8 Wetlands Management:

- Reviews 404 dredge and fill applications for wetland activities
- Determines if wetland activities will ensure water quality standards are met pursuant to Section 401 of the Clean Water Act
- Maintains an inventory of coastal wetlands in Oregon

3.1.2.3 Oregon Department of Fish And Wildlife

Oregon's Fish and Wildlife Department aims to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations. The agency attempts to accomplish this mission by conducting research on fish and wildlife issues, and making recommendations to other state and federal agencies with regulatory authority. The department is divided into several divisions. The most important to LCREP are the Fish Division, Habitat Conservation Division, Wildlife Division, and the Information and Education Section. The following activities are of interest to the mainstem lower Columbia River and estuary:

3.1.2.3.1 Dams, Reservoirs, and Hydroelectric Power Activities:

- Evaluates Water Resources Department and Division of State Lands permit applications and recommends conditions for fish passage, fish screening, and mitigation of adverse impacts on habitat

- Reviews hydroelectric project applications and offers recommendations regarding fish and wildlife resources

3.1.2.3.2 Fish and Wildlife Programs:

- Implements Salmon and Trout Enhancement Program
- Operates 34 fish hatcheries and 15 satellite rearing facilities
- Performs freshwater production studies
- Prepares Fish Management Subbasin Plan
- Inventories fish populations, production, and harvest and monitors factors affecting populations
- Develops habitat improvement projects with other federal agencies
- Reviews federal, state, and local governments' activities for potential impact on fish and wildlife

3.1.2.3.3 Ocean Resources:

- Manages ocean and intertidal fisheries and marine wildlife resources
- Participates in the Ocean Management Task Force
- Reviews ocean and near-shore permit applications

3.1.2.3.4 Water Quality:

- Assists DEQ with identifying and providing for fish and wildlife water quality needs
- Develops policies and procedures for investigation of and compensation for toxic spills in waterways

3.1.2.3.5 Watershed and Riparian Management:

- Reviews federal land management plans and programs
- Works with landowners to develop riparian management projects
- Recommends permit conditions for forest and riparian zone projects affecting fish resources

3.1.2.3.6 Wetlands Management:

- Reviews fill and removal permits
- Examines the implementation of the Wetland Mitigation Bank Program, the Wetland Priority Plan, and Wetland Conservation Plans

3.1.2.4 Oregon Department of Forestry

The Department of Forestry strives to serve the people of Oregon through the protection, management, and promotion of a healthy forest environment which will enhance Oregon's livability and economy for today and tomorrow. The Department has three areas of concentration that are important to the Lower Columbia River Estuary: forest practices, forest assistance, and protection from fire. Through these three programs, the agency maintains forest productivity, water quality, and fish and wildlife habitat.

3.1.2.4.1 Dams, Reservoirs, and Hydroelectric Power:

- Examines impacts of hydroelectric development on the commercial forest land base
- offers recommendations to decision makers regarding findings

3.1.2.4.2 Forest Assistance Program:

- Provides technical and financial assistance to help perpetuate Oregon's forest resources
- Promotes forest health
- Enhances and protects critical natural resource values on non-federal forest land

3.1.2.4.3 Forest Practices Program

- Administers the Oregon Forest Practices Act
- Works to assure that the continuous growing and harvesting of forest tree species and maintenance of forest land for forest purposes are the primary uses of privately owned forest lands
- Assures that forest practices are consistent with sound management of soil, air, water, fish, and wildlife resources
- Threatened and Endangered Species:
- Inventories resource sites used by threatened and endangered species in Oregon
- Determines protection requirements needed during forest operations
- Administers watershed-specific practices for threatened and endangered species on forest lands
- Inventories resource sites on forest lands in the state that affect bird species using sensitive nesting, roosting, and watering sites
- Determines protection requirements needed during forest operations for such birds

3.1.2.4.4 Water Quality:

- Regulates forest timber management practices according to Forest Practices Rules in order to protect water quality
- Administers watershed-specific practices on forest lands for water quality limited watersheds
- Protects water quality during mixing and application of chemicals on forest lands

3.1.2.4.5 Watershed and Riparian Management:

- Manages state forest lands
- Reviews and comments on federal land management plans and programs
- Provides advice to landowners regarding management of forest resources
- offers assistance to the Governor's Watershed Enhancement Board
- Establishes riparian management areas along streams, lakes, and wetlands on forest lands

3.1.2.4.6 Wetlands Management:

- Inventories significant wetlands in the state's forest lands

- Determines what wetland protection is needed during forest operations

3.1.2.5 Oregon Department of Human Resources: Oregon Health Division

The Oregon Health Division is a program within the Oregon Department of Human Resources. The Health Division's mission is to preserve, protect, and promote the health of all Oregonians.Specific to water quality and fish contamination, the Division is responsible for the protection of drinking water supplies and investigation of public health hazards.

3.1.2.5.1 Water Quality:

- Responds to public health complaints related to water contamination
- Watershed and Riparian Management:
- Identifies watersheds used for drinking water supplies for interagency protection
- Provides training to water purveyors on watershed management issues

3.1.2.5.2 Water Planning Coordination:

- Coordinates development of plans for water systems and wellhead protection
- Issues health warnings regarding fish and seafood consumption

3.1.2.6 Oregon Department of Land Conservation And Development

The main purpose of the Department of Land Conservation and Development (DLCD) is to improve Oregon's quality of life through sound land use planning. In keeping with its mission, DLCD is responsible for monitoring and implementing the State of Oregon's Land Use Planning Program. The primary implementers of Oregon's land use program are local governments – cities and counties. All the cities and counties in the state have adopted comprehensive plans to comply with Oregon's 19 Statewide Planning Goals. The Land Conservation and Development Commission (LCDC) is responsible for developing the Statewide Planning Goals and for promulgating rules and guidelines for their implementation. The Department monitors the adoption, implementation, and amendment of local plans to ensure their continued compliance with the Statewide Planning Goals. The Department also administers the Oregon Coastal Management Program, a federally funded program for the use and conservation of valuable coastal resources. The agency's responsibilities include:

3.1.2.6.1 Land Use Planning

- Adopts administrative rules and implementation guidelines for Statewide Planning Goals
- Coordinates state and federal programs that affect land use
- Monitors local plan implementation and amendments to assure their continued compliance with the Statewide Planning Goals
- Provides technical assistance to local governments on comprehensive planning issues
- Administers grants to cities and counties for comprehensive planning assistance
- Certifies the programs of state agencies for coordination on resource issues and matters affecting land use planning, including water resources planning and development

3.1.2.6.2 Ocean and Coastal Resources:

- Administers a federal grant under section 306 of the Coastal Zone Management Act for coastal resource management
- Reviews federal activities affecting the coastal zone to assure their consistency with the policies of the Oregon Coastal Management Program
- Manages the Oregon Ocean Policy Advisory Council

3.1.2.6.3 Water Quality and Aquatic Habitat:

- Reviews and comments on state and federal permits for coastal projects
- Implements the Coastal Nonpoint Source Pollution Control Program under section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990
- Provides comments where appropriate on state and federal agency permit applications for in-water activities and alterations

3.1.2.7 Oregon Department of Transportation

The mission of the Oregon Department of Transportation (ODOT) is to provide an efficient, safe transportation system that enhances Oregon's competitiveness and livability. ODOT is committed to the protection and preservation of Oregon's unique environment, and employs a group of scientists, engineers, historians, archaeologists, and environmental project managers to study and mitigate the effects of transportation projects on a wide variety of natural and cultural resources. The Environmental Services Section is responsible for coordinating environmental regulatory compliance for all transportation improvement programs in the state which use federal funds. The Environmental Resources Section is broken down into a Wetlands and Water Quality Team, Biological Resources Team, and Cultural Resources Team.

3.1.2.7.1 Biology Team Activities:

- Conducts programmatic biological assessments within watersheds
- Conducts biological evaluations for impacts on sensitive species for projects on BLM or Forest Service lands
- Ensures that department activities do not negatively impact state-listed plant species
- Conducts necessary environmental impact statements for department activities which address fish and wildlife concerns
- Administers corridor studies to identify biological resources in development areas (done by Planning Section)

3.1.2.7.2 Water Quality Activities:

- Extends the requirements of NPDES stormwater permits to every project administered by ODOT
- Develops erosion and sediment control programs for construction sites
- Wetland Mitigation and Monitoring Program:
- Ensures that proposed wetland permits analyze water impacts and conceptual mitigation activities
- Provides studies on possible impacts of transportation projects on endangered and threatened species in wetland environments
- Monitors wetland mitigation sites for 5 years, often longer if deemed necessary

3.1.2.8 Oregon Division of State Lands

The Division of State Lands (DSL) acts for the state as owners and stewards of the submerged and submersible lands of all publicly owned navigable streams and lakes in Oregon. DSL has permit authority for fill and removal of 50 cubic yards or more of material in all waterways and wetlands, and coordinates the state resource agency's review of the Army Corps of Engineers permit applications for any alteration or construction activities in navigable waters. The agency also administers programs in the following areas:

3.1.2.8.1 Ocean Resources:

- Manages geological and geophysical exploration survey permitting program

- Develops and manages the hard minerals exploration program for management of submerged and submersible lands of the state territorial sea
- Participates with Ocean Resources Management Task Force in developing Ocean Resources Management Plan

3.1.2.8.2 Water Planning Coordination:

- Provides technical assistance to local units of government on development proposals affecting "waters of the state" (e.g. wetland inventories, wetland conservation plans, waterway development management plans)

3.1.2.8.3 Watershed and Riparian Management:

- Manages state-owned range and forest lands and navigable waters (e.g. leases, easements, etc.)

3.1.2.8.4 Wetlands Management:

- Prohibits fill and removal activities in significant wetlands, major marshes, or other waters of the state designated for protection under state land use goals 5, 15, 16, 17
- Permits and administers the removal of material from the beds and banks or filling of the waters of the state under ORS 196.800 to 196.990
- Administers the Wetlands Mitigation Bank
- Prepares a Wetland Priority Plan for acquisition in consultation with other state and federal agencies

3.1.2.9 Oregon Governor's Watershed Enhancement Board

The Governor's Watershed Enhancement Board was created by the 1987 Legislature for the purpose of providing assistance to land owners and managers to undertake activities which would enhance the ability of their watershed to function and produce greater water quality and quantity. The Board comprise representatives from five of the state natural resource boards and commissions (Oregon Fish and Wildlife Commission, Board of Forestry, Oregon Soil and Water Conservation Commission, Water Resources Commission and the Environmental Quality Commission). The board is chaired by the Governor's Natural Resource Advisor and has non-voting members from the U.S. Forest Service, Bureau of Land Management, Oregon Department of Agriculture, Oregon State University Extension Service, and Natural Resources Conservation Service. The Board's two standing advisory committees, the Technical and Education Advisory Committees, comprise state and federal resource agency representatives.

- GWEB provides grant funds for watershed restoration, education, watershed council coordinators, and conducting watershed assessments/action plans and monitoring. GWEB provides funding statewide through a grant application, review and award process.

- In 1995, through the passage of House Bill 3441, GWEB received the additional responsibility of supporting watershed councils. Watershed councils are local, volunteer, broad-based citizen groups recognized at the local government level for the purpose of identifying and coordinating local watershed protection and enhancement. There are nearly 50 locally recognized watershed councils across the state. GWEB is also integrally involved in Oregon's Coastal Salmon Restoration Initiative and the Healthy Streams Partnership. The program supports, through grants, local efforts to restore fish and wildlife habitat and improve water quality.

3.1.2.10 Oregon Marine Board

The Marine Board is Oregon's recreational boating agency. The agency registers and titles motorboats, sailboats over 12 feet in length, floating boats, boat houses, and houseboats. Ocean charterboats are licensed by the Board, and guides and outfitters operating in the state must be registered with the Board. The Board sets equipment and operating requirements for recreational watercraft and enforces boating laws on boundary waters. The Marine Board is administered by a five-member citizen board appointed by the governor. The following are some other areas of interest to the mainstem Lower Columbia River and estuary study area:

3.1.2.10.1 Water Planning Coordination:

- Develops and implements Oregon Boating Facilities Plan
- Provides statewide funding for the coordination of boating law enforcement
- Provides funds to local and state agencies, including port and park districts, to allow boating access and support for facilities
- Administers federal Clean Vessel Act funds

3.1.2.10.2 Water Quality:

- Funds pumping stations for recreational boat holding tanks that control water pollution
- Adopts rules regarding marine toilets, restricting motor use on boating waters of the state, and regarding equipment on boats
- Reviews plans and designs of funded facilities for potential water quality impacts
- Issues permits for polystyrene foam flotations

3.1.2.11 Oregon office of Energy

The purpose of the Oregon office of Energy is to ensure that Oregon's energy future is built on a least-cost mix of conservation, renewable, and conventional energy resources and to clean up nuclear waste. The Energy Resource Division serves as staff to the Energy Facility Siting Council (EFSC), reviewing applications for large energy facilities. The office carries out radioactive waste cleanup and radioactive materials transport responsibilities of the Siting Council as well. Oversight of the Hanford (Washington State) cleanup effort is the responsibility of the Nuclear Safety Division. In order to achieve the State's energy goals, the office of Energy creates energy plans and policies to guide state agency programs. In the area of water management, this agency conducts activities in the following areas:

3.1.2.11.1 Energy Facilities:

- Is responsible for power plants (excluding hydroelectric) greater than 25 MW, large transmission lines and natural gas pipelines, and large natural gas storage and fuel production facilities
- Decides all conditions related to a proposed energy facility, including fish and wildlife habitat issues
- Reviews application documents and makes recommendations to EFSC
- Responsible for ongoing oversight of approved facilities

3.1.2.11.2 Ocean Resources:

- Governs off-shore energy facilities, but extent is not clear

3.1.2.12 Oregon Parks and Recreation Department

The Parks and Recreation Department strives to provide and protect outstanding natural, scenic, cultural, historic, and recreational sites for the enjoyment and education of present and future generations. The agency is responsible for purchasing, developing, and managing state parks. It also provides areas for recreation, as well as research and preservation of historic sites and unique natural areas.

3.1.2.12.1 Dams, Reservoirs and Hydroelectric Power:

- Evaluates recreation benefits and other impacts resulting from proposed publicprojects
- Reviews storage and hydroelectric project applications to assure that recreational, historical, archaeological, and visual quality standards are addressed
- Assures that projects are compatible with the State Scenic Waterway and Willamette River Greenway programs

3.1.2.12.2 Ocean Shores Program:

- Conducts improvements west of the vegetation line
- Regulates pipelines, cables, conduits, and removal of natural products
- Protects access to public beaches
- Regulates vehicular traffic on beach

3.1.2.12.3 Scenic Waterways Program:

- Encourages new development that blends in with the natural landscape
- Classifies each designated waterway into six categories which govern the amount and type of development allowed
- Sets performance and design standards

3.1.2.12.4 Water Planning Coordination:

- Administers state Scenic Waterway System
- Reviews all federal actions for compliance with National Historic Preservation Act

3.1.2.12.5 Administers Willamette River Greenway program

- Develops State Park Master Plans

3.1.2.12.6 Watershed and Riparian Management:

- Reviews local and state planning actions affecting the Willamette River Greenway, scenic waterways, ocean shores, recreational trails, and state-owned parks
- Produces statewide comprehensive outdoor plans
- Awards federal and state grants-in-aid

3.1.2.12.7 Wetlands Management:

- Incorporates wetlands priority plan as part of the State Comprehensive Outdoor Recreation Plan (SCORP)

3.1.2.12.8 Willamette River Greenway Program:

- Coordinates the Greenway Plan, which describes the greenway boundaries, scenic easements, and known subsurface mineral and aggregate deposits
- Acquires land along the Willamette River for recreation, scenic, and fish and wildlife purposes

3.1.2.13 Oregon Water Resources Department

The mission of the Water Resources Division is to serve the public by practicing and promoting wise long-term water management. Its primary work that is of interest to the LCREP involves protecting and restoring streamflows and watersheds, safety of dam construction activities, and appropriation of water rights.

3.1.2.13.1 Dams, Reservoirs, and Hydroelectric Power:

- Evaluates and issues permits for construction of reservoirs, storage of water, and use of stored water
- Monitors safety of existing dams
- Analyzes water permit and license applications for hydroelectric project development
- Prepares recommendations for Water Resources Commission
- Designates beneficial uses of water
- Coordinates state input on the operation of federal multiple-purpose reservoirs

3.1.2.13.2 Water Planning Coordination:

- Adopts and maintains the Oregon Water Management Program, including statewide water policies and basin programs
- Assists local governments in local water planning activities
- Issues and regulates water rights

3.1.2.13.3 Water Quality:

- Enforces instream water rights necessary for pollution abatement to sustain fish life and support recreation

- Maintains well construction and abandonment rules
- Adopts and enforces rules for monitoring wells and other artificial openings

3.1.2.13.4 Watershed and Riparian Management:

- Identifies potential watershed and riparian zone enhancement projects
- Administers and provides assistance to the Governor's Watershed Enhancement Board
- Provides loan funds for watershed improvement projects
- Reviews federal land management plans and programs for watershed and riparian area management practices

3.1.2.13.5 Wetland Management:

- Clarifies water use permitting requirements for constructed or enhanced wetlands and "disturbed sites"

3.1.3 *State of Washington Government Agencies*

3.1.3.1 Washington Conservation Commission

The mission of the Washington State Conservation Commission is to protect, conserve, and enhance the natural resources of this state through the practice of conservation and stewardship. The Commission provides leadership to, and represents, 48 of Washington's locally governed conservation districts. The Commission encourages the cooperation and collaboration of the federal, state, regional, interstate, and local public agencies which assist the conservation districts. The Commission is made up of three individuals elected by conservation district supervisors, the president of WACD, two individuals appointed by the Governor, and representatives of four state agencies.

3.1.3.1.1 Conservation Projects:

- Administers grants to conservation districts for conservation projects
- Formalizes and administers memos of understanding with other state and federal natural resource agencies to synchronize their missions, goals, and objectives

3.1.3.1.2 Habitat Conservation Measures:

- Works through the Conservation District Network to coordinate model salmon habitat improvement projects
- Acts as lead state agency in coordinating salmon recovery efforts with Idaho, Oregon, and Montana
- Leads a committee in establishing standards for improving fish and wildlife habitat on agricultural and grazing land managed by state agencies

3.1.3.1.3 Water Management:

- Administers direct technical assistance to dairy operators to reduce non-point source pollution caused by manure

3.1.3.2 Washington Department of Agriculture

This state department is responsible for assisting agricultural producers in Washington to ensure that the marketing, grading, and standardizing of commodities are carried out in a fair andefficient manner without unnecessary restraints. The Department is divided into eight divisions. The two divisions that are relevant to the mainstem lower Clumbia River and estuary study area are:

3.1.3.2.1 Food Safety and Animal Health Division:

- Licenses and inspects dairy farms and food processing plants
- Certifies organic food production
- Administers animal health programs
- Pesticide Management Division:
- Registers products for sale
- Licenses applicators to use pesticides
- Addresses groundwater protection and farm worker safety

3.1.3.3 Washington Department of Community, Trade, And Economic Development

The Washington Department of Community, Trade, and Economic Development (CTED) works to build and sustain strong social, environmental, and economic foundations for Washington State. Effective July 1, 1996, the energy policy functions formerly performed by the Washington State Energy office, along with the responsibilities of the Energy Facility Site Evaluation Council, were transferred to the newly created Energy Service Area of CTED. The 1995 Legislature also established the Land Use Study Commission, with the overall goal of integrating Washington's land use and environmental laws into a single, manageable statute. CTED's other program significant to the mainstem lower Clumbia River and estuary study area is the Growth Management Program, which helps communities plan for growth and development in a way that is consistent with the state's Growth Management Act (GMA).

3.1.3.3.1 Energy Service Area (houses the following two programs):

.3.1.3.3.1.1 The Washington Energy Policy Group:

- Provides the Governor, legislature, and other state and local governments with information, analysis, and expert testimony to facilitate the inclusion of public interest criteria into state, regional, and national energy policy.
- Develops, collects, and analyzes data on energy resources
- Develops and represents the state's energy interests in external policy forums

.3.1.3.3.1.2 The Energy Facility Site Evaluation Council:

- Sites major energy facilities
- Protects the environment and safety interests in regard to the energy facilities 2) Land Use Study Commission:

- Reviews the effectiveness of existing land use and environmental laws
- Identifies revisions needed in the laws to adequately plan for growth and to achieve
- economic and environmentally sustainable development

3.1.3.3.2 Growth Management Program:

- Coordinates state agency actions and policies related to managing growth
- Provides training and technical assistance to counties and cities planning under GMA
- Delivers financial assistance to counties and cities to assist in GMA responsibilities
- Coordinates the adoption of rules guiding development and adoption of comprehensive plans and development regulations
- Provides state review and comment on county and city comprehensive plans and development regulations implementing GMA
- Represents CTED in development of state water policy

3.1.3.4 Washington Department of Ecology

The mission of the Department of Ecology is to protect, preserve, and enhance Washington's environment and promote the wise management of our air, land, and water for the benefit of current and future generations. The agency is responsible for water resources, water pollution controls, and shoreline management. It also administers the State Environmental Policy Act (SEPA) and coordinates environmental permits. of the 11 agency programs, three are relevant to the mainstem lower Clumbia River and estuary study area:

3.1.3.4.1 Environmental Investigations and Lab Services:

- Collects environmental data and analyzes samples
- Provides guidance on maintaining agency data quality
- Conducts technical water quality investigations
- Administers watershed assessments where existing or emerging point source and nonpoint source pollution problems exist
- Conducts studies focusing on the occurrence and significance of toxic metals and organic chemicals in surface waters
- Performs inspections at municipal and industrial wastewater treatment plants to determine compliance
- Provides GIS support to other Ecology departments

3.1.3.4.2 Shorelands and Water Resources Program:

- Administers Coastal Zone grants
- Develops information on water availability in the state's watersheds
- Represents the state in reviewing federal programs related to ocean issues
- Reviews water rights issuance, shoreline permit and SEPA review, proposed Clean Water Act permits that affect wetlands, and shoreline enforcement
- Works to improve public access to shorelines

- Provides technical assistance to local governments on non-regulatory efforts to preserve and restore wetlands

3.1.3.4.3 Water Quality Programs:

- Manages the Coastal Zone Non-point Pollution Prevention Plan
- Coordinates the Permit management process to control the discharge of pollutants from point sources and non-point sources
- Develops and revises water quality standards to identify and protect the designated beneficial uses of the state's surface and groundwater
- Sets water quality criteria to protect the vitality of aquatic plants and animals and the health and safety of Washington's citizens
- Encourages actions that will prevent pollution from being generated
- Promotes a stewardship ethic by informing people how their actions affect water quality and what they can do to be part of the solution
- Maintains integrated information management systems containing environmental and management information
- Provides financial and technical assistance to local governments

3.1.3.5 Washington Department of Fish And Wildlife

The Department of Fish and Wildlife is responsible for the protection, preservation, and perpetuation of Washington's fish resources in waters of the state and offshore waters. The agency also preserves and protects wildlife and game fish resources of the state. The department has five divisions that are particularly relevant to the management of the Lower Columbia River: Fish Management, Habitat Management, Hatcheries, Outreach and Education, and Wildlife Management.

3.1.3.5.1 Fish Management:

- Manages all game fish, food fish, and unclassified aquatic species
- Provides information and expertise on the management of fish and shellfish populations
- Conducts activities through four divisions: - Anadromous Fish Division - Inland Fish Division - Marine Resources Division - Resource Assessment Division

3.1.3.5.2 Habitat Management:

- Preserves, restores, and enhances habitat for fish and wildlife
- Conducts activities through three divisions:
  *Conservation Services
  *Habitat Protection Services
  *Land and Restoration Services

3.1.3.5.3 Hatcheries Program:

- Produces game and food fish for stocking state waters
- Serves as a management tool to increase harvest opportunities for fishers
- Conducts activities through five divisions:
  *Operations Division
  *Assessment and Development Division
  *Columbia River Coordination Division
  *Facility Support Division
  *Fish Health Division

3.1.3.5.4 Outreach and Education Program:

- Focuses on public outreach and extension services
- Promotes volunteerism to benefit fish and wildlife

3.1.3.5.5 Wildlife Management Program

- Manages over 640 species of vertebrates and thousands of species of invertebrates
- Manages wildlife populations and their habitats, while promoting recreational opportunities
- Conducts activities through four divisions:
  *Game Division
  *Wildlife Diversity Division
  *Wildlife Resource Data Systems Division
  *Wildlife Research Division

3.1.3.6 Washington Department of Health

The mission of the Department of Health (DOH) is to empower individuals and communities to make informed health choices; to assure access to quality prevention and illness care; to protect people from environmental threats to health; and to advocate sound cost-effective health policies. This Department is Washington State's health agency with responsibility for all environmental health issues. The Department of Health has five divisions; the Environmental Health Division is the most significant to the mainstem lower Clumbia River and estuary study area. This Division helps carry out the core functions of public health: health assessment, policy development, prevention, and quality assurance to protect people from chemical, physical, and biological hazards in the environment.

3.1.3.6.1 office of Shellfish Programs

- Licenses and certifies commercial shellfish operations
- Implements Puget Sound Water Quality Authority tasks associated with shellfish

3.1.3.6.2 office of Toxic Substances

- Investigates alleged, suspected, or potential exposures to toxic substances
- Assesses health hazards and exposure pathways
- Provides health education on prevention and action strategies

3.1.3.7 Washington Department of Natural Resources

The Department of Natural Resources (DNR) manages more than 5 million acres of state-owned lands, including Natural Area Preserves, Natural Resources Conservation Areas, state trust lands, state tide and shore lands, harbor areas, and beds of navigable waters, for long-term benefits to public beneficiaries. Washington's aquatic lands are managed as a public trust for the benefit of all current and future citizens, rather than for specific designated beneficiaries. Certain aquatic rights are maintained in trust for the people of Washington, including the public rights of fishing, navigation and commerce. These rights are public ownership interests that apply to all tidelands, shorelands, navigable waters, and underlying bedlands.

The Aquatic Resources Division staff have a broad range of responsibility, including: natural resource trustee, sediment management, land use planning for urban waterfronts and environmentally sensitive areas, managing the geoduck fishery, co-managing shellfish resources with tribes, maintaining public ownership records, and leasing.

The agency also provides wildfire protection, regulates forest practices, and provides scientific information about ecologically sensitive areas and plant species. In particular, DNR provides:

3.1.3.7.1 Financial and Technical Assistance:

- Provides scientific information about geologic hazards and ecologically sensitive areas and plant species
- Provides financial grant assistance to local communities

3.1.3.7.2 Regulatory Activities:

- Protects unimproved private and state-owned lands from wildfire

- Regulates forest practices, surface mine reclamation, and oil, gas and geothermal exploration

3.1.3.8 Washington Department of Transportation

Washington's Department of Transportation (WSDOT) has a Biology Program, Geographic Information System, Hazardous Materials Program, and Water Quality Program, all of which deal in some respects with habitat, water quality, and toxic contaminants. In addition, they are involved in a number of efforts to improve land use, regulatory, and zoning laws. All of the efforts are in place to help the department avoid and/or mitigate impacts resulting from transportation projects, while allowing WSDOT to conduct its core business of constructing and maintaining transportation facilities statewide. Summaries of the programs listed above follow:

3.1.3.8.1 Biology Program:

- Surveys project area and assesses impacts on wetland, fish, and wildlife populations
- Develops mitigation plans to compensate for wetland losses
- Monitors mitigation sites for a minimum of five years
- Geographic Information Systems
- Builds and maintains GIS data for a number of relevant resources, including: sensitive groundwater layer, priority habitats and species, wetlands, water resource inventory
- areas, potential hazardous materials sites, stormwater outfalls

3.1.3.8.2 Hazardous Materials Program:

- Assesses possible sources of contamination prior to designing projects
- Determines appropriate methods for containment, cleanup of existing contamination
- Works with other programs and agencies to prevent hazardous materials contamination

3.1.3.8.3 Water Quality Program:

- Administers NPDES municipal stormwater permits for Clark County, including the Lower Columbia Water Quality Management Area
- Inventories stormwater outfalls and investigates stormwater BMP retrofits
- Develops temporary erosion and sediment control plans
- Conducts BMP effectiveness research
- Develops vegetative filter strips to reduce runoff

3.1.3.9 Washington Parks And Recreation Commission

The Washington State Parks and Recreation Commission acquires, operates, enhances, and protects a diverse system of recreational, cultural, historical, and natural sites. The Commission's purpose is to foster outdoor recreation and education statewide to provide enjoyment and enrichment for all. The Commission is charged with protecting, enhancing, and interpreting thenatural history of Washington State.

3.1.3.9.1 Dams, Reservoirs and Hydroelectric Power:

- Evaluates recreation benefits and other impacts resulting from proposed public projects

- Reviews storage and hydroelectric project applications to assure recreational, historical, archaeological, and visual quality standards are addressed through Federal
- Energy Regulatory Commission (FERC) review process
- Seashore Conservation Area (SCA)
- Acquires property to preserve the natural state of the ocean beaches
- Protects access to public beaches
- Regulates vehicular traffic on the beach

3.1.3.9.2 Water Planning Coordination:

- Administers state Scenic Rivers System

3.1.3.9.3 Watershed and Riparian Management:

- Reviews local, state and federal planning actions affecting scenic waterways, ocean beaches, recreational trails, and state-owned parks

3.1.3.9.4 Wetlands Management:

- Provides for the interpretation and preservation of wetlands on lands of the Commission
- Classifies lands for protection and preservation through designations of natural areas and natural area preserves
- Protects targeted sensitive areas threatened by commercial development through acquisition program
- Reviews all internal programs and projects for possible impacts to wetlands and adjusts projects accordingly to achieve no net loss of wetlands

3.1.4 *Regional Agencies: Associations and Councils*

3.1.4.1 Association of Clean Water Agencies

The Oregon Association of Clean Water Agencies (ACWA) is a professional organization comprising 75 agencies and associate members providing wastewater, stormwater, and water quality services to Oregon's urban areas. ACWA utilizes a watershed approach to support water quality management, and address policy and educational issues that face wastewater management. The following is a list of relevant members in the Lower Columbia River vicinity: City of Troutdale, Clackamas County, City of St. Helens, City of Astoria, City of Gresham, City of Portland, and Unified Sewerage Agency. These local governments and other ACWA members carry out the following activities:

3.1.4.1.1 Stormwater Activities:

- Collect and manage stormwater runoff
- Regulate industries to prevent the discharge of toxic substances into waterways
- Water Quality Activities:
- Educate the public about water quality
- Publish brochures for educational purposes

- Adopt and collect fees for municipal water quality services

3.1.4.1.2 Wastewater Activities:

- Provide sewerage collection and treatment
- Provide beneficial uses for reclaimed water, biosolids, and compost

3.1.4.2 Columbia Basin Fish and Wildlife Authority

The Columbia Basin Fish and Wildlife Authority is an association of the Indian tribes and agencies charged with managing fish and wildlife resources throughout the Columbia River Basin. The Authority's members include: the twelve treaty tribes in the basin, the National Marine Fisheries Service, the U.S. Fish and Wildife Service, and the state fish and wildlife management agencies of Idaho, Montana, Oregon and Washington. This agency facilitates the needs of resource agencies for joint actions through various committees, work groups and forums. The nonprofit Authority enters into contractual agreements to accomplish the following fish and wildlife goals:

3.1.4.2.1 Fish and Wildlife Activities:

- Facilitates basin-wide goals, plans, work priorities, solutions and policies regarding fish and wildlife issues
- Presents consensus member positions regarding fish and wildlife issues at relevant meetings
- Mediates disputes between member organizations, on request
- Provides expertise to award and monitor contracts on fish and wildlife investigations and mitigation measures

3.1.4.2.2 Plans Developed:

- Developed Subbasin Plans for the 31 major drainages in the Columbia Basin, under contract with the Northwest Power Planning Council
- Developed an Integrated System Plan which proposes strategies for salmon and steelhead production
- Developed many other plans for programs relevant to the Northwest Power Planning Council

3.1.4.3 Columbia River Estuary Study Taskforce

The Columbia River Estuary Study Taskforce (CREST) is a bi-state organization made up of local governments of the Columbia River Estuary. CREST is not a regulatory agency, but is a regional organization that provides a forum for members to identify and discuss issues of regional importance. The initial purpose of this organization was to gather scientific data and produce a management plan for the estuary. This was the first attempt to systematically study the Columbia River Estuary. CREST's members include: Clatsop County, City of Astoria, City of Warrenton, and Port of Astoria in Oregon, and Pacific County, Wahkiakum County, City of Ilwaco, Port of Ilwaco, and Port District No. 2 in Washington. CREST's activities include:

3.1.4.3.1 Environmental Education Activities:

- Develops environmental education programs and activities

- Administers a college-level ecotourism course
- Created a diving tour brochure of the cultural and natural resources of the Columbia River Estuary
- Produced numerous publications on the Columbia River Estuary

3.1.4.3.2 Technical Assistance for Local Governments:

- Assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plans, and Shoreline Master Program amendments
- Assists local governments with issues related to wetlands, Goal 5 inventory and review, and dredging and dredged material disposal
- Developed a GIS natural resource and planning database and hard-copy atlas
- Provides assistance with scientific and environmental projects and issues

3.1.4.4 Cowlitz-Wahkiakum Council of Governments

The Cowlitz-Wahkiakum Council of Governments is a voluntary association of local governments in Cowlitz and Wahkiakum counties, Washington; it also includes the City of Rainier, Oregon. The members consist of municipal and special-purpose governments, along with economic and social service agencies. The purpose of the Council is to provide a forum for its members to work together in a collaborative manner on a wide variety of public, environmental, and economic development issues, as well as to provide local review of state and federal grants. The agency also provides planning and technical services to the local area.

3.1.4.5 Marine Education and Research Training Station

The Marine Education and Research Training Station (MERTS) is an environmental center located in Clatsop County, Oregon. The station, which opened its doors in January 1996, is closely linked with Clatsop Community College's Maritime Sciences Department. The Coastal Studies and Technology Center at Seaside High School, the Oregon Graduate Institute of Science and Technology, and Portland State University are also involved in MERTS by providing environmental research and natural resource programs. MERTS is the logistical and telecommunications hub for research conducted by the Oregon Graduate Institute's Center for Coastal and Land-Margin Research (CCALMR). The activities conducted by CCALMR include studying sediments, materials transport, contamination, and effects of natural and human-made disturbances and tides.

3.1.4.6 Oregon Watershed Improvement Coalition

The Oregon Watershed Improvement Coalition (OWIC) was developed to improve communications among various groups interested in the management of riparian zones in the rangeland environments of Oregon. OWIC is not a public agency; it acts as a consensus-building coalition of interested parties. The goal of the group is to ensure the long-term sustainability of Oregon's watersheds. The objectives of OWIC include:

3.1.4.6.1 Agency Communication:

- Provides a mechanism for landowners, resource managers, and the public to determine achievable objectives for watershed management

- Promotes effective public policy through improved communication
- Conducts an educational program to promote a greater understanding of watershed management

3.1.4.6.2 Watershed Management:

- Promotes the idea that watersheds vary in potential and that solutions must be sitespecific to be effective
- Facilitates the development of management programs to address riparian and upland ecological processes

3.1.4.7 Water Resources Education Center

The Water Resources Education Center, located in Vancouver, WA, was built in association with the wastewater treatment facility. It serves to teach people of all ages to make wise decisions about water. The staff at the education center coordinate school visit programs to educate the students on water use and conservation. The center also offers classes for children and adults on exploring water education through art and using computers to find water-related information. Wetland walks are guided by the center staff.

3.1.5 *Regional Agencies: Quasi-Governmental Organizations and Compacts*

3.1.5.1 Lower Columbia Estuary Partnership (LCREP)

The Lower Columbia River Estuary Partnership is a two-state, public-private initiative. It is implementing a comprehensive management plan for the 146 miles of the lower Columbia River and estuary. It has a strong record of bringing diverse interests together to reach consensus in the best interests of this complex river system. Using a watershed approach, the Estuary Partnership cuts across political boundaries, integrating 28 cities, 9 counties, and the states of Oregon and Washington. LCREP managed the development of a Comprehensive Conservation Management Plan (CCMP), which identifies seven priority issues, based on the detailed technical studies of

the Bi-State Program and Estuary Program:

- Biological Integrity
- Impacts of Human Activity and Growth
- Habitat Loss and Modification
- Conventional Pollutants
- Toxic Contaminants
- Institutional Constraints
- Public Awareness and Stewardship

The Management Plan has no regulatory authority, and the Management Plan actions rely on voluntary participation. The plan continues to be supported by a broad stakeholder group now engaged in its implementation.

3.1.5.2 Pacific Fishery Management Council

This council is one of eight in the country created by Congress to make recommendations regarding fishery management. It is a cooperative effort involving federal, state and tribal agencies and the public. The Pacific Council develops management measures for the ocean area out to 200 nautical miles off the coasts of Washington, Oregon, and California. Because of limited funding, councils focus their energies on the major fisheries requiring regional management (salmon, groundfish, and Pacific halibut). The Pacific Council has 13 voting members, which include the principal fishery officials from the states of California, Idaho, Oregon and Washington, the regional director of the National Marine Fisheries Service, and eight appointed citizens. A 14th voting member representing Indian tribes will be added in August 1997.

3.1.5.2.1 Groundfish Plan:

- Provides recommendations to the National Marine Fisheries Service regarding activities that affect groundfish populations and habitat
- Administer activities based on The Pacific Coast Groundfish Fishery Management Plan
- Monitors catch rates throughout the year, recommends annual harvest limits, and analyzes impacts of alternative management measures through the Groundfish Management Team
- Addresses habitat concerns through the Habitat Committee

3.1.5.2.2 Pacific Halibut Plan:

- Allocates the U.S. Pacific halibut quota south of Canada among sport and commercial fishers and treaty Indian tribes
- Forwards recommendations to the International Pacific Halibut Commission and to the National Marine Fisheries Service

3.1.5.2.3 Salmon Plan:

- Provides recommendations to the National Marine Fisheries Service regarding activities that affect salmon populations and habitat
- Administers activities based on the Salmon Fishery Management Plan
- Provides reports which summarize the previous season, estimate abundance for the coming season, and analyze impacts of the Council's proposed and final management recommendations through the Salmon Technical Team
- Addresses habitat concerns through the Habitat Committee

3.1.5.3 Pacific States Marine Fisheries Commission

The Pacific States Marine Fisheries Commission (PSMFC) is one of three interstate commissions dedicated to resolving fishery issues in the states of California, Oregon,

Washington, Idaho, and Alaska. The goal of the program is to promote and support policies and actions directed at the conservation, development, and management of Pacific Coast fishery resources of mutual concern to member states through a coordinated regional approach to research, monitoring, and utilization. PSMFC does not have any regulatory authority, but rather provides a forum for discussion and consensus. The agency addresses issues that fall outside of state or regional management council jurisdiction.

3.1.5.3.1 Coordinated Fisheries Information:

- Provides information regarding Pacific Coast fishery resources through the following services:
- Coordinated Information System (CIS)
- Regional Mark Processing System (RMPC) - PIT Tag Information System (PTAGIS)
- Pacific Fisheries Information Network (PacFIN) - Recreational Fisheries Information Network

3.1.5.3.2 F.I.S.H. Habitat Education Project:

- Educates fishers and teachers about the importance of estuaries and bays to marine fish production
- Promotes pollution prevention activities
- For the Sake of the Salmon Program:
- Protects and restores salmon populations by identifying and protecting healthy habitat
- Seeks to improve existing efforts to restore degraded habitats

3.1.5.3.3 Marine Mammal Observer Program:

- Researched the Columbia River, Grays Harbor, and Willapa Bay salmon gillnet fisheries to determine marine mammal mortality associated with fisheries in 1991-1992

3.1.5.4 Northwest Power Planning Council

The Northwest Power Planning Council was established by Congress and the legislatures and governors of Idaho, Montana, Oregon, and Washington through the Northwest Power Act of 1980. The Council is called upon to develop a 20-year electrical power plan, produce a program to protect and rebuild fish and wildlife populations in the Columbia River Basin, and conduct an extensive public involvement program regarding power planning and fish and wildlife protection. The Council is a planning and policy-making body.

3.1.5.4.1 Columbia River Basin Fish and Wildlife Program:

- Addresses the Columbia River and its tributaries as a single system

- Addresses salmon survival at every stage of their life cycle. Activities include:
  *Improvements in spawning habitat
  *Better coordination of hatchery operations
  *Increases in flows and river velocities to speed young salmon past dams -
  *Corrections in the dams to help divert salmon from the turbines

*Refinements in the use of barges to transport salmon
*Controls on predators that feed on young salmon - Tighter restrictions on salmon harvests

3.1.5.4.2 Northwest Conservation and Electric Power Plan Activities:

- Developed 1996 Northwest Power Plan
- Implementing 1991 Northwest Power Plan
- Researching alternative resource strategies

3.1.6 *Regional Agencies*

3.1.6.1 Columbia River Gorge Commission

The Columbia River Gorge Commission was established to implement the Columbia River Gorge National Scenic Area Act. The Act directs the Commission to protect and enhance scenic, cultural, natural, and recreational resources, while protecting and supporting the economy of the Columbia River Gorge. The National Scenic Area spans 300,000 acres and includes six counties in Oregon and Washington (Multnomah, Hood River and Wasco in Oregon; Clark, Skamania, and Klickitat in Washington). The Commission has developed its own Management Plan for the Scenic Area, which defines the policies and guidelines for the Scenic Area. The Commission's activities that are relevant to the mainstem lower Columbia River and estuary are:

3.1.6.1.1 Land Use Planning:

- Implements land use ordinances in each of the six counties
- Reviews and approves proposed developments, such as single-family homes, highway construction, etc.
- Investigates and processes violations of development ordinances
- Reviews new land use ordinances for the two counties that have not yet developed their own
- Monitors decisions issued by the counties to ensure compliance with land use ordinances
- offers economic development grants to counties that adopt land use ordinances consistent with the Management Plan

3.1.6.1.2 Monitoring Program of the National Scenic Area:

- Evaluates the effectiveness of the land use policies and guidelines to achieve the objectives of protecting and enhancing the National Scenic Area resources
- Surveys actual projects to determine the cumulative impacts of development on the landscape

3.1.6.2 Columbia River Inter-Tribal Fish Commission

The Columbia River Inter-Tribal Fish Commission was formed in 1977 by resolution of the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation, and the Confederated Tribes and Bands of the Yakama Indian Nation. Under treaties with the United States in 1855, the Commission's member tribes reserved their sovereign rights to hunt and fish in areas ceded to the U.S. and at all usual and accustomed fishing stations. The tribes are recognized as co-managers of the fish resources in the Columbia River Basin.

The Commission is a technical support and coordinating agency for the fisheries management policies of its member tribes. The Commission is governed by the fish and wildlife committees of these tribes. The Commission employs biologists, other scientists, public information specialists, policy analysts, and administrators who work in fisheries harvest control and coordination, scientific support, advocacy, and planning. The Commission also operates a Columbia River fisheries enforcement program for the four tribes. Inter-tribal police officers protect treaty fishermen from harm and harassment and enforce tribal fishing regulations.

3.1.6.3 Metro

Metro was created in 1977 as an elected regional government responsible for addressing issues of metropolitan concern in Oregon. One of its purposes is to protect water quality and floodplains through land use planning activities in the urbanized portions of the three metropolitan counties: Washington, Clackamas, and Multnomah. Oregon land use laws mandate thatMetro manage the urban growth boundary, and Metro's charter mandates that it address water quality, water supply, storage, and fish and wildlife conservation. Water quality is one of the main issues addressed by Metro in its Urban Growth Management Functional Plan that addresses future growth.

Metro has also established a Water Resources Policy Advisory Committee (WRPAC) that advises the Metro Council on technical matters related to all aspects of water resource management. The Committee also advises the Council on watershed issues related to the Region 2040 project and development of the Regional Framework Plan.

Metro's activities include:

3.1.6.3.1 Fish and Wildlife Conservation:

- Establishes regional performance standards for fish and wildlife conservation to conserve, protect, and enhance fish and wildlife habitat within the identified Fish and Wildlife Habitat Conservation Areas, including:
- Prohibiting development in the Fish and Wildlife Conservation Areas that adversely impacts fish and wildlife habitat
- Limiting the clearing or removal of native vegetation from the Fish and Wildlife Conservation Area to ensure its long-term survival and health
- Requiring the revegetation of disturbed areas with native plants to 90 percent cover within three years
- Requiring compliance with ODFW seasonal restrictions for in-stream work
- Coordinates activities that protect fish and wildlife habitat

3.1.6.3.2 Floodplain Management:

- Establishes regional performance standards for floodplain management to protect against flooding and prevent or reduce risk to human life and properties, including:
- Prohibiting development within the water quality and flood management area - Limiting development in a manner that requires balanced cut and fill - Requiring minimum floor elevations to reduce flood damage - Requiring that temporary fills permitted during construction shall be removed

3.1.6.3.3 Water Quality:

- Establishes regional performance standards for water quality to protect and allow for enhancement of water quality associated with beneficial uses, including:
  * Requiring erosion and sediment control for all new development within the Metro boundary
  * Requiring that native vegetation cover be maintained or re-established during development as much as possible
  * Prohibiting new uses of uncontained areas of hazardous materials as defined by DEQ

3.1.6.4 Clean Water Services (Formerly Unified Sewerage Agency)

The mission of the Unified Sewerage Agency (USA) is to protect and conserve the waters of the Tualatin River Basin, providing cost-effective, environmentally sensitive management of wastewater and surface water. USA's geographic area includes 12 cities and the unicorportated areas within the urban growth boundary (including all of Washington and some of Multnomah and Clackamas County's urban growth area). Two of USA's programs are particularly relevant to the mainstem lower Columbia River and estuary:

3.1.6.4.1 Sanitary Program:

- Collects and treats urban wastewater
- Disposes of solids and liquids in a beneficial manner
- Administers pretreatment program for commercial industries that have industrial wastewater by regulating the amount of toxics to be dispersed into relevant waters
- Administers sewer connection permits
- offers consumer education on what materials can safely be put down the drain
- offers "consumer-based monthly service" rates to homeowners, and "strength surcharge" monthly service based on BOD rates for commercial customers; both aimed to reduce usage

3.1.6.4.2 Surface Water Management Program:

- Addresses non-point source pollution via watershed management planning
- Provides pollution prevention education with an intense, focused public involvement program
- Regulates Best Management Practices (BMP's) design standards
- Regulates on-site stormwater pollution control and erosion control facilities for new developments and administers permits for erosion control
- Administers "River Ranger Program" to educate 4th grade students on water pollution prevention
- Provides technical assistance to citizens interested in stream/wetland enhancement
- Implements regional water quality enhancement projects
- Monitors land use impacts and trends in stream health; includes ambient water quality and biological monitoring

3.1.7 *Oregon Local Government Agencies*

3.1.7.1 Oregon's Statewide Planning Goals And Guidelines

Oregon has maintained a strong land use planning program for over 25 years. The foundation of the state's planning program has been in a set of 19 goals and guidelines. These goals are achieved through city and county planning measures described in their individual local comprehensive plans. This program is a partnership between state and local governments. The state provides the standards and oversight, while the local governments administer most of the regulations.

The original enabling legislation passed into law in 1969 required local governments to develop comprehensive plans. The law outlined 10 goals to assist cities and counties in their planning efforts. This program was replaced in 1993 by a more comprehensive one. At that time, the Land Conservation and Development Commission (LCDC) was created and directed to establish new goals and guidelines for statewide planning. After extensive public input and hearings, in 1994 LCDC adopted the current goals 1 through 14. Goals 15-19 were adopted in 1975 and 1976.

3.1.7.1.1 Summary of Oregon Statewide Planning Goals 1-19:

Goal 1: Citizen Involvement

- develop a citizen involvement program that insures the opportunity for citizens to be involved in all phases of the planning process.

Goal 2: Land Use Planning

- establish a land use planning process and policy framework as a basis for all decisions and actions related to use of land and to assure an adequate factual base for such decisions and actions.

Goal 3: Agricultural Lands

- preserve and maintain agricultural lands.

Goal 4: Forest Lands

- conserve forest lands by maintaining the forest land base and to protect the state's forest economy by making possible economically efficient forest practices that assure the continuous growing and harvesting of forest tree species as the leading use on forest land consistent with sound management of soil, air, water, and fish and wildlife resources and to provide for recreational opportunities and agriculture.

Goal 5: Open Spaces, Scenic and Historic Areas, and Natural Resources

- conserve open space and protect natural and scenic resources.

Goal 6: Air, Water and Land Resources Quality

- maintain and improve the quality of the air, water, and land resources of the state.

Goal 7: Areas Subject to Natural Disasters and Hazards

- protect life and property from natural disasters and hazards.

Goal 8: Recreational Needs

- satisfy the recreational needs of the citizens of the state and visitors and, where appropriate, to provide for the siting of necessary recreational resorts.

Goal 9: Economic Development:

- provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens.

Goal 10: Housing

- provide for the housing needs of the citizens of the state.

Goal 11: Public Facilities and Services:

- plan and develop a timely, orderly, and efficient arrangement of public facilities and services to serve as a framework for urban and rural development.

Goal 12: Transportation:

- provide and encourage a safe, convenient, and economic transportation system.

Goal 13: Energy Conservation:

- conserve energy.

Goal 14: Urbanization:

- provide for an orderly and efficient transition from rural to urban land use.

Goal 15: Willamette River Greenway:

- protect, conserve, enhance, and maintain the natural, scenic, historical, agricultural, economic, and recreational qualities of lands along the Willamette River as the Willamette River Greenway.

Goal 16: Estuarine Resources:

- recognize and protect the unique environmental, economic, and social values of each estuary and associated wetlands; and to protect, maintain, where appropriate develop, and where appropriate restore, the long-term environmental, economic, and social values, diversity, and benefits of Oregon's estuaries.

Goal 17: Coastal Shorelands:

- conserve, protect, where appropriate develop and where appropriate restore, the resources and benefits of all coastal shorelands, recognizing their value for protection and maintenance of water quality, fish and wildlife habitat, water-dependent uses, economic resources, and recreation and aesthetics. The management of these shoreland area shall be compatible with the characteristics of the adjacent coastal waters; and to reduce the hazard to human life and property, and the adverse effects upon water quality and fish and wildlife habitat, resulting from the use and enjoyment of Oregon's coastal shorelands.

Goal 18: Beaches and Dunes

- conserve, protect, where appropriate develop, and where appropriate restore, the resources and benefits of coastal beach and dune areas; and to reduce the hazard to human life and property from natural or man-induced actions associated with these areas.

Goal 19: Ocean Resources

- conserve the long-term values, benefits, and natural resources of the nearshore ocean and the continental shelf. All local, state, and federal plans, policies, projects, and activities which affect the territorial sea shall be developed, managed, and conducted to maintain, and where appropriate enhance and restore, the long-term benefits derived from the nearshore oceanic resources of Oregon. Since renewable ocean resources and uses, such as food production, water quality, navigation, recreation, and aesthetic enjoyment, will provide greater long-term benefits than will nonrenewable resources, such plans and activities shall give clear priority to the proper management and protection of renewable resources.

For the purposes of this inventory, and because of their relevance to the management of the Lower Columbia River, goals 2, 5, 6, 16, 17, 18, and 19 will be discussed in the program summaries for the Oregon city and county governments included in this document.

3.1.7.2 Clackamas County

3.1.7.2.1 Regulatory Activities:

- Surface water management - managing stormwater runoff to improve water quality and minimize flooding
- Issue 1200C Erosion Control Permits
- Wastewater treatment program/facilities

3.1.7.2.2 Non-Regulatory Activities:

- Wetland inventory: evaluate and decide management actions for north urban area of county
- River and Stream Quarter Conservation Area - locate streams and provide protective measures based on size of stream for future development (e.g. setbacks, etc.)
- Sensitive-bird habitat protection activities (e.g. zoning, etc.)
- Best Management Practices (BMP's) to prevent pollution
- Non-point source pollution prevention programs
- Masterplans for surface water and wastewater management
- RiverRangers educational presentations to 3rd and 4th graders
- Technical assistance to communities regarding water quality and flooding issues

3.1.7.2.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning: -

- Zoning and development ordinances

Goal 5: Natural Resources: -

- Identifies wetlands
- Principle River Conservation Area provisions - Historical zoning district overlay - Open space management district - Willamette River Greenway district

Goal 6: Air, Water and Land Resources: -

- Flood management district

3.1.7.3 Clatsop County

3.1.7.3.1 Regulatory Activities:

- Wastewater treatment program/facility
- Solid waste management is handled by the cities
- Stream maintenance and restoration

3.1.7.3.2 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Designation of development area categories

Goal 6: Air, Water and Land Resources:

- Encourage concentration of urban development in the urban growth boundary (UGB)
- Provide an efficient transportation system
- Encourage improvement of pollution control facilities
- Participate in the regional Columbia River planning process
- New subdivisions must have an on-site stormwater management plan

Goal 16: Estuarine Resources: - Maintain a buffer strip of riparian vegetation to preserve water quality

- Dredging and dredged material disposal shall have minimum impacts on the estuary
- Endangered and threatened habitat shall be protected
- Riparian corridor/buffer provisions
- Wetlands protection
- Coastal shorelands protection

3.1.7.4 Columbia County

3.1.7.4.1 Regulatory Activities:

- Stormwater controls program/drains for open ditches
- Most activities for the county are contracted out
- Household hazardous waste program
- Solid waste management
- Mitigation factors for new development

3.1.7.4.2 Non-Regulatory Activities:

- Wetlands inventory

3.1.7.4.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Community development code
- Zoning ordinance
- Sensitive-bird habitat overlay

Goal 5: Natural Resources:

- Identifies water areas and wetlands
- Protects fish and wildlife habitat
- Protects defined Natural Area overlay

Goal 6: Air, Water and Land Resources:

- Monitors non-point source pollution during applicable seasons
- Oil spill prevention
- Identifies industrial waste sources and septic tanks
- Erosion control ordinances
- Adopted well-spacing standards to reduce well-to-well interference

3.1.7.5 Hood River County

3.1.7.5.1 Regulatory Activities:

- Maintains a closed landfill site
- removes and treats materials leaching from the site to protect water quality
- Toxic cleanup activities for landfill

3.1.7.5.2 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning

Goal 5: Natural Resources:

- Identifies conflicting uses in natural area zone
- Historic preservation
- Natural scenic area to regulate development and maintain open space

Goal 6: Air, Water and Land Resources:

- Addresses wetlands, streams, ponds and all other bodies of water
- Identifies wildlife and rare plants
- Provides recreational resources

3.1.7.5.3 National Scenic Area Plan:

- Applies land use guidelines developed by the Columbia River Gorge Commission based on the Management Plan for the Columbia River Gorge National Scenic Area of 1992

3.1.7.6 Multnomah County

3.1.7.6.1 Regulatory Activities:

- Mitigation factors for new development: in the West Hills regarding wildlife habitat,
- streams, significant views, and wetlands
- Wastewater treatment is handled by the City of Portland
- Stormwater controls are handled by Unified Sewerage Agency (USA) in most areas

3.1.7.6.2 Non-Regulatory Activities:

Health Department provides:

- Mosquito-control program using IPM
- Human health assessments of conventional and toxic pollutants in the county
- Consultation for the Columbia Slough area

3.1.7.6.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning and development ordinances
- Zoning ordinance for Multnomah Channel

Goal 5: Natural Resources:

- Significant environmental concern overlay
- Protected aggregate overlay zone
- Historical zoning district overlay
- Willamette River Greenway overlay

Goal 6: Air, Water and Land Resources

- Noise and air pollution reduction
- Grating and erosion control ordinance

3.1.7.6.4 National Scenic Area Plan:

- Adopts land use ordinances based on the Management Plan for the Columbia River Gorge National Scenic Area of 1992

3.1.7.7 Washington County

3.1.7.7.1 Regulatory Activities:

- Wastewater and stormwater are handled by Unified Sewerage Agency (USA) for the urban growth area

- County is responsible for wastewater and stormwater controls in the rural areas caused by development activities
- Mitigation and habitat protection factors for new developments within significant natural resource areas

3.1.7.7.2 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Community development code
- Zoning

Goal 5: Natural Resources:

- Identifies water areas and wetlands
- Identifies wildlife habitat
- Identifies Natural Area for highest level of protection
- Provides floodplain protection

Goal 6: Air, Water and Land Resources:

- Reduced lot sizes
- Noise buffers on certain roads
- Establishes setback requirements for development
- Adopted well-spacing standards to reduce well-to-well interference

3.1.7.8 City of Astoria

3.1.7.8.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Combined sewer overflow studies--To reduce and possibly eliminate combined sewer overflows (CSOs) by designing system improvements
- Household hazardous waste program
- Erosion control activities
- Stormwater control program/drains
- Solid waste management and recycling program
- Mitigation factors for new development
- Toxic clean-up activities
- Habitat protection measures
- Groundwater protection program
- Conventional pollutant monitoring for industry

3.1.7.8.2 Non-Regulatory Activities:

- Watershed planning

- Technical assistance to communities regarding water quality
- River and stream inventory and protection
- No-interest loans for community restoration/improvement
- Household hazardous waste program

3.1.7.8.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning and subdivision ordinance
- Streambank setbacks

Goal 5: Natural Resources:

- Protects open space and scenic views
- Identifies fish and wildlife habitat
- Protects historic properties

Goal 6: Air, Water and Land Resources:

- Maintains and protects water quality in estuarine waters
- Reduces pollution by construction of bypass
- Erosion control measures
- Reduces landslide possibilities related to development
- Maintains steep slopes in natural conditions
- Reduces excavation to minimum

Goal 16: Estuarine Resources:

- Manages groundwater
- Protects streams and estuarine waters
- Identifies and protects wetlands

Goal 17: Coastal Shorelands:

- Promotes uses to maintain integrity of estuary
- Maintains and restores vegetation adjacent to coastal waters
- Provides land for water-dependent/water-related uses

3.1.7.9 City of Cascade Locks

3.1.7.9.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Building a new sewage plant that recycles non-potable water for watering lawns and cooling industrial plants
- Stormwater control program (manages toxic contaminants)
- Floodplain management program

3.1.7.9.2 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning ordinance

Goal 5: Natural Resources

- Open space and scenic area designation
- Wetland conservation

Goal 6: Air, Water and Land Resources:

- Maintains and improves the air, water, and land resources of the state

3.1.7.10 City of Clatskanie

3.1.7.10.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Stormwater control program/drains
- Floodplain management program - protects town and Clatskanie River
- Toxics cleanup program - monitors groundwater for toxic contaminants

3.1.7.10.2 Non-Regulatory Activities:

- Public tours of water treatment plant
- Works with public schools to hire students for positions in Public Works Department through grant program

3.1.7.10.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning and subdivision regulations

Goal 5: Natural Resources:

- Open space and scenic views program
- Identifies fish and wildlife habitat
- Addresses air and water quality, energy and noise sources

Goal 6: Air, Water and Land Resources:

- Identifies watersheds and forestlands

Goal 16: Estuarine Resources:

- Identifies water areas, wetlands, watersheds, fish and wildlife habitat, and groundwater resources

3.1.7.11 City of Columbia City

3.1.7.11.1 Regulatory Activities:

- Wastewater treatment program/facilities: pumped to the City of St. Helens
- Oregon State Health Division Drinking Water Program - Drinking water is purchased from the City of St. Helens

3.1.7.11.2 Non-Regulatory Activities:

- Grant program to provide no-interest loans to low-income families for home weatherization

3.1.7.11.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning ordinance

Goal 5: Natural Resources:

- Overlay zone for McBride Creek
- Fence ordinance in the urban growth area to preserve view

Goal 6: Air, Water and Land Resources:

- Stormwater program with the City of St. Helens
- Subdivider catchbasins for stormwater

3.1.7.12 City of Fairview

3.1.7.12.1 Regulatory Activities:

- Groundwater protection program that addresses toxic contaminants
- Buffer overlays to protect fish and wildlife habitat
- Sewage program is handled by the City of Gresham
- Floodplain ordinance
- Stormwater control program/drains
- Solid waste and recycling program in conjunction with the City of Gresham

3.1.7.12.2 Non-Regulatory Activities:

- Incentive program for developers to dedicate certain areas for open space and public parks

3.1.7.12.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning and subdivision ordinance
- Design review ordinance for new development

Goal 5: Natural Resources:

- Riparian buffer overlay for creeks

- Significant environmental concern overlay--covers wetlands and wooded areas

Goal 6: Air, Water and Land Resources:

- Erosion control ordinance in new construction areas
- Groundwater protection ordinance for new developments

3.1.7.13 City of Gladstone

3.1.7.13.1 Regulatory Activities:

- Wastewater activities are contracted out
- Toxic cleanup activities are contracted out
- Most of the city is fully developed - no need for new ordinances
- Stormwater control program/drains
- Solid waste management and recycling program
- Industrial pre-treatment program via contracts
- Erosion control activities
- Identification of point sources of pollution

3.1.7.13.2 Non-Regulatory Activities:

- Watershed planning
- Wetland, river, and stream inventory
- Stormdrain stenciling program
- Non-point source pollution prevention program
- BMPs to prevent pollution
- Pollution prevention outreach and education activities
- Naturescaping projects
- Mitigation banking for habitat protection
- Household hazardous waste program

3.1.7.13.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Waterfront property is zoned for open space and parks
- Zoning and development codes

Goal 5: Natural Resources:

- Wetland protection

Goal 6: Air, Water and Land Resources:

- Identifies wetlands

3.1.7.14 City of Gresham

3.1.7.14.1 Regulatory Activities:

- NPDES Stormwater Management Program - planning, designing, constructing and maintaining stormwater system
- Protecting and enhancing surface and groundwater
- Solid waste and recycling management
- Wastewater treatment program/facilities
- Industrial pre-treatment program
- Erosion control activities

Non-Regulatory Activities:

- Household hazardous waste program in conjunction with Metro

3.1.7.14.2 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Development code
- Zoning and subdivision ordinance

Goal 5: Natural Resources:

- Physical constraints policy for steep slopes
- Geologic constraints policy
- Soil constraints policy
- Topographical constraints policy
- Hydraulic constraints policy
- Natural resources district buffer to protect waterways

Goal 6: Air, Water and Land Resources:

- Natural resources district
- Open space areas designated
- Fish and wildlife policy

3.1.7.15 City of Hood River

3.1.7.15.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Industrial pre-treatment program
- Erosion control activities

3.1.7.15.2 Non-Regulatory Activities:

- Watershed planning
- Stormwater stenciling program

3.1.7.15.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning and subdivision ordinance

Goal 5: Natural Resources:

- Retention of existing trees and natural topographic features
- Grading and drainage activities shall not negatively impact stormwater drainage

Goal 6: Air, Water and Land Resources:

- Conditional use ordinance and erosion control plan

3.1.7.16 City of Lake Oswego

3.1.7.16.1 Regulatory Activities:

- Prevents toxic contaminants entering surface water
- Developers must provide water quality treatment
- Wastewater collection and treatment

3.1.7.16.2 Non-Regulatory Activities:

- Stream enhancement and restoration
- Stormdrain stenciling program
- Neighborhood grants to restore wetlands and riparian areas

3.1.7.16.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Development and zoning code
- Community design and aesthetics policy

Goal 5: Natural Resources:

- New sensitive lands ordinance to regulate activities in development
- Tree-cutting ordinance
- Open space standards for new developments
- Willamette River Greenway activities

Goal 6: Air, Water and Land Resources:

- Reduces air pollution in metro areas
- Surface water management--ensures protection of natural systems
- Solid waste program to reduce amounts going to landfills
- Stream corridor standard and floodplain ordinance

3.1.7.17 City of Milwaukie

3.1.7.17.1 Regulatory Activities:

- Surface water management plan
- Johnson Creek program - cleanup and manage the amount of sediments accumulated, and protect water quality
- Fish enhancement program - improve fish spawning grounds
- Wastewater treatment program/facilities
- Stormwater control program/drains
- Solid waste management and recycling program
- Toxic clean-up activities contracted out
- Dry well management program
- Wellhead protection program
- Habitat protection measures
- Wetlands restoration contracted out
- Identification of point and non-point pollution sources

3.1.7.17.2 Non-Regulatory Activities:

- Watershed planning
- Stormwater stenciling program
- River and stream inventory and protection
- Water quality studies
- Technical assistance to community regarding water quality
- BMPs to prevent pollution

- Naturescaping projects
- Alternative discharge control programs
- Household hazardous waste program

3.1.7.17.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Development and zoning code

Goal 5: Natural Resources:

- Natural resources overlay - includes habitat restoration activities
- Willamette River Greenway activities that relate to riparian restoration and floodways

Goal 6: Air, Water and Land Resources:

- Protects groundwater from pollution
- Collection and treatment of sewage
- Erosion control ordinance
- Collection of sediments from runoff
- Protection of waterways

3.1.7.18 City of Oregon City

3.1.7.18.1 Regulatory Activities:

- Tri-city service district plan with the Cities of Gladstone and West Linn to provide sewer and stormwater services
- Solid waste management provided by garbage company

3.1.7.18.2 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning code

Goal 5: Natural Resources:

- Water resources ordinance - Historic sites ordinance
- Willamette River Greenway overlay district

Goal 6: Air, Water and Land Resources:

- Erosion control
- Floodplain ordinance

3.1.7.19 City of Portland

3.1.7.19.1 Regulatory Activities:

Bureau of Buildings Activities:

- Erosion control activities

Bureau of Environmental Services Activities:

- Municipal NPDES permits for stormwater control
- Surface water management addressing toxic and conventional pollutants
- Natural resource management plan for watersheds in area - involves habitat protection measures, recreation, and fisheries
- Industrial pre-treatment program
- Residential and commercial recycling

Department of Parks and Recreation Activities:

- Integrated pest management to reduce use of toxic chemicals
- Natural area management plans -- for recreational and water quality purposes

Portland Water Bureau Activities:

- Wellhead protection program

Planning Commission Activities:

- Environmental zone program - to protect environment and minimize
- Native plants program
- Wetlands program

3.1.7.19.2 Non-Regulatory Activities:

Bureau of Environmental Services Activities:

- Combined sewer overflow program - to reduce and possibly eliminate combined sewer overflows (CSOs) by designing system improvements (e.g., downspout disconnection)
- BMPs for industries that are not required to pre-treat waste
- Alternative discharge control mechanisms to meet goals of pre-treatment
- Industry educational programs with updated information
- Stewardship program for watershed areas
- Memorandum of agreement for sediment cleanup in Columbia Slough
- Reduced rates for reduction in trash generation
- Mitigation banking for habitat enhancement
- Naturescaping projects
- Stormdrain stenciling program
- Backyard program that teaches about wildlife and habitat
- Pollution prevention activities

Department of Parks and Recreation Activities:

- BMPs for habitat protection
- Public education on park programs

Planning Commission Activities:

- Native plant handbook

3.1.7.19.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning and subdivision code

Goal 5: Natural Resources:

- Environmental overlays - includes a Conservation Zone and a Protection Zone
- Plan districts
- Natural resource management plan - set-aside areas for specific purposes

Goal 6: Air, Water and Land Resources:

- Environmental zones to protect water quality
- Urban growth boundary designation
- Open space goal

3.1.7.20 City of Rainier

3.1.7.20.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Wetland restoration program
- Stormwater control program/drains
- Erosion control activities
- Industrial pre-treatment program

3.1.7.20.2 Non-Regulatory Activities:

- Stormdrain stenciling program
- Public education on salmon restoration
- Watershed planning
- Wetlands inventory
- Water quality studies

3.1.7.20.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning and development codes

Goal 6: Air, Water and Land Resources:

- Watershed management plan - Timber management plan
- Water and wastewater management regulations

3.1.7.21 City of Scappoose

3.1.7.21.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Potable water program
- Maintain and regulate 3 diversion dams in area - with fish ladders to protect species
- Solid waste management contracted out
- Stormwater control program/drains

3.1.7.21.2 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Development and zoning code

Goal 5: Natural Resources:

- Fish and wildlife overlay zone
- Environmental performance standards
- Local wetland inventory

Goal 6: Air, Water and Land Resources:

- Stormwater drainage master plan
- Wellhead protection plan
- Sensitive lands ordinance
- Floodplain ordinance

3.1.7.22 City of St. Helens

3.1.7.22.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Conventional pollutant tests for Boise Cascade pulp and paper mill
- Pre-treatment program for improving water quality (NPDES)
- Stormwater control program/facilities
- Industrial pre-treatment program
- Zoning and development codes

3.1.7.22.2 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning ordinance

Goal 5: Natural Resources:

- Wetlands inventory
- Scenic views identification
- Riparian habitat area identification

Goal 6: Air, Water and Land Resources:

- Resource conservation program for Sand Island
- Resource management planning
- Flood hazard ordinance
- Steep slope policy

3.1.7.23 City of Troutdale

3.1.7.23.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Stormwater control program/drains
- Erosion control activities
- Habitat protection measures

3.1.7.23.2 Non-Regulatory Activities:

- Pre-treatment program for industry and households
- Stormdrain stenciling program
- Pre-application meetings and site and design review

3.1.7.23.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning ordinance

Goal 5: Natural Resources:

- Open space and scenic areas designation
- Wetland conservation
- Restoration activities for Beaver Creek and the Sandy River

Goal 6: Air, Water and Land Resources:

- Protection of headwater areas
- Flood hazard ordinance

3.1.7.24 City of Warrenton

3.1.7.24.1 Regulatory Activities:

- Stormwater control program/drains

- Wastewater treatment program/facilities
- Solid waste management
- Wetlands restoration
- Skipanon mediated agreement- covers the east bank of the Skipanon and includes a zoning ordinance which provides riparian buffers from rivers and sloughs

3.1.7.24.2 Non-Regulatory Activities:

- Watershed planning council with CREST
- Environmental education presentations
- Mitigation banking and planning

3.1.7.24.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Zoning ordinance
- Comprehensive plan

Goal 5: Natural Resources:

- Wetland conservation plan, and inventory, mitigation, and restoration
- Protection of vegetation along water bodies
- Protection of fish and wildlife habitat

Goal 6: Air, Water and Land Resources:

- Erosion control

Goal 16: Estuarine Resources:

- Regulates development in the Lower Columbia River Estuary
- Diking and dredging regulations

3.1.7.25 City of West Linn

3.1.7.25.1 Regulatory Activities:

- Stormwater control program/drains
- Erosion control activities
- Habitat protection measures

3.1.7.25.2 Non-Regulatory Activities:

- Erosion control training and education

3.1.7.25.3 Local Comprehensive Plan Activities:

Goal 2: Land Use Planning:

- Community development code

- Comprehensive Plan

Goal 5: Natural Resources:

- Willamette River Greenway
- Flood hazard construction
- Tualatin River protection
- Wetland and riparian area protection
- Natural drainageway protection

Goal 6: Air, Water and Land Resources:

- Storm drainage master plan
- Mitigation of soil erosion before and after development
- Minimize introduction of pollutants into ground and surface
- New development must be connected to sewer system

3.1.8 *Washington Local Government Agencies*

3.1.8.1 Washington's Land Use Regulations

In the 1970s, the Washington State Legislature enacted two landmark environmental acts: the State Environmental Policy Act (SEPA) and the Shoreline Management Act (SMA). Twenty years later another significant piece of legislation titled the Growth Management Act (GMA) changed local land use planning and regulation from being optional to being state mandated.

The Shoreline Management Act (SMA), enacted by the state legislature in 1971, is intended to protect valuable shoreline resources, to plan and manage uses, to increase public usage and enjoyment of state shorelines, and to assure public involvement in decisions about shoreline resources. The SMA regulates most shorelines of the state, including marine waters, streams and rivers (with a mean annual flow of 20 cubic feet per second or more), lakes and reservoirs (larger than 20 acres), associated wetlands, and portions of the floodplain.

The Act defines shoreline management as a cooperative effort between the state and local government. Local governments have the primary responsibility for administering and enforcing the SMA through local Shoreline Master Programs (SMPs). The Department of Ecology acts in a supportive capacity and reviews compliance with the SMP and SMA, while assisting local governments. However, the state is authorized to enforce shoreline programs if local government is not taking action.

The Growth Management Act of 1990 establishes the framework for local governments to perform comprehensive planning in order to address growth-related issues. Unlike Oregon's Statewide Planning Goals, most GMA requirements do not apply to all counties and cities in the state. In 1996, two of the five counties in the Lower Columbia River area (Clark and Pacific) are required to plan under the GMA. These requirements apply to counties and their cities that a) have a population of 50,000 or more and a growth rate of 10 percent over the previous 10 years, or b) a growth rate of over 20 percent in the previous 10 years regardless of population. Moreover, counties in the second option are given the opportunity to remove themselves from the requirements within a specified period of time. Other counties not required to comply with

GMA requirements were given the option to be governed by the Act. Many unsuccessful proposals have been presented to extend the GMA requirements to all counties and cities. There are several GMA requirements that apply to all counties in Washington State, including non-GMA counties and cities. These include: 1) their development regulations must be consistent with any adopted comprehensive plans; 2) they must designate and protectively regulate critical areas; and 3) they must designate, but need not regulate, natural resource lands. Clark County and Pacific County, along with other GMA counties in Washington, are required to plan under the following 13 statutory goals identified in the state legislation:

Goal 1: Encourage development in areas where adequate public facilities exist or can be provided in an efficient manner

Goal 2: Reduce urban sprawl

Goal 3: Encourage efficient multi-modal transportation systems

Goal 4: Encourage the availability of affordable housing to all economic segments of the population

Goal 5: Encourage economic development throughout the state

Goal 6: Assure private property is not taken for public use without just compensation

Goal 7: Encourage predictable and timely permit processing Goal 8: Maintain and enhance natural resource-based industries

Goal 9: Encourage retention of open space and development of recreational opportunities

Goal 10: Protect the environment and enhance the State's quality of life Goal 11: Encourage the participation of citizens in the planning process

Goal 12: Ensure adequate public facilities and services necessary to support development

Goal 13: Identify and preserve lands and sites of historic and archeological significance

The Department of Ecology is drafting a set of guidelines in 1997 that will discuss how to assure consistent behavior between the GMA and SMA programs, and will add a 14th goal to the GMA which includes a shoreline protection element. The Department of Ecology has established a Shoreline Management Act Regulatory Reform Team (SMAART) to investigate the procedural components to this integration.

3.1.8.2 Clark County

3.1.8.2.1 Regulatory Activities:

- Surface and groundwater management programs
- Stormwater control program/drains
- Dry-well management project
- Wellhead protection program
- Identification of long-range point and non-point sources of water pollution
- Habitat protection activities

3.1.8.2.2 Non-Regulatory Activities:

- "Business Partners for Clean Water Program" --BMPs to prevent pollution
- Pollution prevention outreach and education
- Watershed planning
- BMPs for agricultural activities
- Non-point source pollution prevention program
- RiverRangers educational program

3.1.8.2.3 Critical Areas Ordinance:

- Critical areas ordinance was adopted but is in the process of being revised

3.1.8.2.4 Growth Management Plan:

- Adopted an updated Comprehensive Plan in 1994 with amendments in 1996 - is in compliance with the Washington State Growth Management Act

3.1.8.2.5 National Scenic Area Plan:

- Adopts land use ordinances based on the Management Plan for the Columbia River Gorge National Scenic Area of 1992

3.1.8.2.6 Shoreline Master Plan and Comprehensive Land Use Plan:

- Original Comprehensive Plan was adopted in the 1970s

3.1.8.3 Cowlitz County

3.1.8.3.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Stormwater control program/drains
- Zoning and development codes

3.1.8.3.2 Critical Areas Ordinance:

- Classifies, designates, and protects critical areas
- offers a range of incentives intended to provide protection for critical areas
- Requires the adoption of development regulations to assure conservation
- Critical areas include: wetlands, aquifer recharge areas, geologically hazardous areas, fish and wildlife habitat, and frequently flooded areas

3.1.8.3.3 Growth Management Plan:

- Not applicable to Cowlitz County in 1996

3.1.8.3.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Original shoreline plan developed in 1977 - still utilizing these regulations

- Original comprehensive plan outlining regulations passed in 1976

3.1.8.4 Pacific County

3.1.8.4.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Solid waste management

3.1.8.4.2 Critical Areas Ordinance:

- Being developed in 1997

3.1.8.4.3 Growth Management Plan:

- Required to have one - being developed in the near future

3.1.8.4.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Original shoreline plan developed in the 1970s - still utilizing these regulations
- Comprehensive Land Use Plan being developed in 1997

3.1.8.5 Skamania County

3.1.8.5.1 Regulatory Activities:

- Solid waste management
- No stormwater control program
- Cities handle the wastewater treatment and management

3.1.8.5.2 Non-Regulatory Activities:

- Water quality study in 1996 to address how land use impacts water quality

3.1.8.5.3 Critical Areas Ordinance:

- Developed in 1996 to address the protection of sensitive areas (e.g., buffer zones)

3.1.8.5.4 Growth Management Plan:

- Not applicable to Skamania County in 1996

3.1.8.5.5 National Scenic Area Plan:

- Adopts land use ordinances based on the Management Plan for the Columbia River Gorge National Scenic Area of 1992 - requirements are similar to GMA provisions

3.1.8.5.6 Shoreline Master Plan and Comprehensive Land Use Plan:

- Original shoreline plan developed in 1974 - still utilizing these regulations, but will be updating regulations based on state regulatory reform
- Original comprehensive plan outlining regulations passed in 1977

3.1.8.6 Wahkiakum County

3.1.8.6.1 Regulatory Activities:

- Stormwater control program/drains for Cathlamet ditches
- Solid waste management contracted to Cowlitz County
- Wastewater treatment is not in jurisdiction

3.1.8.6.2 Critical Areas Ordinance:

- Does not have ordinance in 1996

3.1.8.6.3 Growth Management Plan:

- Not applicable to Wahkiakum County in 1996

3.1.8.6.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Original shoreline plan developed in the 1970s - last updated in 1992
- Comprehensive Land Use Plan being developed in the near future

3.1.8.7 City of Camas

3.1.8.7.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Stormwater control program/drains
- Solid waste management plan

3.1.8.7.2 Critical Areas Ordinance:

- Sensitive lands ordinance that addresses fish and wildlife habitat and other critical land areas

3.1.8.7.3 Growth Management Plan:

- Adopted an updated Comprehensive Plan in 1994 - is in compliance with the Washington State Growth Management Act

3.1.8.7.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Original shoreline plan developed in 1971 - implementation is outlined in Zoning Plan

3.1.8.8 City of Cathlamet

3.1.8.8.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Construction requirements for shoreline permits
- Solid waste management is contracted out
- Floodplain ordinance
- Wetlands restoration

3.1.8.8.2 Critical Areas Ordinance:

- Does not have ordinance in 1996

3.1.8.8.3 Growth Management Plan:

- Not applicable to the City of Cathlamet in 1996

3.1.8.8.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Adopted and utilizes Wahkiakum County's land use plans

3.1.8.9 City of Ilwaco

3.1.8.9.1 Regulatory Activities:

- Wastewater treatment program/facilities for Ilwaco and Seaview
- Solid waste management is contracted out
- Stormwater control program/drains outlined in Comprehensive Plan
- Habitat protection measures
- Floodplain ordinance

3.1.8.9.2 Critical Areas Ordinance:

- Adopted "Resource Lands and Critical Areas Designation Policies for City of Ilwaco" in 1993

3.1.8.9.3 Growth Management Plan:

- Adopted the city's Comprehensive Plan in 1995 - is in compliance with the Washington State Growth Management Act

3.1.8.9.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Shoreline Master Plan is incorporated with Pacific County

3.1.8.10 City of Kalama

3.1.8.10.1 Regulatory Activities:

- Pre-treatment ordinance and sewer ordinance - bans toxins going into the sewer
- Erosion control ordinance - relies on BMPs for implementation
- Wetlands protection and restoration
- Subdivision ordinance
- Stream ordinances
- Wastewater treatment program/facilities

3.1.8.10.2 Critical Areas Ordinance:

- Developing a critical areas ordinance in 1997

3.1.8.10.3 Growth Management Plan:

- Not applicable to the City of Kalama in 1996

3.1.8.10.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Adopted Cowlitz County's Shoreline Master Plan
- Adopted Comprehensive Plan in 1994

3.1.8.11 City of Kelso

3.1.8.11.1 Regulatory Activities:

- Stormwater control program/drains - reviews new developments for potential
- Solid waste management is contracted out
- Wastewater treatment program/facilities is handled by the City of Longview
- Floodplain management

3.1.8.11.2 Non-Regulatory Activities:

- Stormdrain stenciling program

3.1.8.11.3 Critical Areas Ordinance:

- Adopted a "Land Clearance Permit" in 1995 with many of the same requirements as a critical areas ordinance - will be updating ordinance in 1997

3.1.8.11.4 Growth Management Plan:

- Not applicable to the City of Kelso in 1996

3.1.8.11.5 Shoreline Master Plan and Comprehensive Land Use Plan:

- Adopted Cowlitz County's Shoreline Master Plan - will be making revisions in 1997
- Original Comprehensive Plan was adopted in 1980 and revised in 1992 - will be undergoing further revisions in 1997

3.1.8.12 City of Longview

3.1.8.12.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Solid waste disposal program
- Environmental review process for new developments

3.1.8.12.2 Non-Regulatory Activities:

- Stormdrain stenciling program
- Household hazardous waste program

3.1.8.12.3 Critical Areas Ordinance:

- Developing a critical areas ordinance in the near future

3.1.8.12.4 Growth Management Plan:

- Not applicable to the City of Longview in 1996

3.1.8.12.5 Shoreline Master Plan and Comprehensive Land Use Plan:

- Adopted Cowlitz County's Shoreline Master Plan
- Original Comprehensive Plan was adopted in 1974 and revised in 1993

3.1.8.13 City of North Bonneville

3.1.8.13.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Solid waste management
- Stormwater control program/drains

3.1.8.13.2 Critical Areas Ordinance:

- Does not have ordinance in 1996

3.1.8.13.3 Growth Management Plan:

- Not applicable to the City of North Bonneville in 1996

3.1.8.13.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Does not have comprehensive plan in 1996
- Adopted Skamania County's Shoreline Master Plan

3.1.8.14 City of Ridgefield

3.1.8.14.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Solid waste management contracted out
- Non-point source pollution system with biofiltration system
- Stormwater control program/drains
- Gee Creek Restoration Plan - restore fish runs and maintain clean water

3.1.8.14.2 Non-Regulatory Activities:

- Stormdrain stenciling program
- Tree-planting program in Gee Creek

3.1.8.14.3 Critical Areas Ordinance:

- Does not have ordinance in 1996

3.1.8.14.4 Growth Management Plan:

- Adopted the city's Comprehensive Plan in 1995 - is in compliance with the Washington State Growth Management Act

3.1.8.14.5 Shoreline Master Plan and Comprehensive Land Use Plan:

- Adopted Shoreline Master Program in 1978

3.1.8.15 City of Stevenson

3.1.8.15.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Stormwater control program drains
- Solid waste management is contracted out

3.1.8.15.2 Critical Areas Ordinance:

- Does not have ordinance in 1996

3.1.8.15.3 Growth Management Plan:

- Not applicable to the City of Stevenson in 1996

3.1.8.15.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Adopted Shoreline Master Program in 1984
- Adopted Comprehensive Plan in 1974 - was revised in 1975

3.1.8.16 City of Vancouver

3.1.8.16.1 Regulatory Activities:

- Groundwater protection program
- Wellhead protection program
- Wastewater treatment program/facilities
- Industrial wastewater pre-treatment program
- Stormwater control program/drains - based on Puget Sound Manual
- Erosion control activities
- Wetland protection ordinance

3.1.8.16.2 Non-Regulatory Activities:

- Established the Water Resources Education Center (described under regional programs)
- Co-developed the Environmental Education Center
- Sewer Connections Incentive Program - elimination of septic tanks
- Annual Water Quality Report - reports data from testing all supply points
- Stormdrain stenciling program
- Mitigation banking for habitat protection: wetlands

3.1.8.16.3 Critical Areas Ordinance:

- Adopted critical areas ordinance in 1993 - underwent revisions in 1996

3.1.8.16.4 Growth Management Plan:

- Adopted the city's Comprehensive Plan in 1995 - is in compliance with the Washington State Growth Management Act

3.1.8.16.5 Shoreline Master Plan and Comprehensive Land Use Plan:

- Original Shoreline Master Plan passed in 1975 - was revised in 1996

3.1.8.17 City of Washougal

3.1.8.17.1 Regulatory Activities:

- Stormwater control program/drains - based on Puget Sound Manual
- Erosion and sediment control activities
- Wastewater treatment program/facilities
- Wellhead protection program
- Wetlands protection ordinance
- Floodplain protection ordinance
- Shoreline development ordinance

3.1.8.17.2 Non-Regulatory Activities:

- Stormdrain stenciling program
- Public education newsletters

3.1.8.17.3 Critical Areas Ordinance:

- Does not have ordinance in 1996

3.1.8.17.4 Growth Management Plan:

- Adopted the city's Comprehensive Plan in 1994 - is in compliance with the Washington State Growth Management Act

3.1.8.17.5 Shoreline Master Plan and Comprehensive Land Use Plan:

- Adopted city's Shoreline Master Plan in 1971 - will be updated in 1997

3.1.8.18 City of Woodland

3.1.8.18.1 Regulatory Activities:

- Wastewater treatment program/facilities
- Stormwater control program/drains
- Solid waste management is contracted out

3.1.8.18.2 Critical Areas Ordinance:

- Adopted critical area ordinance in 1995

3.1.8.18.3 Growth Management Plan:

- Adopted the city's Comprehensive Plan in 1995 - is in compliance with the Washington State Growth Management Act

3.1.8.18.4 Shoreline Master Plan and Comprehensive Land Use Plan:

- Adopted Cowlitz County's Shoreline Master Plan

3.1.9 *Tribal Governments*

Indian tribes represent unique legal entities in the United States, as well as Oregon and Washington, and are distinct political communities. Tribal sovereignty predates the creation of the federal, state or local government. With the creation of these governments, treaties and executive agreements have been established to develop a trust relationship between the tribes and the federal government.

The history of treaty fishing rights along the Columbia River is a complex issue that began many years ago. Currently, the four Columbia River Tribes (the Nez Perce, Umatilla, Warm Springs, and Yakama) are the only tribes in the basin to have reserved rights to anadromous fish that were established in 1855 treaties with the United States government. In these treaties, these tribes became co-managers of the salmon and retained their rights to continue their fishing, hunting, gathering and pasturing practices. Each treaty contained a provision securing the tribes' right to take "fish at all usual and accustomed places in common with citizens of the United States." This included the right to fish inside their respective reservations, as well as outside of their ceded areas.

In the federal court cases, United States v. Oregon and United States v. Washington, the United States Supreme Court has confirmed that the tribes are entitled to 50 percent of the harvestable number of fish destined to pass usual and accustomed fishing locations. Furthermore, in 1975, Judge Belloni, from the United States v. Oregon case, applied the 50/50 standard to the Columbia River. Finally, a decision in 1980 came into effect saying that hatchery salmon do count in the number allowed to be caught by the tribes.

These decisions apply to the following four federally recognized Columbia River treaty tribes:

3.1.9.1 Nez Perce Tribe:

- 1992 Land Base: 750,000 acres, 13% owned by tribe
- 1992 Tribal Population: 3,000 people
- 1992 Tribal Fisheries: Clearwater River, Columbia River, Rapid River, North Fork Salmon River, and Selway River

3.1.9.2 Confederated Tribes of theUmatilla Indian Reservation:

- 1992 Land Base: 172,000 acres, about 50% owned by tribe
- 1992 Tribal Population: 1,456 people

- 1992 Tribal Fisheries: Columbia River, Lookingglass Creek, and Umatilla

3.1.9.3 Confederated Tribes of theWarm Springs Indian Reservation of Oregon:

- 1992 Land Base: 640,000 acres
- 1992 Tribal Population: 3,410 people
- 1992 Tribal Fisheries: Columbia River, Deschutes River at Sherar's Bridge, John Day River, and Warm Springs River

3.1.9.4 Confederated Tribes And Bands of theYakama Indian Nation:

- 1992 Land Base: 1.2 million acres
- 1992 Tribal Population: 8,344 people
- 1992 Tribal Fisheries: Columbia River, Klickitat River, Wenatchee River, Wind River and Yakima River

Beyond these four treaty tribes, there are many other tribes in the Columbia River basin that do not have reserved rights to the salmon. In the 1950s, federal trusteeship of roughly 3 percent of the country's Indian population was terminated, and these tribes were no longer recognized by the federal government. In recent years, vigorous efforts have taken by federally unrecognized tribes to reestablish the trust relationships. Such non-federally recognized tribes and bands along the Columbia River include the Chinook Tribe, Cowlitz Tribe, and Klickitat Tribe. These tribes are important stakeholders in the management of the lower Columbia River and estuary.

3.1.10 *Non-Governmental Agencies*

The Pacific Northwest is a unique region characterized by a large number of non-governmental conservation organizations working to protect the environment. These groups vary in terms of their location, mission, and structure. Many concentrate on educational issues regarding the river and water quality and living resources protection, while others play more of an advocacy role. The following list includes some of the non-governmental groups located in the Lower Columbia River basin. The list is not exhaustive.

3.1.10.1.1 1000 Friends of Oregon, Portland, OR

Nonprofit public service organizationworking to realize Oregon's land use laws at the state and local levels

3.1.10.1.2 American Fisheries Society, Portland, OR

Conservation organization which promotes protection of critical fish habitat through science and education

3.1.10.1.3 American Rivers -NW Region, Seattle, WA

Conservation organization that defends the quality of our drinking water, the natural beauty of our environment, the recreational value of our waterways, and the countless species of plants and animals they support

3.1.10.1.4 Association of Northwest Steelheaders, Milwaukie, OR

Conservation group dedicated to the preservation and enhancement of steel head, trout, and salmon

3.1.10.1.5 Audubon Society, Portland, OR

Nonprofit, conservation organization that promotes enjoyment, understanding, and protection of the natural world, particularly native wildlife and its habitat

3.1.10.1.6 Audubon Society, Vancouver, WA

3.1.10.1.7 Audubon Society--Columbia Gorge Region, Hood River, OR

3.1.10.1.8 Clark County Natural Resources Council, Vancouver, WA

Conservation group working to preserve, protect, and enhance the natural resources and environment of Clark County through education and advocacy

3.1.10.1.9 Clark County Water Quality Resource Council, Vancouver, WA

Conservation, umbrella group for eight Clark County drainage basins with steward members who monitor, report, and work to improve surface and groundwater quality in

3.1.10.1.10 Clark County Columbia Land Trust, Vancouver, WA

Grassroots group that acquires, sells, or exchanges real property in order to pre serve it for open space, habitat, and protec tion of water quality and quantity

3.1.10.1.11 Columbia Slough Watershed Council, Portland, OR

Conservation organization that provides a forum for information and collaborative efforts within the watershed to address protection and enhancement of the Slough

3.1.10.1.12 Defenders of Wildlife, Lake Oswego, OR

Conservation group dedicated to the perpetuation of all native species and their enjoyment to the public

3.1.10.1.13 Environmental Information Center, Vancouver, WA

Environmental education provider that serves as a clearinghouse for environmen tal information in Clark County

3.1.10.1.14 Friends of the Columbia Gorge, Portland, OR

Conservation group that works to protect the Columbia Gorge through education, legal work, and forest and land use monitoring

3.1.10.1.15 Friends of Wetlands, Portland, OR

Grassroots organization that promotes the preservation, enhancement, and restoration of wetlands in the greater Portland Vancouver area

3.1.10.1.16 Greenpeace USA,Portland, OR

Conservation group that strives to create a green and peaceful world by conducting campaigns on forest issues, ocean protection, toxic poisoning, and safe nuclear energy

3.1.10.1.17 Lower Columbia Fish Enhancement Group, Vancouver, WA

Conservation group that assists the WA Department of Fish and Wildlife with its goal to double the salmon runs by the year 2000

3.1.10.1.18 National Coalition for Alternatives to Pesticides, Eugene, OR

Conservation group that provides assistance in developing model policies to protect our groundwater, food supply, and forest watersheds from pesticide contamination

3.1.10.1.19 National Wildlife Federation - Western Natural Resource Center Portland, OR

Conservation group whose purpose is to educate, inspire, and empower individuals and organizations to take actions to conserve fish, wildlife, and other natural resources

3.1.10.1.20 The Nature Conservancy of Oregon, Portland, OR

Conservation group that purchases and manages natural areas in order to protect habitat for Oregon's plants, wildlife, and ecosystems

3.1.10.1.21 Northwest Earth Institute, Portland, OR

Conservation group dedicated to providing individuals with opportunities to consider how their values and habits affect the earth

3.1.10.1.22 Northwest Environmental Advocates, Portland, OR

Environmental advocacy organization work ing to restore the environment of the Pacific Northwest by working on water and air quality, safe energy, and habitat protection issues; primarily in the Columbia River basin

3.1.10.1.23 Northwest Environmental Defense Center, Portland, OR

Environmental information provider that provides legal and scientific services in the public interest with special emphasis on water quality issues

3.1.10.1.24 Oregon Adopt-A-River, Hillsboro, OR

Conservation group which helps volunteers adopt a stretch of any Oregon river, stream, creek or lakefront in order to clean up and preserve the waterways

3.1.10.1.25 Oregon Environmental Council, Portland, OR

Conservation organization that works to lessen human impacts on Oregon's air, water, and land

3.1.10.1.26 Oregon Natural Resources Council, Portland, OR

Conservation group that works to protect and enhance the natural resource values on public lands, waters and oceans

3.1.10.1.27 Oregon Trout, Portland, OR

Conservation group that works to change man agement of fish populations and their habitats

3.1.10.1.28 Oregon Water Trust, Portland, OR

Conservation organization that uses a market based approach to help maintain and enhance surface water flows to benefit the state's fisheries and other aquatic species

3.1.10.1.29 Oregon Waterfowl and Wetlands Association, Portland, OR

Conservation group dedicated to preserving, protecting, and restoring wetlands and wildlife

3.1.10.1.30 Oregon Wildlife Federation, Milwaukie, OR

Conservation organization dedicated to the preservation, conservation, and enhancement of our natural resources, wildlife, fish, and habitat

3.1.10.1.31 Pacific Rivers Council, Portland, OR

Nonprofit organization that develops scientific tools, legislative policies, and community enhancement strategies to restore the ecologi cal integrity and sustainable human use of America's river systems

3.1.10.1.32 Ridgefield National Wildlife Refuge, Ridgefield, WA

Wintering/migrating area for waterfowl

3.1.10.1.33 River Network, Portland, OR

Conservation group dedicated to helping people save rivers

3.1.10.1.34 Sauvie Island Conservancy, Portland, OR

Grassroots group dedicated to the preservation of island rural life, wildlife, and natural recreation areas

3.1.10.1.35 Save Our Salmon, Portland, OR

Conservation coalition of 44 environmental, fishing, and energy groups to coordinate the efforts to save salmon species and habitat

3.1.10.1.36 Sea Resources, Chinook, WA

Conservation group working on a revitalization project on the Chinook River; includes salmon research and student education

3.1.10.1.37 Sierra Club Columbia Group, Portland, OR

Conservation organization that addresses issues in the Columbia Basin related to ancient forest preservation, energy conservation, transportation, and population

3.1.10.1.38 Sierra Club SW Washington Group, Vancouver, WA

Conservation organization that addresses issues in Clark, Cowlitz, and Skamania counties related to growth management, wetland and forest issues, and wildlife habitat protection

3.1.10.1.39 Trout Unlimited Gladstone, OR Hillsboro, OR

Conservation organization that works to preserve, protect, and enhance the cold-water fishery

3.1.10.1.40 Trust for Public Land, Portland, OR

Nonprofit land conservation organization that helps citizen groups and public agencies to protect open space lands having significant natural, recreation, historical, cultural, or scenic resources

3.1.10.1.41 Urban League of Portland, Portland, OR

Advocacy organization that has developed an "E" team environmental program which focuses on environmental justice, toxics, greenspaces, parks, and outreach for the Coalition for a Livable Future

3.1.10.1.42 Washington Environmental Council, Seattle, OR

Conservation organization working to pro tect, preserve, and restore the environment of Washington State

3.1.10.1.43 WaterWatch of Oregon Portland, OR

Grassroots organization dedicated to protecting the public interest in Oregon's water by restoring and protecting instream flow in rivers and streams

3.1.10.1.44 The Wetlands Conservancy, Tualatin, OR

Conservation group and land trust that owns and manages wetlands for their many values to society and wildlife

3.1.10.1.45 Wildlife Too, Warren, OR

Conservation group that works to protect and enhance wildlife habitat and resource lands throughout Columbia County

3.1.10.1.46 Wild Salmon Nation, Portland, OR

Grassroots group that advocates for public support of abundant wild salmon

3.1.11 *Port Districts*

3.1.11.1 Oregon Ports

3.1.11.1.1 Port of Astoria

- Port Piers and Lands, Astoria
- Airport and Lands, Warrenton
- Industrial Park, Warrenton
- West Basin Marina, Astoria
- East Basin Marina, Astoria
- Skipanon Property, Astoria
- Red Lion Restaurant and Convention Center, Astoria

3.1.11.1.2 Port of Cascade Locks

- Interstate Toll Bridge, City of Cascade Locks
- 2 Sternwheeler Vessels, City of Cascade Locks
- Marine Park (100 acre), City of Cascade Locks
- Visitors Center and Gift Shop, City of Cascade Locks
- Museum, City of Cascade Locks
- Public Marina (75 slips), City of Cascade Locks
- Wind-surfing Beach, City of Cascade Locks
- Industrial Park (175 acres), City of Cascade Locks

3.1.11.1.3 Port of Hood River

- 3 Industrial Parks, City of Hood River
- Public Marina (151 slips) , City of Hood River
- Airport, City of Hood River
- Hood River/White Salmon, City of Hood River
- Toll Bridge, City of Hood River

3.1.11.1.4 Port of Portland

- Portland International Airport, City of Portland
- PDX International Center, City of Portland
- Terminal 1,2,4,5,6, City of Portland
- Portland Ship Yard, City of Portland
- Industrial Park, City of Portland
- Troutdale Airport, City of Troutdale
- Hillsboro Airport, City of Hillsboro
- Pier 33, City of Portland

3.1.11.1.5 Port of St. Helens

- Airport, City of Scapoose
- Public Marina (80 slip), City of St. Helens
- Industrial Parks (3), City of St. Helens
- Industrial Park, City of Columbia City
- Industrial Park, City of Ranier
- Industrial Park City of Scapoose, City of Clastkanie

3.1.11.2 Washington Ports

3.1.11.2.1 Port of Camas-Washougal

- Airport (65-plane general aviation), Clark County
- Pleasure Boat Marina (350 slip), City of Washougal
- Gibbons Creek (Pump Overflow) , City of Washougal
- Industrial Park, , City of Washougal

3.1.11.2.2 Port of Chinook

- Marina (380 slips), City of Chinook
- Seafood Processing Plant, City of Chinook

3.1.11.2.3 Port of Ilwaco

- Airport, City of Ilwaco
- Marina (950 slips), City of Ilwaco
- Boat Storage Yard, City of Ilwaco

3.1.11.2.4 Port of Kalama

- Public Marina (222 slips), City of Kalama
- Wastewater Treatment Plant, Cowlitz County
- Industrial Park, Cowlitz County
- RV Park, Cowlitz County
- Marine Park, City of Kalama (1/2), Cowlitz County (1/2)

3.1.11.2.5 Port of Longview

- Marine Terminals, City of Longview
- Industrial Properties, City of Longview

3.1.11.2.6 Port of Ridgefield

- Golf Course, Clark County
- Industrial Parks (2), City of Ridgefield

3.1.11.2.7 Port of Skamania

- Industrial Park, City of North Bonneville
- Industrial Park, City of Stevenson
- Sternwheeler Dock, City of Stevenson
- Day-use Boat Launch, City of Stevenson

3.1.11.2.8 Port of Vancouver

- Industrial park (40 tenants), City of Vancouver
- Marine Operations (4 terminals), City of Vancouver
- 1000 acres undeveloped land, City of Vancouver
- City of Vancouver
- City of Vancouver

3.1.11.2.9 Port of Wahkiakum I

- Marina (200+ slips), Town of Cathlamet

3.1.11.2.10 Port of Wahkiakum II

- Public Park, Town of Skamokawa

3.1.11.2.11 Port of Woodland

- Industrial Parks (2), City of Woodland
- Undeveloped Waterfront Property, Cowlitz County

3.2 Plans, Programs, projects

To help develop the management plan, planning partners and stakeholders provided information relevant to the Lower Columbia Estuary and mainstem. This information includes plans, programs, projects and research. While the previous section (agencies and authorities) provides the framework under which programs and plans exist, this section provides additional information about the actual activities in and related to the subbasins.

This list includes those activities forwarded to the subbasin planning team or identified by the planning team as relevant to this effort. As such, it is by no means, a comprehensive list. The Lower Columbia Fish Recovery Board, a partner in this subbasin planning effort, also has programs and projects summarized as part of its planning efforts for 11 Washington subbasins in the Lower Columbia Estuary and Lower Mainstem province. This information is included LCFRB's Lower Columbia Salmon and Steelhead Recovery and Subbasin Plan Technical Foundation, Volume 4: Programs and Projects Directory.

Also, the Lower Columbia River Estuary Partnership is compiling a comprehensive database on the restoration activities in the two subbasins. The information from process will be integrated into this inventory once completed.

In collecting and summarizing the estuary activities, classification of these activities presents a challenge. One interest's program is another's project; some projects include plans; some plans include research. In other words, the boundary between categories is often crossed.

To avoid wide-spread repetition in this inventory, the planning team developed a single, sortable database, which can be built upon and amended as future activities are added.

These programs, plans, projects and RME studies are listed in the table below, along with the lead agency (or agencies) for each. The type of activity is identified, as is the subbasin area (E-Estuary; M-Mainstem or B-both) to which the activity applies. Summaries of each of these activities are included later in this section in alphabetical order by the activity's title. The titles used are, in most cases, those provided by the respective sponsoring agency. In some cases, the titles have been modified to ensure that the title is descriptive in this context.

Table 3-2: Condensed list of plans, programs, project, or other RME activies (E=Estuary; M=Mainstem; B=Both)

Name of Program , Plan, Project or RME activity	Lead Organization	Reach	Program	Plan	Project	RME
Abernathy, Germany, and Mill Creeks—Multiple Projects	WDFW	E			X	
Acoustic Tracking Array for Studying Ocean Survival and Movements of Columbia River Salmon (BPA#3007)	Kintama Research Organization	E			X	X
Action Plan to Implement the Federal Columbia River Power System Biological Opinion in the Columbia River Estuary	BPA Fish and Wildlife Division, USACE	E		X		
Agency Partnering, WDFW, Columbia Land Trust and the City of Vancouver	WDFW, Columbia Land Trust, City of Vancouver	M		X	X	
Aquatic Conservation Strategy, Forest Service Management Plan	USDA Forest Service	B	X	X		
Avian Predation on Juvenile Salmonids in the Lower Columbia River: Multiple Projects	USGS, Oregon Cooperative F&W Research Unit at OSU, Columbia River Inter-Tribal Fish Commission	M			X	
Biological Opinions and 2004/2004-2008 Implementation Plan	NOAA Fisheries, USFWS, BPA, USACE, US Bureau of Reclamation	B		X		
Bi-State Water Quality Program, States of Oregon and Washington, 1989	WA Department of Ecology, OR DEQ	B	X			
Blind Slough Restoration Project - Brownsmead, Oregon, (CRE #200301500, BPA#30004)	CREST	E			X	
Bonneville Tributaries Subbasin – Limiting Factors Analysis, 2000	WA State Conservation Commission	M			X	
Bull Trout Biological Opinion Effects to Listed Species from Operations of the Federal Columbia River Power System - SEE Biological Opinions and 2004/2004-2008 Implementation Plan	USFWS	B		X		
Canada-USA Shelf Salmon Survival Study (BPA#30010)	Fisheries & Oceans Canada Pacific Biological Station Nanaimo, B.C. Canada V9R 5K6	E				X
Caspian Tern 2000 Draft Season Summary - SEE Avian Predation on Juvenile Salmonids in the Lower Columbia River: Multiple Projects	Oregon State University, WDFW, Columbia River Inter-Tribal Fish Commission, Real Time Research				X	

Name of Program , Plan, Project or RME activity	Lead Organization	Reach	Program	Plan	Project	RME
Characterization of Salmon Habitat in the Tidal-Fluvial Reach of the Columbia River to Support Recovery Planning (BPA#30017)	University of Portland	E			X	X
Chinook River Restoration and Monitoring SEE Pacific Coastal Salmon Recovery Fund (PCRF)	Sea Resources	E			X	
Deep River Restoration SEE Pacific Coastal Salmon Recovery Fund (PCRF)	Columbia Land Trust	E			X	
Coastal Cutthroat Movements in the Columbia River Estuary (BPA #30009)	USFWS	E			X	X
Columbia River Channel Improvements Biological Assessment	USACE	B				X
Columbia River Estuary and The Columbia River Basin Fish and Wildlife Program Report, 2000	Independent Scientific Advisory Board (ISAB), NWPPC	B				X
Columbia River Estuary Atlas of Physical and Biological Characteristics, Columbia River Estuary Data Development Program (CREDDP), 1984	Columbia River Estuary Data Development Program (CREDDP)	E				X
Columbia River Estuary Dredged Material Management Plan, 2001, CREST	CREST	E		X		
Columbia River Estuary Regional Management Plan, 1979, Columbia River Estuary Study Taskforce	CREST	E		X		
Columbia River Terminal Fisheries Research Project (BPA# 199306000) (aka Evaluate Columbia River Select Area Fisheries, and Select Area Fishery Evaluation Project)	ODFW, WDFW, CCEDC	B			X	X
Comprehensive Conservation and Management Plan for the Lower Columbia River, 1999	LCREP	E		X		
Conservation Planning & Implementation SEE Pacific Coastal Salmon Recovery Fund (PCRF)	East Multnomah SWCD	B			X	
Consideration of Ocean Conditions in the Management of Salmon	Bisbal and McConnaha, 1998	B				X
Ecology of Bald Eagles on the Lower Columbia River, 1988	Oregon State University	B			X	X

Name of Program , Plan, Project or RME activity	Lead Organization	Reach	Program	Plan	Project	RME
Ecology Of Marine Predatory Fishes: Influence on Salmonid Ocean Survival, 1998 to present	NMFS	E			X	X
Ecosystem Restoration Plan with Emphasis on Salmonids in the Columbia River Estuary (159 Plan)	USACE	E		X		
Effectiveness Monitoring of the Chinook River Estuary Restoration Project (BPA#30006)	Sea Resources	E			X	X
Endangered Species Act 2004/2004-2008 Implementation Plan for the Federal Columbia River Power System	USACE, US Department of the Interior Bureau of Reclamation, BPA	B		X		
Endangered Species Management Plans for Lower Columbia Coho Salmon	Multiple Agencies	B		X		
ESA Salmon Recovery Planning	NOAA Fisheries, USFWS, States of OR and WA	B		X		
Estuarine Habitat and Juvenile Salmon – Current and Historic Linkages in the Lower Columbia River and Estuary, 2000-present	NMFS, USACE, University of Washington, ODFW, WDFW, Oregon Graduate Institute	E				X
Estuarine Habitat Restoration/Reconnection of Clatskanie River SEE Pacific Coastal Salmon Recovery Fund (PCRF)	Lower Columbia Watershed Council	B			X	
Evaluate Live Capture Selective Harvest Methods for Commercial Fisheries on the Columbia River (BPA# 200100700) *(Not same project as Col Riv Terminal Fisheries Research)*	ODFW, WDFW	B			X	X
Evaluation of Spawning for Fall Chinook and Chum Salmon just below the four Lower most Columbia River Dams (BPA 1999-003-001)	WDFW	M			X	X
Expedited Reconnaissance Study 2001		B				X
Feasibility Study for Pacific Ocean Salmon Tracking (POST) (CRE Project 200008000) - SEE An Acoustic Tracking Array for Studying Ocean Survival and Movements of Columbia River Salmon (BPA#3007)	Kintama Research Organization				X	
Franz Lake National Wildlife Refuge Management Plan	USFWS, Franz Lake National Wildlife Refuge	M		X		

Name of Program , Plan, Project or RME activity	Lead Organization	Reach	Program	Plan	Project	RME
Grays Bay Restoration (multiple phases) SEE Pacific Coastal Salmon Recovery Fund (PCRF)	Columbia Land Trust	E			X	
Gourlay Creek Fish Passage and Fish Habitat Project (LCR Project 200103800)	City of Scappoose, OR	M			X	
Habitat Criteria Summary/Workshop Outcomes, Lower Columbia River (draft)	CREST, LCREP, USACE, American Rivers, 2001	B				X
Habitat Restoration Site Inventory 2001	LCREP, CREST	B				X
Habitat Restoration Program, 2004	LCFRB	B				X
Historic Habitat Opportunities and Food-Web Linkages of Juvenile Salmon in the Columbia River Estuary and Their Implications for Managing River Flows and Restoring Estuarine Habitat	NMFS Northwest Fisheries Science Center	E				X
Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids	NMFS Northwest Fisheries Science Center, WDFW	M				X
Identifying Historical Populations of Chinook and Salmon and Steelhead within the Lower Columbia River and Upper Willamette River ESUs, May 2002 - SEE Historical Population Structure of Willamette and Columbia River Basin Pacific Salmonids	NMFS Northwest Fisheries Science Center, WDFW					X
Implement the Habitat Restoration Program for the Columbia Estuary and Lower Columbia River. (CRE#200301100, BPA#30016)	LCREP and CREST	B			X	
Independent Multidisciplinary Science Team (IMST) Report on the Recovery of Wild Salmonids in Western Oregon Lowlands	Independent Multidisciplinary Sicence Team (IMST)	E				X
Independent Populations of Chinook, Steelhead, and Sockeye for Listed Evolutionarily Significant Units Within the Interior Columbia River Domain	Interior Columbia Basin Technical Recovery Team	M				X
Interagency Fish Passage	USFWS	B	X		X	
Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Samonids	Willamette/Lower Columbia River Technical Review Board	M				X
Lewis and Clark National Wildlife	USFWS, Lewis and Clark	E		X		

Name of Program , Plan, Project or RME activity	Lead Organization	Reach	Program	Plan	Project	RME
Refuge	National Wildlife Refuge					
Lower Columbia Fish Recovery Board Subbasin Planning	LCFRB	B		X		
Lower Columbia Habitat Mapping (LCR #200201200)	LCREP	B			X	X
Lower Columbia River and Columbia River Estuary Ecosystem Monitoring and Data Management (CRE#200301700, BPA#30015)	LCREP	B			X	X
Lower Columbia River and Estuary Research Needs Identification Workshop Proceedings 2003	USACE	E				X
Lower Columbia/Clatskanie Watershed Assessment	Lower Columbia River Watershed Council	B			X	X
Lower Columbia: Grays River Estuary SEE Pacific Coastal Salmon Recovery Fund (PCRF)	Columbia Land Trust	E			X	
Map Subtidal Large Woody Debris and Other Habitat Features in Relation to Fish Distribution in the Lower Columbia River Estuary (BPA#30014)	Battelle Marine Sciences Laboratory	E			X	X
McCarthy Creek Wetland RestorationSEE Pacific Coastal Salmon Recovery Fund (PCRF)	Ducks Unlimited	M			X	
Monitoring of the Chinook River Estuary Restoration Project. (CRE Project 200301600)	Sea Resources	E			X	X
Native Fish Conservation Policy *(See website for other policies)*	ODFW	B	X			
Ocean Survival Of Juvenile Salmonids In The Columbia River Plume, 1998 to present (CRE 2000 Project 199801400)	NMFS Northwest Fisheries Science Center, Oregon Sate University, Oregon Graduate Institute	E				X
Optimization of FCRPS Impacts on Juvenile Salmonids: Restoration of Lower-Estuary and Plume Habitats (BPA#30002)	OHSU, Oregon Graduate Institute	E			X	X
Oregon Columbia Tributaries West: Watershed Analysis, 2001	USDA Forest Service, Columbia River Gorge NSA	M				X
Oregon Spartina Response Plan	Oregon Department of Agriculture	E		X		
Pacific Bald Eagle Recovery Plan, 1986	USFWS (NO NEED FOR REVIEW)	B		X		
Pacific Coastal Salmon Recovery Fund (multiple projects in this matrix)	States of Washington, Oregon, California and Alaska, NOAA	B	X			

Name of Program , Plan, Project or RME activity	Lead Organization	Reach	Program	Plan	Project	RME
Passage of Juvenile and Adult Salmonids at Columbia and Snake River Dams	NMFS Northwest Fisheries Science Center	M				X
Pierce National Wildlife Refuge	USFWS, Pierce National Wildlife Refuge	M		X		
Preliminary Conclusions Regarding the Updated Status Of Listed ESUs of West Coast Salmon and Steelhead	West Coast Salmon Biological Review Team, Northwest Fisheries Science Center, Southwest Fisheries Science Center	B				X
Preserve and Restore Columbia River Estuary Islands to Enhance Juvenile Salmonid and Columbian White-tailed Deer Habitat (CRE#200301800, BPA#30011)	USFWS - Willapa National Wildlife Refuge Satelites, Columbia Land Trust, USGA - BRD Columbia River Research Laboratory	E			X	
Re-introduction of Lower Columbia River Chum Salmon into Duncan Creek (LCR Project 200103800)	WDFW	M			X	
Research , Monitoring, and Evaluation Plan for the Columbia River Estuary and Plume	BPA, USACE, NOAA Fisheries (NMFS)	E	X	X		X
Return to the River	Independent Science Group	B				X
Review of Methods, Progress and Cross-validation Studies Pertaining to Population Trend and Risk Assessment for Columbia River Salmonids - *Draft Technical Memorandum*	NMFS Northwest Fisheries Science Center	B				X
Review of Relative Fitness of Hatchery and Natural Salmon - *Draft Technical Memorandum*	NMFS Northwest Fisheries Science Center	B				X
Revised Columbia White-Tailed Deer Recovery Plan, *1976*	USFWS	B		X		
Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: And Evaluation of Limiting Factors	NMFS Northwest Fisheries Science Center	E				X
RPAs		B		X		
Salmon and Steelhead Limiting Factors Water Resource Inventory Area 24-28, 2000	Washington State Conservation Commission	B				X
Salmon at the River's End, NMFS, 2001 - IN PROCESS	NMFS	E				X
Salmon Steelhead Habitat Inventory Assessment Program (SSHIAP)	WDFW	B	X			X

Name of Program , Plan, Project or RME activity	Lead Organization	Reach	Program	Plan	Project	RME
Salmonid Population and Habitat Monitoring in the Oregon Portion of the Columbia Estuary (BPA#30018)	ODFW	B			X	X
Sandy River Delta Plan and EIS 1996, Watershed Analysis, 1995	USDA Forest Service, Columbia River Gorge NSA	M			X	
Sandy River Watershed Riparian SEE Pacific Coastal Salmon Recovery Fund (PCRF)	Nature Conservancy	E	X		X	
Scappoose Bay Watershed Assessment, 2000	Scappoose Bay Watershed Council	M				X
Skipanon, Youngs Bay, Nicolai Wickiup Watersheds Action Plans, May 2003 (See also: Youngs Bay . . .Watershed Assessments)	Oregon Watershed Enhancement Board, Skipanon, Youngs Bay, Nicolai Wickiup Watershed Councils	E		X		
Status Assessment and Conservation Recommendations of the Caspian Tern in North America, 2002	USFWS	B				X
Steigerwald Lake National Wildlife Refuge	Steigerwald Lake National Wildlife Refuge	M		X		
Subbasin Plan 1990		B		X		
Support Local Salmon Corps Projects SEE Pacific Coastal Salmon Recovery Fund (PCRF)	CRITFC Columbia River Inter-tribal Fish Commission	B	X		X	
Survival and Growth of Juvenile Salmonids in the Columbia River Plume	NMFS	E			X	X
TMDL		B		X		
US Fish and Wildlife Recovery Planning *SEE* ESA Salmon Recovery Planning	USFWS	B		X		
Washington and Oregon Eulachon (Columbia River smelt) Management Program	WDFW, ODFW	B	X			X
Washington State Salmon Recovery Strategy (*See* ESA Salmon Recovery Planning)				X		
Washougal River: Slough Creek Riparian SEE Pacific Coastal Salmon Recovery Fund (PCRF)	State Parks	M			X	
Western Washington Columbia River Tributaries Watershed Analysis, 2001	USDA Forest Service Columbia River Gorge NSA	M				X
Wetlands Functional Assessment City of Vancouver Marine Park	City of Vancouver Water Resources Education Center	M				X

Name of Program , Plan, Project or RME activity	Lead Organization	Reach	Program	Plan	Project	RME
White Sturgeon Mitigation and Restoration in the Columbia and Snake Rivers Upstream from Bonneville Dam	WDFW, ODFW, USGS	M	X		X	
Wood's Landing Chum Spawning Site Protection (BPA#31006)	City of Vancouver	B			X	
Wood's Landing Chum Spawning Site Protection SEE Pacific Coastal Salmon Recovery Fund (PCRF)	Columbia Land Trust	B	X		X	
Working Implementation Plan for Bald Eagle Recovery in Oregon and Washington, July 1990	WDFW, OR-WA Interagency Wildlife Committee	B		X		
Wy-Kan-Ush-Mi Wa-Kish-Wit Spirit of the Salmon The Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes	Nez Perce, Umatilla, Warm Springs, and Yakama Tribes	B		X		
Youngs Bay, Nicolai-Wickiup River and Skipanon River Watershed Assessments, 1999	Youngs Bay Watershed Council, Nicolai-Wickiup Watershed Council, Skipanon River Watershed Council	E				X

3.2.1 *Abernathy, Germany, and Mill Creeks—Multiple Projects*

Lead: Washington Department of Fish and Wildlife

Related to the mainstem Columbia, the Washington Department of Fish and Wildife is implementing projects to determine abundance and monitor natural production of juvenile, smolt and adult salmonids in Abernathy, Germany and Mill Creeks. Adult trapping of coho will provide additional data necessary to better evaluate the origin (hatchery vs. wild) of naturally produced smolt.

These projects include:

- Juvenile Trapping: The WDFW began trapping juvenile coho and steelhead outmigrants in the spring of 2001 on Abernathy, Germany and Mill Creeks. A cone screw-trap was used on Abernathy Creek, and "V"-weirs were used on Germany and Mill Creeks to develop juvenile/smolt production estimates for these systems.
- Adult Trapping: The WDFW is preparing to trap adult fish (primarily coho) on Abernathy creek beginning in October 2001.
- Steelhead Redd Surveys: The WDFW conducts annual winter steelhead redd surveys on these creeks to develop wild winter steelhead population estimates.
- Chinook/Coho Spawning ground surveys: PSMFC conducts these surveys to recover CWTs and gather data for natural spawner escapement estimates.

3.2.2 *Acoustic Tracking Array for Studying Ocean Survival and Movements of Columbia River Salmon (BPA #30007)*

Lead: Kintama Research Organization

There is evidence that different regions of the Pacific Ocean respond in different ways to climate change. These differences should affect the productivity of salmon stocks if specific stocks migrate to different regions.

This project will provide key information on the migratory behaviour and feeding areas of individual stocks of salmon in the ocean. It will develop and evaluate a tracking array to help determine where upper Columbia and Snake River chinook migrate to, and also measure the efficacy of the array in the river and at sea. If results from this pilot study are successful, it will be possible to expand the array's geographic extent and allow concurrent studies on the movements of a wide variety of other Columbia River anadromous fish stocks (all species of salmon, sturgeon, eulachons, shad, and lamprey) at low incremental cost.

The project assesses the feasibility of the array concept on upriver chinook. As a species, the marine distribution of juvenile chinook makes them particularly amenable to experimental evaluation in a pilot study, thereby improving the likelihood that the testing and evaluation phase will be a success. At the same time the project should be able to provide testable scientific results on whether the different survivals of Upper Columbia and Snake River chinook stocks is due these stocks residing in different regions of the coastal ocean. This information will directly address several key areas identified in the 2000 Biological Opinion.

The 2000 Biological Opinion directs the Federal Columbia River Power System (FCRPS) operators to evaluate the full life cycle of the Snake and Columbia River salmon and steelhead. The marine phase of the life history is only dimly understood. Various assumptions have been made in regional planning and computer modeling efforts that the effects of passage through the hydrosystem cause delayed mortality in the estuary or the ocean or that collection and transportation around the dams cause differentially higher delayed mortality than experienced by in river migrants. Major regional decisions and the fate of the fish listed under the Endangered Species Act depend on knowing where mortality is occurring, and what management measures are appropriate to reduce mortality.

This project was a culmination of several previous studies, including A Feasibility Study for Pacific Ocean Salmon Tracking (POST) (CRE Project 200008000).

3.2.3 *Action Plan to Implement the Federal Columbia River Power SYSTEM Biological Opinion in the Columbia River Estuary (Prepared in Response to RPA 158)*

Leads: BPA, USACE

The Fish and Wildlife Division of the Bonneville Power Administration and the U. S. Army Corps of Engineers (known collectively as the Action Agencies for this plan) prepared this Action Plan in response to Reasonable and Prudent Alternative Action 158 of the National Marine Fisheries Service's (NOAA Fisheries) Biological Opinion (BiOp) on operation of the Federal Columbia River Power System, dated December 21, 2000. The intent is to develop a useful Action Plan that articulates the Action Agencies' completed, ongoing, and planned work that implements the BiOp in the Columbia River Estuary, while fulfilling Reasonable and

Prudent Alternative Action 158. The actions outlined in this document are collectively referred to as the Action Agencies' "Estuary Program."

A core team of staff from the Bonneville Power Administration, Corps of Engineers, Pacific Northwest National Laboratories, and NOAA Fisheries, developed the Action Plan based on the agencies' current, planned, and future work to meet the Reasonable and Prudent Alternatives that relate to the Columbia River Estuary.

3.2.4 *Agency Partnering, WDFW, Columbia Land Trust and the City of Vancouver*

Leads: WDFW, Columbia Land Trust and the City of Vancouver

Several agencies developed a plan to protect the area between the Grays River and Hamilton/Hardy Creeks in Vancouver, Washington, approximately one mile upstream of the I-205 bridge on the north shore of the Columbia River, under the guidelines of the 2000 FCRPS biological opinion, action 157. The partners, including WDFW, Columbia Land Trust and the City of Vancouver, submitted a grant proposal to the Washington State Salmon Recovery Funding Board to acquire the parcel of land adjacent to the seeps and conservation easements on two surrounding pieces of property.

The partners have identified an additional land acquisition and purchase of conservation easements of the uplands, wetlands and creek. This second project would entail development of an offshore spawning channel, habitat restoration, removal of non-native plants and vegetation, removal of a fish passage barrier, educational tours and installation of a salmon-viewing camera. WDFW would continue biological research and monitoring for spawning adults, and emerging and outmigrating juveniles.

3.2.5 *Aquatic Conservation Strategy, Forest Service Management Plan*

Lead: United States Forest Service

The Aquatic Conservation Strategy, an integral part of the Northwest Forest Plan, was developed to restore and maintain the ecological health of watersheds and aquatic ecosystems contained within them on public lands. The strategy protects salmonid habitat on federal lands managed by the Forest Service and Bureau of Land Management within the range of the Pacific Ocean anadromy. The components of the Aquatic Conservation Strategy are Riparian Reserves, Key Watersheds, Watershed Analysis, and Watershed Restoration.

3.2.6 *Avian Predation on Juvenile Salmonids in the Lower Columbia River: Multiple Projects*

Lead: USGS-Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, and the Columbia River Inter-Tribal Fish Commission

This effort was initiated in 1997 to assess the impacts of piscivorous waterbirds (i.e., gulls, terns, and cormorants) on the survival of juvenile salmonids in the lower Columbia River. The effort consists of multiple projects funded by BPA between 1998 and 2003.

The project funded in 1998 estimated the numbers of juvenile salmonids consumed by colonial waterbirds (i.e., double-crested cormorant, Caspian tern, California gull, ring-billed gull, glaucous-winged gull) in the lower Columbia River, and identified avian predation conditions and locales.

The project funded in 1999 developed a management plan to reduce avian predation on juvenile salmonids. It implemented chosen management options and evaluated their efficacy through continued monitoring of smolt losses to birds.

The project funded in 2000 monitored and evaluated the efficacy of management initiatives to reduce predation by colonial waterbirds on juvenile salmonids in the lower Columbia River. The project assisted resource managers in the development of a long-term avian predation management plan.

The project funded in 2002 monitored and evaluated the efficacy of management initiatives to reduce predation by colonial waterbirds on juvenile salmonids in the lower Columbia River. It assisted resource managers in the development of a long-term avian predation management plan.

The project funded in 2003 determines predation rates by waterbirds on juvenile salmonids, evaluates the efficacy of management initiatives to reduce avian predation, and assists resource managers in the development of plans for long-term management of avian predation, as warranted.

Season summaries are available at columbiabirdresearch.org. The summaries were compiled by researchers from Oregon State University, U.S. Geological Survey, Columbia River Inter-Tribal Fish Commission, and Real Time

3.2.7 *Biological Opinions and Esa 2004/2004-2008 Implementation Plan*

Leads: NMFS, USFWS, BPA, USACE, Bureau of Reclamation

The National Marine Fisheries Service (NOAA Fisheries) and the U.S. Fish and Wildife Service (USFWS) issued Biological Opinions (BiOps) in December 2000 for the operation and maintenance of the Federal Columbia River Power System (FCRPS). This complex of dams and reservoirs is operated by the U.S. Army Corps of Engineers (Corps), the U.S. Bureau of Reclamation (Reclamation) and the Bonneville Power Administration (BPA), referred to collectively as the Action Agencies. The BiOps examine effects of FCRPS operation on threatened and endangered fish in the Columbia River Basin and prescribe actions to be taken by the Action Agencies to avoid jeopardy to these Evolutionarily Significant Units (ESU) of fish.

The BiOps guide implementation of measures by the Action Agencies to protect and further the recovery of Endangered Species Act (ESA) listed Columbia River basin salmon,

steelhead and bull trout, and Kootenai River white sturgeon (See Table 1-1 for a list of these species). They provide a flexible framework of performance standards for the FCRPS and other conservation measures over the 10-year period from 2000 to 2010.

Implementation plans are called for under the BiOps and provide the conceptual foundation and the management framework for coordinating actions to further recovery. These plans are intended to inform and be informed by, other ongoing state, tribal and regional planning efforts, such as the Northwest Power and Conservation Council's (Council) Fish and Wildlife Program. The 2004/2004–2008 Implementation Plan is the third issued by the Action Agencies and builds on the lessons from our first three years of BiOp planning and implementation.

The Action Agencies again issued this year's one-and five-year implementation plan as a single combined document.

3.2.8 *Bi-State Water Quality Program, States of Oregon and Washington, 1989*

Lead: Washington Department of Ecology, Oregon DEQ

In 1989, the States of Washington and Oregon recognized that more information was needed about the health of the lower Columbia River. A nomination to the National Estuary Program was being discussed, but data was lacking to confirm the degradation that would warrant participation in the program. To address that need, the Lower Columbia River Bi-State Water Quality Program (Bi-State Program) was created in 1990. Its study area was the lower part of the river from Bonneville Dam to the Pacific Ocean, a stretch of 146 river miles.

The Bi-State Program was a public/private partnership jointly administered by the Washington Department of Ecology and the Oregon Department of Environmental Quality and assisted by a Bi-State Steering Committee. Steering Committee members included: environmentalists, industry representatives, private citizens, public ports, local governments, fishing interests, Native American tribes, the Northwest Power Planning Council and state and federal agencies dealing with environmental and natural resource issues.

The Bi-State Program assessed the health of the river by looking at how well the "beneficial uses" of the river were being met. Beneficial uses are defined in state laws and regulations and include water supply, agriculture, fish and wildlife, recreation and commercial uses. The program focused on those beneficial uses that relate to the health of humans, fish and wildlife.

The findings of the Bi-State Program supported nomination of the Lower Columbia River Estuary to the National Estuary Program. The U.S. Environmental Protection Agency announced the Columbia River as one of the waterways accepted into the program in July 1995.

3.2.9 *Blind Slough Restoration Project Brownsmead, Oregon (BPA #30004) (Cre#200301500)*

Lead: Columbia River Estuary Study Taskforce

This project restores tidal exchange between the Columbia River Estuary and Blind Slough in the community of Brownsmead, Oregon. The project includes development and implementation of an effectiveness monitoring program.

The Columbia River Estuary Study Taskforce (CREST), Clatsop Diking Improvement Company No. 7, and the Army Corps have prioritized the following array of activities to restore Blind Slough: installation of water control structures to breach the Blind Slough dike, replacement and/or installation of five constricted culverts, and channel enhancement. The goal of these activities is to restore historic hydrologic and bio-physical connection to the Columbia River Estuary. Restoration of Blind Slough enhances water quality and reconnects seven miles of habitat for aquatic species including migrating salmonids.

The effectiveness monitoring program partners Clatsop Diking Improvement Company No. 7, CREST, the Nicolai-Wickiup Watershed Council, and volunteer landowners from the Brownsmead area. The monitoring activities assist in testing scientific assumptions developed about reconnecting diked tidelands to the estuarine tidal prism. These assumptions were identified in part by the success of previous restoration projects implemented in the Brownmead area which demonstrated water quality improvements and increased fish access to tidal wetland habitat. Through the development of a comprehensive effectiveness monitoring program, information on water quality improvements and increased fish use of the Blind Slough will be compiled and applied to future restoration projects.

3.2.10 *Bonneville Tributaries Subbasin – Limiting Factors Analysis*

Lead: Washington State Conservation Commission, 2000

A number of the Bonneville subbasin tributaries fall within the Columbia River Gorge National Scenic Area and are protected from future development pressure. However, timber harvests, transportation corridors, passage barriers, and rural development have all contributed to habitat degradation in the subbasin, and smaller communities are rapidly developing.

3.2.11 *Bull Trout Biological Opinion Effects to Listed Species from Operations of the Federal Columbia River Power System*

Lead: U.S. Fish and Wildlife

The U.S. Fish and Wildife Service has reviewed the biological assessment and National Environmental Policy Act documents dated December, 1999 submitted by the Bonneville Power Administration, Corps of Engineers, and the Bureau of Reclamation (Bureau) regarding operations of the Federal Columbia River Power System. The action agencies' request for formal consultation was received in December, 1999. This document represents the Service's biological opinion of the effects of the proposed action on two listed fish species: the endangered Kootenai River white sturgeon (Acipenser transmontanus) and the threatened bull trout (Salvelinus confluentus).

3.2.12 *Canada-USA Shelf Salmon Survival Study (BPA # 30010)*

Lead: Fisheries & Oceans Canada Pacific Biological Station Nanaimo, B.C. CANADA V9R 5K6

This project surveys the size, condition, and biological condition of juvenile salmon occupying the British Columbia & SE Alaskan continental shelf regions in the autumn (October). The survey also includes extensive collection of oceanographic data.

This project develops an expanded, multi-year research survey. The survey maps ocean conditions determining the growth and survival of Pacific salmon along the West Coast of North America from the British Columbia-Washington border into SE Alaska, and identifies which stocks of Columbia River salmon forage in the continental shelf of these areas. The expanded

geographic study area is needed because initial results clearly demonstrate that a proportion of the Columbia River salmon are undertaking rapid, directed migrations that quickly take them well out of the area around the mouth of the Columbia River, and into regions with quite different growth and survival potential.

3.2.13 *Characterization of Salmon Habitat in the Tidal-Fluvial Reach of the Columbia River to Support Recovery Planning (BPA) #30017)*

Lead: University of Portland

The Willamette and Lower Columbia Technical Recovery Team has been tasked with developing population delisting criteria for five salmonid Evolutionarily Significant Units (ESUs)1 and assisting the National Marine Fisheries Service (NMFS) and local entities in the development and implementation of habitat recovery measures.

This project facilitates the analysis and recommendations of the Willamette and Lower Columbia Technical Recovery Team (WLC-TRT) and the recently formed Interior Columbia-Snake Technical Recovery Team (ICS-TRT), and generally benefits regional salmon recovery efforts, by identifying and securing essential habitat data on estuary/tidewater areas in the lower Columbia River and its principal tributaries. Consistent with needs identified in the NWPPC's Fish and Wildlife Program, the FCRPS Biological Opinion, and BPA's evaluation criteria for Reasonable and Prudent Criteria, the project addresses four primary objectives:

- Characterize habitat/fish productivity relationships;
- Identify factors for decline and factors that limit recovery;
- Identify early actions for recovery; and
- Identify research, monitoring, and evaluation needs.

The information obtained through this project would enable estimates of current and historic estuary/tidewater habitat capacities, which will be informative in setting goals and monitoring fish performance (e.g., distribution, abundance, and survival and growth rates), and identifying the location, amount, type, and quality of habitat needed to ensure recovery. In combination with data being collected under the auspices of NMFS, USACE, LCREP and other research programs, this project will greatly improve our knowledge base, identify critical uncertainties and knowledge gaps, and provide information necessary to assess habitat health and prioritize conservation actions in the Columbia River estuary and tidewater areas.

The Columbia River estuary and tidally influenced areas serve as important migratory, rearing, and, in the case of certain chum populations, spawning habitat for ESA-listed and non-listed anadromous fish stocks that originate in the Columbia River and Snake River basins. This project will describe the historical and current availability (opportunity) and use of tidewater habitat by different life stages of all anadromous species. Data collection and analysis will be carefully coordinated with LCREP, NMFS, WLC-TRT, ICS-TRT, and other research and management entities active in the lower Columbia River. In particular, we will work closely with the WLC- and ICS-TRTs and regional salmon recovery planning bodies (e.g., Lower

[1] Lower Columbia Steelhead, Lower Columbia Chum, Lower Columbia Chinook, Upper Willamette Steelhead, and Upper Willamette Chinook.

Columbia River Fish Recovery Board) to ensure that their information needs are met and that opportunities for review and comment occur on an ongoing basis. All information generated by this project will be shared with interested parties and disclosed to the public in a timely manner.

3.2.14 *Coastal Cutthroat Movements in the Columbia River Estuary (BPA #30009)*

Lead: U.S. Fish and Wildife Service

This project evaluates the spatial and temporal use of Lower Columbia River habitat by emigrant juvenile and adult coastal cutthroat trout using radio and acoustic telemetry. Specifically, emigrating juveniles (smolts) from Abernathy, Mill and Germany Creeks will be implanted with radio tags and located daily via aerial surveys. Juveniles from the Chinook River will be implanted with acoustic tags and monitored using an array of 36 tethered acoustic receivers in the estuary. Adult cutthroat trout (sexually mature and kelts) will be captured from these four tributaries and implanted with acoustic tags. A reduced acoustic array will be maintained year round to monitor adult movement. This information will be augmented by monthly boat surveys. Where possible, spatial patterns of historical catch data will be reviewed and contrasted with physical parameters generated by the CORIE model of the Lower Columbia River to search for relationships between abundance and hydrology. These data will provide the context in which to gauge how power-associated shifts in the hydrology and ecology of the Lower Columbia River impact cutthroat trout.

3.2.15 *Columbia River Estuary and Columbia River Basin Fish and Wildlife Program Report, 2000*

Lead: Independent Scientific Advisory Board (ISAB), NWPPC

The Northwest Power Planning Council (Council) requested the Independent Scientific Advisory Board (ISAB) to undertake a review of the impacts of estuarine conditions on the Council's mission to "protect, mitigate and enhance fish and wildlife in the Columbia River" as affected by development and operation of the hydroelectric system. The ISAB agreed to undertake the review but cautioned that it was unlikely that it could quantify the impact of changes in the estuary relative to specific program or management actions taken in the upper river. The ISAB could, however, provide a historical perspective and qualitative assessment of impacts, identify potentially useful collaborations, and provide recommendations concerning future efforts needed to more quantitatively address this issue.

While conducting this review, the ISAB became aware that there was extensive overlap between a study by the National Marine Fisheries Service (NMFS) and this ISAB assignment. The ISAB expects the NMFS study will add significantly to an informed response to the Council. Consequently, this report has been prepared as a preliminary reply, with additional detail possibly following publication of the NMFS study.

The ISAB recognizes the limitations of data to directly assess impacts of changes in the estuary on the Fish and Wildlife Program. After our review it is the ISAB's assessment that these changes have been "detrimental" to salmonids and the rebuilding objectives of the Program. This advice is principally based on three major issues:

- The significant loss of peripheral wetlands and tidal channels. These habitats are important to the early rearing, survival and growth of chum salmon, sub-yearling chinook, and smaller coho salmon in other west coast estuaries.

- The extent of change to seasonal flows following development of the hydrosystem. The effects of these changes are closely associated with the impact of the development of the navigation channel. In combination, these developments have resulted in changes to estuarine circulation, deposition of sediments, and biological processes.
- The need for precautionary advice given the current state of most salmonid populations in the Basin, the magnitude of change in the estuary, and the lack of investigations upon which to base alternative advice.

As the Fish and Wildlife Program is developed, the ISAB recommends an aggressive experimental program targeted to reduce the likelihood of prolonged uncertainty about the impact of estuarine conditions. Such a program should incorporate monitoring of the physical environment (such as currently begun via the CORIE program, Oregon Graduate Institute) combined with evaluation of large-scale manipulations of estuarine habitats. The intent of these manipulations would be to study changes presumed to have had negative impacts and to conduct these on a scale that can be measured within the natural environment.

3.2.16 *Columbia River Estuary atlas of Physical and Biological Characteristics*

Lead: Columbia River Estuary Data Development Program (CREDDP), 1984

The Columbia River Estuary Atlas of Physical and Biological Characteristics includes a comprehensive data set of Columbia Estuary ecosystem dynamics. The Atlas was used as an important planning tool for decision makers with a stake in the health of the estuary. The research focused on the linkages among different elements of the food web and the influence on the food web of various physical processes such as current, sediment transport, and salinity intrusion.

3.2.17 *Columbia River Estuary Dredged Material Management Plan, 2001*

Lead: CREST

In 1979, the Columbia River Estuary Study Taskforce (CREST) completed the Dredged Material Management Plan for the Columbia River Estuary. The plan identified 98 dredged material disposal sites, established priorities for their use, and recommended techniques for their protection and control. In 1986, the CREST reevaluated and updated the plan to produce the Columbia River Estuary Dredged Material Management Plan. The objective of this taskforce is to draft a revised and updated Dredged Material Management Plan for the Columbia River Estuary.

3.2.18 *Columbia River Estuary Regional Management Plan, 1979*

Lead: Columbia River Estuary Study Taskforce

This document is the culmination of 4 ½ years of planning by the Columbia River Estuary Study Taskforce (CREST), local jurisdictions, state and federal agencies, and concerned citizens. Impetus for developing the plan came from growing conflicts over use and development of estuarine areas. New environmental protection laws, enacted to preserve rapidly dwindling natural resources, drastically changed the ground rules for development, to the confusion of ports and the private sector. This regional plan was in response to state coastal zone management programs and federal funding under the 1972 Coastal Zone Management Act. The

needs for better management data, long term protection to critical natural resource areas, and channel development all contributed to the planning program.

The Columbia River Estuary Regional Management Plan expresses decisions of the CREST Council on estuarine management issues. The plan has no legal authority except as it is implemented by local governments in revised local comprehensive plans (Oregon) and amended local Shoreline Management Master Programs (Washington). Also, the decisions in the plan do not supercede or negate other management and regulatory authorities, except to the extent provided in state and federal consistency procedures.

The plan includes:

- Summary of Regional Policies
- Management System and Development Standards
- Land and Water Use Plan
- Dredged Material Management Plan
- Restoration and Mitigation Plan
- Plan Implementation

3.2.19 *Columbia River Terminal Fisheries Research Project (CRE Project 9306000)*

Lead: Oregon Department of Fish and Wildife, Clatsop Economic Development Council

The goal of this project is to determine the feasibility of creating or expanding terminal known stock fisheries in the Columbia River Basin to allow harvest of strong anadromous salmonid stocks while providing greater protection of depressed fish stocks. If terminal fishery research proves successful, several benefits are possible: 1. 100-400 percent greater survival of existing hatchery fish when reared/released from net pens. 2. Commercial harvest of hatchery fish with minimal impact on depressed wild runs--fisheries could be 90+ percent ""clean."" 3. Potential for shifting non-Treaty mainstem fisheries to terminal sites allowing much greater escapement of ESA-listed and other stocks.

Project Milestones:

- In 1992, BPA funded 2 year study of overwinter rearing of coho in Youngs Bay net pens, per 1992 NPPC Program.
- In 1993, BPA began 10 year, comprehensive investigation of terminal fishery expansion.
- From l992-l997 this project tested the efficacy of overwinter rearing of coho and spring chinook in Youngs Bay net pens.
- From l995-2003 the plan is to test, rear, and fish in new terminal fishing sites.
- The first year of coho overwinter research returned 33,000 adults to Youngs Bay harvest (2.62% survival) in 1994.

3.2.20 *Columbia River Channel Improvements Project Biological Assessment*

Lead: US Army Corps

The U.S. Army Corps of Engineers (Corps) has prepared this Biological Assessment (BA) for the Columbia River Channel Improvements Project (the Project) to evaluate potential effects on federally listed threatened and endangered salmonids that may be associated with proposed channel improvements1.

In December 1999, Congress authorized the deepening of the Columbia and Lower Willamette Rivers Federal Navigation Channel to 43 feet. The authorized plan would modify the existing federal navigation project for the Columbia and Willamette Rivers and provide for construction of ecosystem restoration features.

This BA is for the Columbia River segment of the authorized project only. This BA was prepared as part of the biological consultation required under Section 7 of the Endangered Species Act (ESA). This reconsultation process was undertaken with the U.S. Fish and Wildife Service (USFWS) and the National Marine Fisheries Service (NMFS).

The location of the proposed project activities will be limited to dredging selected areas; disposing of dredged material in selected pre-approved upland and shoreline locations; and disposing of dredged material in selected flowlane and ocean locations.

Ecosystem restoration features identified as part of the authorized Project include the use of a combined pump/gravity water supply for restoring wetland and riparian habitat at Shillapoo Lake (RM 91); tidegate retrofits for salmonid passage installed at selected locations along the lower Columbia River; and construction of connecting channels at the upstream end of Walker-Lord and Hump-Fisher Islands to improve access to embayments and rearing habitat for juvenile salmonids.

Environmental mitigation features proposed to offset wetland and riparian losses resulting from upland disposal are also included in the authorized project.

3.2.21 *Comprehensive Conservation and Management Plan (CCMP) for the Lower Columbia River, 1999*

Lead: LCREP

The Comprehensive Conservation and Management Plan serves as the strategic plan for the Lower Columbia River Estuary Partnership. It guides all program activities and annual work tasks for the Partnership. Developing and implementing a Comprehensive Conservation and Management Plan is the primary task of a National Estuary Program.

The Management Plan goals are:

- Increase habitat and habitat functions
- Prevent toxic and conventional pollution
- Improve land use practices to protect ecosystems
- Monitor the river for long term and evaluate impact of actions
- Strengthen coordination between the states in water quality and species issues
- Enhance education opportunities about the lower river and estuary to build stewardship among all citizens: individual, municipal, corporate
- The Lower Columbia River Estuary Partnership provides an Actions Status Report for it's Management Plan every 2 years. The most recent report was issued in July, 2003.

3.2.22 *Conservation Partnership: National Performance and Results Measurement System*

Lead: Natural Resource Conservation Service (NRCS)

The Conservation Partnerships in Oregon and Washington are a unique coalition of local, tribal, state and federal groups that mobilizes staff and program funding to help people and communities address natural resource conservation issues. Relying on mixed expertise, authorities, and the common sense each member organization brings to the table, the Partnership strives to realize a shared vision – local people making informed decisions for healthy and economically viable lands.

Natural Resource Conservation Service (NRCS) and the rest of the conservation partnership use the National Performance and Results Measurement System (PRMS) to report conservation progress on private lands. PRMS is not complete for SWCDs and other conservation partners to enter all their accomplishments so the following report underestimates total accomplishments of the partnership. Nationally, state and local options are being added to PRMS which will improve its capability to capture total accomplishments.

During federal fiscal year 2000, over 2,100 acres of resource management systems (RMS) were planned and almost 1,600 acres applied in the lower Columbia and Columbia estuary subbasins. These RMSs benefit fish, wildlife, water quality and overall watershed health by reducing erosion, controlling non-point source pollution and restoring riparian and upland wildlife habitat.

Conservation Planning & Implementation

Lead: East Multnomah SWCD

This proposal is for continuation of an earlier OWEB-funded project. It focuses on providing landowners with technical assistance to develop site-specific conservation plans and installing conservation practices. OWEB funds are requested for personnel, travel, training, supplies, operations, administration and site monitoring for five years.

3.2.23 *Consideration of Ocean Conditions in the Management of Salmon*

Lead: Bisbal and McConnaha, 1998

This paper presents and ecologically based conceptual foundation as a way to incorporate environmental variability in salmon management. The argument addresses the problem of accommodating marine environment variability through actions in freshwater. The paper argues for an approach that considers marine and freshwater environments as integral components of a larger salmonid ecosystem. This contrasts with previous propositions that either relied heavily on technological fixes in the freshwater environment or questioned the value of any recovery effort designed to withstand overwhelming ocean forces. Salmon management requires a more holistic approach incorporating modern understanding of the salmonid ecosystem and its variability.

The paper suggests two strategies. The first calls for deliberate improvement of estuarine and nearshore ocean conditions through regulation of upstream flows, river operations, hatchery production, and other actions. The second calls for improving the resilience of salmon to a variable environment. This requires relaxing anthropogenic factors that hinder the natural range of salmon life history diversity within and between populations, a survival mechanism that evolved in response to changing conditions. These strategies recognize that although the ocean primarily determines overall salmon abundance, management actions, particularly in freshwater, are critical to the ability of salmon to cope with a variable ocean environment.

3.2.24 *Ecology of Bald Eagles on the Lower Columbia River, Oregon State University, 1988*

Lead: Oregon State University

This report provides information regarding diet, management implications and environmental contaminants impacting bald eagles on the lower Columbia River. The major limiting factors included in this report include:

- Declines of bald eagles are due to environmental contaminants including DDE, DDD, hexachlorobenzene, mirex, PCBs, mercury, cadmium and lead.
- Declines in raptor populations have been associated with eggshell thinning induced by the DDT-metabolite DDE (Newton 1979:239).
- Contaminants entering the Columbia River system have an effect on the population.
- The Columbia River acts as a sump for many kinds of contaminants including PCBs.

3.2.25 *Ecology of Marine Predatory Fishes: influence on Salmonid Ocean Survival*

Lead: U.S. National Marine Fisheries Service, 1998 to present

This project, supported by BPA, characterizes, over a 5-year period, the temporal and dynamic nature of the marine fish community off the Columbia River during the spring-summer transition (peak salmonid migration period) and relate dynamics in this marine fish community with salmonid survival.

A primary focus will be identification of the strength of trophic linkages between forage and fish predator species, and the influence of these relationships on predation rates on juvenile salmon. To identify if large marine fishes are a major source of salmon smolt mortality, the project will collect predatory and forage fishes off the mouth of the Columbia River, estimate their abundance, and determine predatory fish feeding habits. Sampling will be conducted from late April to June when juvenile salmon begin outmigration into the nearshore ocean environment. A representative sample of these large marine fish predators will be identified, measured, weighed, and their stomach contents retained for analysis.

The project will also assess ocean water conditions (salinity, temperature, and chlorophyll a). These data will be used to estimate the relationship between the marine fish community structure and juvenile salmon consumption rates in the nearshore ocean adjacent to the Columbia River and begin to describe the environmental factors that influence this predation.

3.2.26 *Ecosystem Restoration Plan With Emphasis on Salmonids in the Columbia River Estuary (RPA 159 Plan)*

Lead: US Army Corps of Engineers

Habitat restoration in the Columbia River estuary (CRE) is an important off-site mitigation action in the 2000 Biological Opinion (BiOp), an operation of the Federal Columbia River Power System. In response to the decline in available habitat, the BiOp's Reasonable and Prudent Alternative (RPA) included mandates to "…develop a plan addressing the habitat needs of juvenile salmon and steelhead in the estuary" (RPA Action 159) and "…develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats…" (RPA Action 160). To meet Action 159 and support Action 160, this document develops a science-based approach designed to improve ecosystem functions through habitat restoration activities in the CRE.

The CRE habitat restoration program's goal and principles focus on habitat restoration projects in an ecosystem context. The program's goal is: Implementation of well-coordinated, scientifically sound projects designed to enhance, protect, conserve, restore, and create 10,000 acres of tidal wetlands and other key habitats to aid rebuilding of ESA-listed salmon populations and native species using the CRE.

The intent of this document is to provide a scientific basis and implementation guidelines for a habitat restoration program designed to improve ecosystem functions and enhance juvenile salmonid survival in the CRE. The approach advocated in this document may be summarized in the following sequence of steps.

- Describe the fundamentals of restoration science.
- Determine usage of CRE habitats by salmonid life history type, i.e., determine which habitats are most important and why
- Determine what CRE habitats have been lost relative to historical conditions (predevelopment in 1900s).

- Identify and prioritize restoration strategies for the CRE and establish a reasonable future condition, given constraints on the system (e.g., flow regulation).
- Determine what specific habitats can be restored and where, i.e., develop an inventory of possible actions.
- Implement locally supported and scientifically based restoration projects.
- Monitor actions using standardized protocols and apply the results to adaptively manage future restoration actions.

3.2.27 *Effectiveness Monitoring of the Chinook River Estuary Restoration Project (BPA #3006)*

Lead: Sea Resources

This project will design and implement a long-term monitoring and evaluation plan to investigate salmon responses to the Chinook River estuary restoration project. It will establish a pre-restoration baseline condition of existing estuary use by juvenile salmon as well as monitor certain habitat attributes. This project will continue to monitor these parameters after the restoration project is completed in order to complete pre and post project comparative analyses. It will use a variety of capture and marking techniques to determine abundance and length of residency of salmon in the Chinook River estuary. This project will also implement a concurrent habitat monitoring component to measure specific habitat attributes by installing five data loggers for continuous monitoring of temperature, salinity, dissolved oxygen and tidal stage.

Since little is known about the ecological importance of the estuary for Columbia River salmon, current restoration plans in the estuary are based on inferences from studies in other watersheds. Therefore, it is important that any early restoration projects in the Columbia River estuary be carefully monitored in order to evaluate salmon responses to estuary restoration. The Chinook River estuary restoration project offers an excellent opportunity to answer some of the uncertainties regarding estuary restoration and salmon recovery.

3.2.28 *Endangered Species Act 2004/2004-2008 Implementation Plan for the Federal Columbia River Power System*

Lead: USACE, US Department of the Interior Bureau of Reclamation, BPA

This *2004/2004–2008 Implementation Plan* is the third issued by the Action Agencies and builds on the lessons from their first three years of BiOp planning and implementation. The Action Agencies are again issuing this year's one- and five-year implementation plans as a single combined document. The following is an overview of sections included in this document:

Section 1.0–Overview

Describes the context for the Action Agencies' five- and one-year implementation plans, the structure of this year's document and a summary of shifts from prior implementation plans.

Section 2.0–Goals

Identifies the goals derived from the "All-H Strategy" and evaluated using established performance standards.

Section 3.0–Performance Measures and Standards

Describes the performance standards and measures, or metrics, that will be used to determine success of implementation actions. Proposed changes to the performance standards and measures are also explained.

Section 4.0–Strategies to Achieve Recovery

Describes the Action Agencies' strategic approach for coordinating and implementing fish recovery efforts over the life of the BiOps.

Section 5.0–Priorities, Work Plans and Outcomes (2004–2008)

Details the Action Agencies five-year outcomes and one and five-year work plans for BiOp implementation. The five-year portion serves as a "big picture" blueprint that organizes collective efforts by the three Action Agencies to achieve certain outcomes by 2008. The one-year portion provides a more detailed description of implementation measures planned for the upcoming fiscal year (October 2003 to September 2004). The work plans describe the specific tasks that need to be accomplished to achieve the identified outcomes.

Section 6.0–Coordination Forums

Describes the regional forums and other entities with which the Action Agencies coordinate fish recovery measures.

Appendix A–Project Tables (separate document)

Lists of specific projects the Action Agencies propose to implement from 2004 to 2008, based on the listed ESUs and H-categories, respectively. New and ongoing actions planned for implementation by the Action Agencies are included. Further project level detail is available to NOAA Fisheries and USFWS on request.

As expected, the implementation plans are dynamic and will continually evolve as information and experience advance. Each year, new implementation plans and a progress report will be issued and will inform NOAA Fisheries' annual Findings Letter. Each year, the plans will be further refined as progress and results are reported. Future updates to the plans will reflect new information, including recommendations from the fish recovery planning processes or input received through the regional coordinating forums.

3.2.29 *Endangered Species Management Plans for Lower Columbia Coho Salmon*

Leads: Oregon Department of Fish and Wildlife, Oregon Department of Forestry, Oregon Department of Transportation, Division of State Lands, Oregon Parks and Recreation Department, Oregon Water Resources Department.

The Oregon Fish and Wildlife Commission (OFWC) listed lower Columbia River wild coho salmon as an endangered species in July 1999. Under provisions of Oregon's threatened and endangered Species law, state agencies that have a conservation role must prepare an endangered species management plan and have this plan approved by the OFWC by July 2001.

Agencies that have produced endangered species management plans are: ODFW, ODF, DSL, WRD, OPRD, ODOT.

These plans address the key elements as described by OAR 635-100-0140, section 6. Those elements include:

- Land covered in the plans

- The role that land will play in conservation of the species
- How the agency will manage that land
- Monitoring
- Schedule for subsequent reviews
- Relationship to other state and federal plans
- Process used to develop plans

3.2.30 *ESA Salmon Recovery Planning*

Lead: Multiple agencies

Chinook and chum salmon, steelhead, and bull trout in the lower Columbia have been listed as threatened under the ESA. As the listing agency under the ESA, NOAA Fisheries (NMFS) is responsible for developing plans to recover chinook and chum salmon and steelhead. The US Fish and Wildife Service (USFWS) is responsible for developing a bull trout recovery plan.

NOAA Fisheries Recovery Planning

The basic unit used by NMFS for listing and delisting salmonid species is the Evolutionarily Significant Unit. An ESU is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout that is uniquely adapted to a particular area or environment and cannot be replaced. In the lower Columbia region of Oregon and Washington, there are three ESUs: Chinook River chum salmon; Lower Columbia Steelhead; and Lower Columbia chinook salmon.

A recovery domain is a collection of geographically proximate ESUs. The Willamette/Lower Columbia Domain includes the three lower Columbia ESUs and two Willamette ESUs. NMFS has initiated efforts to develop a single recovery plan for the Willamette/Lower Columbia Recovery Domain.

NMFS desires to develop this domain recovery plan through a collaborative effort involving federal and state agencies, tribes, local governments, and the public. Under the proposed approach, the recovery plans being developed in Washington and Oregon for the lower Columbia ESUs will be combined with the recovery plans being developed for the Willamette ESUs to create a single domain plan. The Willamette/Lower Columbia ESA Executive Committee is coordinating the overall domain planning effort and will ensure 1) that the separate Oregon and Washington planning efforts are consistent and compatible, and 2) that they will result in a domain plan that meets ESA requirements. The committee comprises policy-level representatives from federal agencies, tribes, Washington and Oregon agencies, and local governments.

The LCFRB is coordinating the Washington recovery planning efforts for the lower Columbia. The LCFRB recovery/subbasin plan will be incorporated in the Willamette/Lower Columbia Domain Plan. It is expected that NMFS will approve the LCFRB plan as the ESA recovery plan for those areas of the three listed lower Columbia ESUs in Washington, even if Oregon has not completed its plan for the Oregon portions of the ESUs.

NMFS also has established the Willamette/Lower Columbia Technical Recovery Team (TRT) to provide technical advice on recovery-related issues. The TRT comprises scientists from NMFS, state agencies, academic institutions, and private consulting firms. The TRT has focused

on developing guidelines for viability criteria for the listed species. These guidelines will assist NMFS in identifying criteria for delisting species. These criteria will describe the conditions under which a listed species or ESU is no longer in danger of extinction (endangered) or likely to become so in the foreseeable future (threatened).

US Fish and Wildlife Recovery Planning

Bull trout was listed as threatened in the coterminous United States in November 1999. In December 1999, USFWS completed a draft bull trout recovery plan for five western states—Washington, Oregon, Idaho, Montana, and Nevada. The plan is broken down into four Distinction Population Segments. Each Distinct Population Segment is broken into recovery units and mini-recovery plans have been developed for each recovery unit. Much of the USFWS Lower Columbia Recovery Unit falls within the LCFRB planning area.

The objectives of the draft USFWS bull trout plan are to:

- maintain the current distribution of bull trout within core areas and to restore distribution where possible
- maintain stable or increasing trends in bull trout abundance
- restore and maintain suitable habitat conditions for all bull trout life history stages
- conserve genetic diversity and provide opportunity for genetic exchange

The recovery planning process being coordinated by the LCFRB will build on the provisions of the USFWS Lower Columbia Recovery Unit plan to refine bull trout recovery strategies for the lower Columbia and will ensure that bull trout recovery efforts are woven into the broader salmonid recovery strategies and actions for the lower Columbia.

State Recovery Efforts

Some states have developed their own management and recovery plans for Columbia Basin fish and wildlife resources. Coordination with basinwide recovery efforts is ensured through participation of key state representatives in regional groups.

The Oregon Plan for Salmon and Watersheds is the state framework for implementing state activities that benefit listed fish within the Oregon portion of the river basin. Success depends on implementing and integrating four key parts of the plan— agency actions, voluntary restoration actions, monitoring, and science oversight—that together provide innovative solutions to support recovery of native fish, improve water quality and restore watersheds.

Washington's 1998 Salmon Recovery Planning Act provided the framework for developing and funding habitat protection and restoration projects. The Statewide Strategy to Recover Salmon guides programs to improve the habitat of listed species and assist in recovery planning.

Estuarine Habitat and Juvenile Salmon – Current and Historic Linkages in the Lower Columbia River and Estuary

Leads: NMFS, USACE, University of Washington, ODFW, WDFW, and the Oregon Graduate Institute, 2000-present

This is a study to identify important estuarine habitats and to evaluate the role of the Columbia River estuary to juvenile salmon. The approach will be to 1) determine the relationship between habitat and the presence, use, and benefit to juvenile salmon, with an emphasis on subyearling chinook salmon, in the lower Columbia River and estuary and 2) understand change in flow, sediment input, and availability of habitat in the lower Columbia River and estuary.

A modeling effort to evaluate the impact of physical change (natural and anthropogenically-induced variability) on the availability of critical salmon habitat is planned as part of the study. To accomplish this objective, researchers plan to use the CORIE numerical modeling system for the lower Columbia River and estuary. This modeling system is being independently developed and validated. It will be used here to evaluate availability of habitat affected by variation imposed by both natural processes and anthropogenic manipulation of the system and further, to a limited extent, associations between salmon use and habitat type.

3.2.31 *Estuarine Habitat Restoration/Reconnection of Clatskanie River*

Lead: Lower Columbia Watershed Council

This project would breach a 110-foot long dike on the Clatskanie River that currently joins Anunde Island with the mainland, thus restoring the free flow of water through the historic side channel, and stabilize and re-vegetate the newly exposed surfaces.

3.2.32 *Evaluation of Live Capture Selective Harvest Methods for Commercial Fisheries on the Columbia River, 2001. (Lcr 200100700)*

Lead: Oregon and Washington Departments of Fish and Wildlife

The primary goal of this ongoing project is to develop, evaluate, and implement commercial live capture, selective harvest methods in the Lower Columbia River. The states' intent is for commercial fishers to contribute to the conservation of depressed or listed species by selectively harvesting fish from strong stocks, while releasing those from weak stocks live and unharmed to continue their upstream migration.

Studies concerning live capture commercial fishing gears and methods were initiated with an Oregon Department of Fish and Wildlife (ODFW)-funded pilot project in 2000 and expanded with Bonneville Power Administration (BPA)-funded projects in 2001 and 2002. Since 2000, a significant amount of knowledge has been gained from these projects. Data collected and analyzed is providing guidance regarding live capture commercial fishing gears and methods. Additionally, a once skeptical commercial fishing industry has become supportive of efforts to institute live capture commercial fisheries in the lower Columbia River.

Results to date indicate that small mesh gear is effective at allowing high survival rates for spring chinook handled; however, results to date also raise concerns as to the handle of non-target species, especially winter steelhead. In response to results to date this proposal in

focussing primarily on mesh size studies to identify the appropriate gear to harvest hatchery spring chinook while reducing handle of and impact to winter steelhead.

3.2.33 *Evaluation of Spawning for Fall Chinook and Chum Salmon Just Below the Four Lower Most Columbia River Dams, 1999-2001 (BPA # 1999-003-001)*

Lead: Washington Department of Fish and Wildlife

Fish and Wildlife Program funding for this project began in October 1998 (Fiscal Year 1999). The project is composed of three closely related activities. Pacific States Marine Fisheries Commission (PSMFC) is leading the adult studies portion, ODFW is leading the juvenile studies portion, and the U.S. Fish and Wildife Service (USFWS) is leading the habitat assessment portion of the project.

ODFW and PSMFC have conducted chum salmon spawning ground surveys from The Dalles Dam downstream to the estuary, and are scheduled to continue those surveys. These two Agencies also began adult and juvenile studies in the Ives/Pierce Island complex in 1998, and those studies are also ongoing. USFWS began habitat assessment studies in 1998 and were joined by the U.S. Geological Survey (USGS) and Pacific Northwest National Laboratories (PNNL) in 1999. Habitat assessment studies are ongoing downstream from Bonneville Dam. PNNL is also assisting with portions of the adult and juvenile studies. Adult, juvenile, and habitat studies are designed to be complementary to achieve the purposes of this project, and each lead Agency is responsible for their respective objectives based on their special skills, knowledge, and experience in those areas.

3.2.34 *Expedited Reconnaissance Study 2001*

Lead: Army Corps of Engineers

This feasibility study, authorized by a resolution of the Senate Committee on Environment and Public Works, investigates and recommends appropriate solutions to accomplish ecosystem restoration in the lower Columbia River and estuary, including wetland/riparian habitat restoration, stream and fisheries improvement, water quality and water-related infrastructure improvements.

3.2.35 *Franz Lake National Wildlife Refuge*

Lead: USFWS, Franz Lake National Wildlife Refuge

The Franz Lake National Wildlife Refuge is part of the Ridgefield National Wildlife Refuge in southwest Washington. It contains more than 500 acres of river bottomland and upland riparian habitat with numerous springs, seeps and creeks, grasslands, hardwood and upland forests. Franz Lake is one of the few remaining natural wetlands in the Columbia River Gorge. The refuge provides critical wintering habitat for tundra swans and other waterfowl and year-round habitat for a variety of wildlife species.

The refuge development and management efforts aim to:

- Maintain a native diversity of wetland habitats for breeding/migrating/wintering waterfowl and other aquatic migratory birds, with a special emphasis on tundra swans.
- Provide and enhance habitat for endangered, threatened and sensitive species.
- Enhance wildlife diversity through habitat management.

- Restore natural, dynamic stream/river systems, including their associated in-water and riparian habitats for anadromous fish, breeding neotropical birds and other native fish and wildlife.
- Provide opportunities for quality, wildlife-dependent recreation, education and research to enhance public appreciation, understanding and enjoyment of refuge fish, wildlife and habitats.
- Preserve designated cultural resources.

The Ridgefield National Wildlife Refuge Complex is comprised of five refuges located in the southwest part of the state of Washington: Ridgefield north of Vancouver; Conboy in the southcentral part of the state; and Franz Lake, Pierce and Steigerwald Lake all located in the Columbia River Gorge.

3.2.36 *Gourlay Creek Fish Passage and Fish Habitat Project (LCR Project 200103800)*

Lead: City of Scappoose, Oregon

This project consists of planning, design and construction of a fish passage (ladder) facility in Gourlay Creek and would include an initial 3-year monitoring element as well as longer term fish and flow monitoring.

The project would open up over 2 miles of habitat for ESA candidate species (Coho and cutthroat trout) and nearly 4 miles of habitat for ESA listed steelhead. The City of Scappoose owns and manages close to half of the Gourlay Creek Watershed including high quality habitat above and below the Gourlay Creek Dam. Gourlay Creek is also one of the City's municipal watersheds. The City of Scappoose, the Scappoose Bay Watershed Council (SBWC), local residents, local high school kids, OR Dept. of Fish and Wildlife, OR Trout, OR Dept. of Forestry, Olympic Resources (local timber company), OR Dept. of Water Resources, Bonneville Power Administration, and OR Department of Environmental Quality have undertaken assessment and restoration work in the SBW and Gourlay Creek watersheds. These efforts demonstrate both the ecological importance of the watershed and the significance of addressing the fish barrier problems.

There is a continued high level of support and interest in conserving and restoring salmonid habitat in the Gourlay Creek Watershed. The City has worked with the SBW council for the past 3 years monitoring water quality on Gourlay Creek and over the past 2 years has undertaken extensive assessment and begun restoration work with ODFW, the SBW council, and other watershed partners. The City of Scappoose is also in the process of developing a long-term management plan for City forestlands in the watershed. The Gourlay Creek Fish Passage and Fish Habitat Project is a major piece of the overall fish conservation and restoration efforts in the watershed. Ongoing and proposed fish monitoring efforts will help ensure that the effectiveness of the project and provide a basis for adaptive management in the watershed.

Gourlay Creek Dam is a key limiting factor in the re-generation of salmon and trout in the Gourlay Creek watershed. Currently it provides a complete barrier to fish passage to ESA listed salmonids as well as to salmonids that are under status review for ESA listing. Historically, Gourlay Creek has provided important salmonid habitat within the Scappoose Bay Watershed (SBW). Salmonids still utilize the lower reaches of Gourlay Creek.

3.2.37 *Habitat Criteria Summary/Workshop Outcomes, Lower Columbia River (Draft)*

Leads: CREST, LCREP, Army Corps of Engineers, and American Rivers, 2001

This workshop was convened in Astoria, Oregon, in June, 2001, in order to address the need of resource managers for a scientifically acceptable approach to making decisions regarding projects that impact habitat or affect the protection and restoration of habitat. With the limited knowledge that is available, it is important that projects that have the highest probability of success are identified and implemented and then monitored carefully with appropriate control sites so that an adaptive approach to habitat protection and restoration can be instituted.

The workshop focused on developing scientific criteria for identifying and prioritizing habitat protection and restoration projects on the lower Columbia River. Over one hundred national and regional experts and agency resource managers met for the intensive two-day session. Workshop participants reviewed available information on lower Columbia River ecological processes, particularly those related to salmonid use, and distilled that information through a series of workgroup sessions into a set of draft habitat restoration and protection criteria. The draft criteria represent a set of scientifically educated guesses about where to focus restoration and protection activities in the lower river.

The criteria developed at the workshop were the first step in a process that will ultimately lead to a institutionalized process for selecting habitat projects that are both scientifically sound and contribute to the protection and restoration of salmon and other native species. The Lower Columbia River Estuary Partnership Science Work Group and a select group of workshop participants are engaged with agency scientists and policy makers in refining the criteria and coordinating application of the habitat restoration criteria and priorities into on the ground projects.

3.2.38 *Habitat Restoration Site inventory 2001*

Leads: Lower Columbia River Estuary Partnership, Columbia River Estuary Study Taskforce

Building on past restoration planning activities, CREST and LCREP continues to expand its spatially referenced habitat database identifying potential habitat restoration, protection, and enhancement opportunities in the Lower Columbia from the mouth of the Columbia to Bonneville dam. The data gathered to this point is iterative and interactive to include more site-specific conditions and reflect changes in restoration planning strategies. The database serves as the first “crack” at a comprehensive restoration strategy for the Lower Columbia.

3.2.39 *Habitat Restoration Program (LCREP, 2004)*

The mission of the Lower Columbia River Estuary Partnership’s proposed Habitat Restoration Program is to implement and monitor strategic, well-coordinated, scientifically sound projects designed to rehabilitate, enhance, protect, conserve, create, and restore 16,000 acres tidal wetlands and other key habitats to support native species using the Lower Columbia River estuary from the river’s mouth to Bonneville Dam, with a special emphasis on ESA listed species, and other focal species described in the Comprehensive Conservation Management Plan and the sub-basin plan. The following four goals are contemplated:

- Map, quantify, and compare the pre-twentieth century and current aquatic habitats of the estuary. The historic condition of the estuary provides an important template for restoration planning. It indicates where habitats used to occur, their natural, size, shape, community

composition, and connectedness to other elements of the ecosystem. How much of various habitat types were present, where were they located, how were they organized/arranged, and their geomorphology are all important considerations. Fulfilling this goal will allow us to understand how the estuary aquatic habitats have changed and use data on previous presumably productive habitat conditions to guide the project selection process. This goal is currently included in LCREP's proposed habitat restoration program.

- Establish goals, objectives, and scientific principles for restoration in the estuary. This goal provides a scientific basis for restoration using the best available research data in the context of the mission and specific program objectives Efforts will be undertaking to identify locations where carefully targeted restoration activities should be undertaking where there is high confidence in their ecological benefits and success, and where there is a high likelihood that they will enhance our understanding about how to restore the estuary. Sequencing and prioritizing actions will depend upon the results of earlier actions and unpredicted changes occurring in the landscape.
- Establish a program infrastructure including a framework for soliciting, developing, selecting, and funding priority restoration projects.
- Establish habitat monitoring program. Monitoring is a critical component of ecosystem recovery planning. Monitoring designs are intended to provide high quality data on the restoration of the Estuary, including how it works, how it responds to changes (our actions), and how well we are able to predict what we think is going to happen. Monitoring activities include specific projects designed to gather project-specific data, efforts to assess restoration progress on a regional scale, and projects to continue the collection of long-term trend information for species, habitats, and hydrologic data. Monitoring is intended to provide information that is integrated into an adaptive management process.

3.2.40 *Historic Habitat Opportunities and Food-Web Linkages of Juvenile Salmon in the Columbia River Estuary and their Implications for Managing River Flows and Restoring Estuarine Habitat (BPA #30001)*

Lead: Northwest Fisheries Science Center, National Marine Fisheries Service

This project addresses specific information needs identified in a recent interdisciplinary assessment of the hydroelectric system's impacts on estuarine habitat conditions for juvenile salmon. The primary elements of this project include: (1) retrospective analyses to reconstruct historic bathymetric features and assess effects of climate and river flow on the extent and distribution of shallow water, wetland and tidal-floodplain habitats; (2) computer simulations using a 3-dimensional numerical model to evaluate the sensitivity of salmon rearing opportunities to various historical modifications affecting the estuary (including channel changes, flow regulation, and diking of tidal wetlands and floodplains); and (3) life-history specific information based on present and historic food web sources as determined by stable isotope, microchemistry, and parasitology techniques. From these data and additional modeling simulations selected during an estuarine habitat restoration workshop, this project (4) examines effects of alternative flow-management and habitat-recovery scenarios on habitat opportunity and the estuary's productive capacity for juvenile salmon.

The Columbia River estuary serves as an important migration, rearing, and transition environment for juvenile anadromous salmon before they enter the sea. Historical modifications

to the estuary, including diking of peripheral wetland and floodplain habitats and regulation of river flows by dams, have reduced salmonid access to shallow rearing habitats and may have eliminated sources of macrodetritus that fuel the estuary's food webs. Although there is emerging evidence that these estuarine changes are limiting juvenile salmon production and life history diversity, lack of information about historic and modern habitat conditions in the estuary, or the ecological consequences of habitat change, undermine existing salmon recovery efforts of the Columbia Basin Fish and Wildlife Program.

3.2.41 *Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids*

Lead: NMFS Northwest Fisheries Science Center, WA Department of Fish and Wildlife

In 2000, the Population Identification Subcommittee of the Willamette/Lower ColumbiaTechnical Recovery Team (WLC-TRT) convened to review information relevant to the identification of historical, demographically independent populations of chinook salmon (Oncorhynchus tshawytscha), chum salmon (O. keta), and steelhead (O. mykiss) within their recovery domain. This document presents the preliminary conclusions of the subcommittee.

The historical population boundaries and designations provided are intended to be representative of the range and diversity of populations for each species in the listed evolutionarily significant units (ESUs), not necessarily an exact reconstruction. Furthermore, the population boundaries presented delimit the basin area used by spawning adults from each population. It is understood that many of the populations share areas for juvenile rearing, migration corridors, and ocean feeding.

The Willamette/Lower Columbia Technical Recovery Team's (WLC-TRT) goal is to identify historical and extant independent populations of salmonids in listed evolutionarily significant units (ESUs).

The populations ultimately identified are the demographically independent units for which viability will be estimated. These populations are the independent groups of fish whose historical and present condition will be characterized in future papers. For each population, we will describe numbers and productivity of salmon, life-history and phenotypic diversity, and spatial distribution of spawning and rearing groups. In addition, we will estimate the habitat capacity for each population under historical and present conditions. In the ultimate recovery goals expressed, the populations identified in this document will be those considered when answering the question: "How many and which populations are necessary for the persistence of the ESU?"

Implementation of the Habitat Restoration Program for the Columbia Estuary and Lower Columbia River (BPA # 30016)

Lead: Lower Columbia River Estuary Partnership and Columbia River Estuary Study Taskforce

This project establishes a program to identify and prioritize on-the-ground habitat restoration projects and plan their monitoring and evaluation. It takes action on six restoration projects already processed and approved through regional and local workgroups.

Efforts to protect existing habitat and restore altered habitat have been initiated and a long-term action plan developed. The work to be accomplished under this project will continue to institutionalize this effort as it implements the habitat restoration program for the long-term and takes action on beneficial, already-scrutinized habitat restoration projects in the short-term (three years). The outcome of this project will be increased survival of juvenile salmonids.

Restoration of habitat for juvenile salmonids migrating through the Lower Columbia River (below Bonneville Dam) and the Columbia Estuary is an important component of regional recovery plans. The lower river and estuary are critical areas in the migration corridor for Columbia Basin anadromous fish, especially ocean-type listed as Threatened or Endangered, because they provide refugia from predators, feeding grounds, and areas to transition physiologically from freshwater to saltwater. However, over the last 100 years, the amount of available wetland habitat in this region has decreased by about 75% over historical levels because of dike and levee building, hydrosystem operations, and other activities.

3.2.42 *Independent Multidisciplinary Science Team (Imst) Report on the Recovery of Wild Salmonids in Western Oregon Lowlands*

Lead: Independent Multidisciplinary Science Team (IMST), Oregon Plan for Salmon and Watersheds, 2002

This report discusses major characteristics of western Oregon's lowland rivers, streams, and estuaries that the IMST finds to be important to wild salmonids. It describes how landscape scale factors – landscape structure, landscape function, disturbance regimes, and landscape scale biological processes – historically supported salmonid populations in western Oregon lowlands. The report also covers human modifications to these ecosystems that impact salmonids. It assesses how lowland land use practices may have altered lowland systems so that the landscape's ability to support healthy salmonid populations was reduced. Finally, it discusses how functioning lowland ecosystems might be protected and restored.

The geographic scope of this report is the lowland portion of Oregon west of the crest of the Cascade Range.

3.2.43 *independent Populations of Chinook, Steelhead, and Sockeye wor Listed Evolutionarily Significant Units within the interior Columbia River Domain*

Lead: Interior Columbia Basin Technical Recovery Team

In this document, the Interior Columbia River Basin Technical Recovery Team provides the background, analysis, and recommendations on the identification of independent populations of the seven Evolutionarily Significant Units (ESUs) of anadromous salmonids listed under the Endangered Species Act in this recovery domain.

We describe current population structure in the seven listed salmonid ESUs in the interior Columbia Basin. In addition, we review historical documentation and describe likely differences in population structure prior to major anthropogenic manipulation of the region. The populations identified in this document are the independent groups of fish for which we will assess status and establish viability goals in future reports.

We examined an array of indicators to assess the independence of populations, including: (1) genetic information, (2) geography; (3) life-history traits, (4) morphological traits, and (5) population dynamics. As putative demographically independent units, these main populations become the focus of recovery planning and conservation efforts in the interior Columbia River basin. These delineations will necessarily play an important role in establishing viability goals at both the population and ESU level.

Our delineations of extant populations include the following:

- Snake River spring/summer chinook ESU: 31 populations
- Upper Columbia spring chinook ESU: 3 populations
- Snake River Fall chinook ESU: 1 population
- Snake River steelhead ESU: 25 populations
- Upper Columbia steelhead ESU: 3 populations, and 1 of ambiguous status
- Mid-Columbia steelhead ESU: 17 populations
- Snake River sockeye: 1 population

We also identified historic populations within current ESU boundaries, and discussed large areas currently blocked to anadromous passage. Finally, we describe data needs that would improve population delineation efforts.

3.2.44 *Iinteragency-ODFW Fish Passage*

Lead: ODFW

The Fisheries Restoration and Irrigation Mitigation Act of 2000 (FRIMA) (PL 106-502) created this federal partnership fish screening and passage program in Idaho, Oregon, Washington and western Montana administered by the U.S. Fish and Wildife Service (USFWS). The purpose of this program is to match federal funds with local, state, and tribal programs to increase fish survival, reduce entrainment in existing water distribution systems, and increase access to productive fish habitat.

3.2.45 *Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids*

Lead: Willamette/Lower Columbia River Technical Review Board

This document presents the WLC-TRT's viability criteria guidelines. In approaching the development of criteria for delisting ESUs, the TRT relied on the language in the ESA, information described in the listing decision, concepts outlined in a report on viable salmonid populations by McElhany et al. (2000), and in published research describing salmon populations and their past or potential responses to changes in climate and ocean conditions (e.g., Bradford and Irving 2000).

In considering how viability criteria might inform population delisting requirements, the TRT considered all five of the factors for decline identified by the NMFS. The TRT approach evaluates the extinction risks facing an ESU by assessing the viability of the individual populations within that ESU. The TRT identified population-level viability criteria based on:

- a combination of the four population parameters identified in the VSP document – productivity, abundance, spatial structure, and diversity;
- information about the habitat requirements of the listed salmon; and
- the need to separate population responses to freshwater and estuarine habitat conditions from population responses to fluctuating marine and climatic conditions.
- Building from these population-level criteria, the TRT developed a framework to estabish ESU viability criteria.

3.2.46 *Johnson Lake Revegetation Projects*

Lead: City of Portland

By planting native species and managing invasive species, WRP will restore wetland forest on the 13.2 acre Johnson Lake site, including .4 mile of lake shore and .7 mile of slough channel bank. The 8.5 acre Hayden Meadows project will replace Himalayan blackberry with native riparian vegetation, including .45 mile of slough channel bank, and addresses erosion and sediment control along the slough channel.

Source: Project List Since Summary - Formattted

3.2.47 *Lewis and Clark National Wildlife Refuge*

Lead: Lewis and Clark National Wildlife Refuge, USFWS

Lewis and Clark National Wildlife Refuge includes about a third of the Columbia River estuary in Oregon, beginning 12 miles above the river's mouth and extending for 15 miles. It contains about 20 named islands totaling about 8,300 acres, as well as about 35,000 acres of sandbars, tidal marshes, mudflats, and open water.The estuary is a wintering and resting area for waterfowl that nest in Alaska and winter in Oregon and California. Many species of fish use the estuary for spawning, as a nursery, for feeding, and as a passageway between the ocean and upper Columbia River. Black bear, deer, elk and numerous smaller mammals are also present.

The Refuge’s development and management efforts aim to:

- Manage for conservation and recovery of threatened and endangered animal species in their natural ecosystems.
- Maintain a native diversity of wetland habitats for breeding/migratory/wintering waterfowl and other aquatic migratory birds associated with the Columbia River estuary.
- Maintain a native diversity of habitats for fish and wildlife associated with the Columbia River estuary.
- Provide opportunities for wildlife/wildlands-dependent recreation, education and research.

3.2.48 *Lower Columbia Fish Recovery Board (LCFRB) Subbasin Planning*

Lead: Lower Columbia Fish Recovery Board

LCFRB is a Washington State entity with responsibility for restoring listed fish populations within the state's southwestern five-county regions. It is leading a collaborative approach to restoring threatened anadromous fish species and rebuilding other focal fish and wildlife species in the Washington Lower Columbia River region. This approach integrates ESA recovery planning, NPCC subbasin planning, State salmon recovery strategies, and state watershed planning into a single coordinated regional planning process. The goal of this recovery/subbasin planning initiative is to develop a scientifically credible, socially and culturally acceptable, and economically and politically sustainable plan to:

- restore the region's four fish species listed as threatened under the ESA to healthy, harvestable levels
- protect and enhance other fish and wildlife species that have been adversely affected by the development and operation of the federal Columbia River Power System
- Through this process, by May 2004 eleven distinct subbasin plans will be rolled into a single comprehensive recovery/subbasin plan. The plan will address the recovery of four ESA listed species (chinook, steelhead, chum and bull trout) within the context of the 4Hs: habitat, hydroelectric, harvest, and hatchery impacts. Beyond this, the plan also will address selected anadromous and resident fish and wildlife of interest under the subbasin planning process. These additional focal species include coastal cutthroat trout, coho, sturgeon, smelt, northern pikeminnow, shad, warm water fish, Pacific lamprey, Caspian terns, Columbia white-tailed deer, dusky Canada goose, western pond turtle, sandhill crane, and selected neo-tropical birds.

The eleven subbasins included in the LCFRB comprehensive recovery/subbasin planning initiative are: Columbia Estuary, Columbia Gorge, Cowlitz, Elochoman, Grays, Kalama, Lewis, Little White Salmon, Lower Columbia Mainstem, Washougal, and Wind.

3.2.49 *Lower Columbia Habitat Mapping (LCR Project 200201200)*

Lead: Lower Columbia River Estuary Partnership (LCREP)

This project assessesses aquatic and wetland habitat condition in the lower Columbia River and estuary.

The project includes: acquiring satellite images at 5 and 15 meter resolution; conducting airborne hyperspectral image data collection at 1.5 meters resolution; collecting aerial videography; and using volunteers (citizens and agency experts) to gather vegetative data at selected sites to ground truth the aerial imagery. The data is then analyzed to provide a comprehensive, geographically-accurate dataset on basic tidal and freshwater habitat types, structure, and condition. The GIS maps developed from this process will then be used to identify habitats critical to the life stages of native organisms such as salmonids. Priorities for protecting and restoring critical habitats will be developed based on this assessment and potential projects identified.

A systematic approach to protecting and restoring habitat based on this data set and maps is being developed to guide the planning and implementation of all future habitat projects on the

lower Columbia River that will allow resource managers to make prudent, effective, science based decisions on protecting and restoring habitats critical to native species.

To date, the Estuary Partnership and the collaborating organizations have completed two years worth of data collection. The vegetative habitat of entire 146 miles of river has been classified and mapped and will soon be available in GIS format. In addition, hyperspectral imagery has been obtained for the entire shoreline of the river and several key focus areas. This data will provide habitat data in far greater detail than anything previously available and is critical to our efforts to understand the habitat needs of the lower Columbia River biota and in particular, the microhabitat needs of juvenile salmonids in the estuary.

3.2.50 *Lower Columbia River and Columbia River Estuary Ecosystem Monitoring and Data Management (BPA #30015)*

Lead: Lower Columbia River Estuary Partnership

In this project, the Lower Columbia River Estuary Partnership implements elements of its Aquatic Ecosystem Monitoring and Data Management Strategy to address habitat and toxics monitoring needs, and data management. The project addresses RPAs 161, 163, and 198. The ability to understand the relationship of sensitive organisms such as salmonids to the Lower Columbia River and Columbia River Estuary ecosystem is greatly hindered by major data gaps and poor access to existing data.

A pilot habitat monitoring program will be implemented to develop protocols, procedures, and indicators for measuring habitat condition for both long term habitat monitoring and restoration project monitoring and evaluation requirements. It will focus specifically on habitats important for juvenile salmonids. A technical team will develop the methods, critique and test the methods, assess the results, and recommend future work. Based on the results, a long term habitat monitoring rogram will be implemented.

Additionally, a toxic contaminant monitoring project will be implemented to address issues such as the accumulation of toxic contaminants in sensitive habitat areas, contaminant trends over time, and possible impacts on sensitive species. Toxic contaminant concentrations in fish and macroinvertebrate tissues, sediments and the water column will be determined. A technical team will assess the results and recommend future work. Based on the results, a long term toxics monitoring program will be implemented.

Finally, a prototype information center designed to house, store, analyze and disseminate data specific to the lower Columbia River and estuary will be developed and tested. The prototype will be the first step in the process of building a novel environmental information system that provides on line access to all data on the lower river and estuary in a variety of formats including raw data, processed data in report form, customized data as needed and on line assistance to pinpoint data needs and expedite access for users.

3.2.51 *Lower Columbia River and Estuary Research Needs Identification Workshop Proceedings 2003*

Lead: US Army Corps of Engineers

This workshop was held in March, 2003 in Portland to discuss research status and needs for the Columbia River Estuary (CRE). The objectives of the workshop included:

- Review the basis for USACE involvement in the CRE;

- Review past and ongoing research being conducted in the CRE;
- Identify data gaps and key research needs for future studies; and
- Prioritize as much as possible those research needs.

A large number of themes were discussed at the workshop, including: Developing a conceptual framework for ecosystem restoration in the CRE; Monitoring and selecting meaningful metrics and parameters; Identifying and prioritizing habitat creation and restoration options; Endpoint (target) definition; Mining under-used, older data; Information access and integration; Comparing historic vs. present habitat conditions; Hydrodynamic model data collection; Sediment transport and fate; Hydrograph changes; Linking physical processes with biological systems; Salmonid abundance, habitat use, migration, and timing; Stock identification, hatchery influences and phenotypic expression; Wetlands function; Nutrients, detritus, and primary productivity; Food web dynamics; Tributary conditions and opportunities for off-site mitigation; Toxic contaminants and geochemistry; Invasive species; Risks associated with restoring 10,000 acres in the CRE; and other miscellaneous topics.

The workshop did not end with construction of a list of priority research needs. However, the substance of discussions was noted, and that information has been compiled and synthesized in this document. Highest priority research avenues have been inferred from the workshop discussions in Section 4 of this document, which provides the US Army Corps of Engineers with the starting framework for funding research in the CRE that maximizes restoration potential and addresses key action items specified in the Federal Columbia River Power System Biological Opinion of 2000.

3.2.52 *Deep River Habitat Restoration*

Lead: Columbia Land Trust

This project will acquire and restore approximately 198 acres of forested wetland/floodplain habitat. Restoration will include levee breaches, tidegate removal, ditch filling, and swale enhancement. Reconnecting this floodplain property with the river will improve habitat and water quality, restore salmonid rearing habitat, and will increase basin productivity for all life history stages of salmonids.

3.2.53 *Grays Bay Restroration*

Lead: Columbia Land Trust

The Grays River is home to five species of salmonids: coho, chinook & chum salmon, steelhead, and searun cutthroat. Chinook, chum & steelhead are listed as threatened, and searun cutthroat is proposed as threatened. The Grays River supports the strongest remaining run of chum salmon in the Columbia River ESU. This project addresses limiting factors in the Grays River, including flood plain connectivity, bank stability, large woody debris, side channel availability, substrate fines, riparian condition, and temperature.

This project conserves one mile of riverfront, improving the quality and quantity of habitat for all life history stages of salmonids. This project also benefits all upriver Columbia Basin anadromous fish dependent on the Lower Columbia River estuary for juvenile nursery habitat. There are three elements to the proposed project:

Acquisition of 145 acres of old growth spruce wetland and 57 aces of associated forested upland along Grays Bay & Secret River;

Acquisition and restoration of 200 acres of ditched and diked floodplain at Devil's Elbow, to be reconnected to Grays River;

Acquisition of 125 acres of ditched and diked floodplain at Eden Valley. This project restores tidal function to 200 acres of the Grays River estuary by partial levee breaches and culvert removal. Restoring tidal function to the estuary improves water quality within the Grays and Columbia River estuaries. Reconnecting this floodplain with the river improves habitat & water quality as well as increasing the productivity of the basin

Phase IV will acquire and restore over 260 acres of estuarine wetlands, riparian areas, forested uplands and the lower portions of five creeks that enter the Lower Columbia River estuary in the project area. Brooks Slough provides important estuarine rearing habitat (a regional limiting factor) for Columbia Basin salmonids. This project will add 150 acres to the Lower Columbia estuary. Project activities include: acquiring the land; removing two tidegates, a pump station, and several buildings; installing three large open pipes to restore connection of 150 acres of estuary to the Columbia River; restoring two miles of creek habitat, restoring a 30 acre emergent wetland; and reforesting 30 acres of riparian and upland habitats.

This project will benefit several threatened and endangered species, including salmonids produced within and migrating through the Lower Columbia River Estuary. The habitat objectives are to restore a complex mosaic of stream channels, tidal swales, wetlands and riparian forest with open connection to Brooks Slough. Restoration of stream, flood-plain, estuarine and forested habitats will improve habitat for salmonids, improve water quality and increase productivity of adjacent habitats. Ducks Unlimited, NRCS, and USFWS will assist with project design and implementation. Property will be transferred to USFWS for ownership and management.

3.2.54 *Chinook River Estuary Restoration and Monitoring*

Lead: Sea Resources and partners

Since 1996 Sea Resources has worked with partners on a comprehensive plan to restore the historic natural productivity of the Chinook River Watershed. Sea Resources is planting native vegetation in riparian zones, repairing culverts and bridges, and remediating sediment sources. In addition to these restoration projects, Sea Resources is working in partnership with USFWS, WDFW, NRCS, Ducks Unlimited, Columbia Land Trust, and the Lower Columbia Fish Recovery Board to restore estuarine habitat to almost 1,100 acres of the Chinook River estuary. This restored estuary will provide critical rearing habitat to salmonids from the Chinook River as well as salmonids from the entire Columbia River Basin. For this restoration effort to be successful it is necessary to have a comprehensive monitoring plan in place.

In February 2000 Sea Resources began monitoring smolt migration with two smolt traps. One at the mouth of the Chinook River and one just upstream from the hatchery. In June 2000 we established eight monitoring sites and began measuring temperature, DO, and turbidity at each site. In October of 2000 we received a grant from the US Fish and Wildife Service to purchase new monitoring equipment. That equipment greatly increased our monitoring capability and we began to measure salinity, conductivity, pH, and flow. In addition obtained an additional six HOBO temperature data loggers - one for each site.

3.2.55 *Lower Columbia: Clatskanie Watershed Assessment*

Portland State University prepared the Lower Columbia-Clatskanie Watershed Assessment for the Lower Columbia River Watershed Council in 2001. The watershed assessment will be used as a guide for the prioritization and design of restoration projects.

The Lower Columbia-Clatskanie Watershed Assessment describes the watershed and discusses the following:

- Declining wild salmon and steelhead populations
- Water quality parameters for E. Coli and dissolved oxygen
- Loss of streamside vegetation and functions and increased amount of sediment entering streams from forestry activities
- High summer water temperatures in streams
- Stream straightening and channelization

3.2.56 *Lower Columbia: Grays River Estuary*

Lead: Columbia Land Trust

This project will acquire and restore 112 acres of estuarine wetlands and two miles of river and riparian habitat in the Grays River Estuary along the Lower Columbia River in Wahkiakum County. The Grays River is home to ESA-listed chinook, chum, and steelhead, as well as coho and searun cutthroat trout. Restoration elements include restoring tidal function to the estuary by partially breaching levees and removing culverts. Goals are to improve estuarine salmon nursery habitat, improve water quality, and increase salmon productivity in both the Grays River and Columbia River estuaries. Project partners include WDFW and Ducks Unlimited.

3.2.57 *Map Subtidal Large Woody Debris and Other Habitat Features in Relation to Fish Distribution in the Lower Columbia River Estuary (BPA #30014)*

Lead: Battelle Marine Sciences Laboratory

This project maps and assesses the importance of estuarine and tidal wetland habitats at selected sites in the Columbia River estuary.

The project will use side scan sonar and underwater video to map “types” and “densities” of subtidal LWD. This will be coupled to classified habitats from CASI aerial imagery to provide complementary and seamless GIS maps from upland to subtidal survey depth. The project will also assess fish distributions using a Dual-frequency Identification Sonar (DIDSON) acoustic camera at sites with LWD. The DIDSON camera can capture near-video-quality images, and is not hampered by low light or turbid water. Data will be collected and stratified over both high and low tidal stages. Fish distribution patterns will be spatially linked to distribution of LWD in a geographical information system (GIS) framework. The project will also quantify conditions that foster concentrations of woody debris with occurrences of high salmonid concentrations. The project predicts that this information would be extremely useful in determining the most suitable locations, from a landscape perspective, for placement of woody debris under a restoration or enhancement effort.

3.2.58 *Mccarthy Creek Wetland Restoration*

Lead: Ducks Unlimited

This proposal seeks funding for restoration of floodplain connectivity among three properties. Fishways and water control structures will allow for adaptive management to promote habitat recovery for threatened, endangered, and other wetland-dependent species. OWEB funds are requested for permitting, engineering, contracted labor, construction management/materials and five years of monitoring.

3.2.59 *Monitoring of the Chinook River Estuary Restoration Project*

Lead: Sea Resources

In 1996 Sea Resources began the implementation of a comprehensive plan to restore the historic natural productivity of the Chinook River Watershed. Sea Resources is committed to improving fish habitat in the entire Chinook River Watershed. We are planting native vegetation in riparian zones, repairing culverts and bridges, and remediating sediment sources. In addition to these restoration projects, Sea Resources is working in partnership with USFWS, WDFW, NRCS, Ducks Unlimited, Columbia Land Trust, and the Lower Columbia Fish Recovery Board to restore estuarine habitat to almost 1,100 acres of the Chinook River estuary. This restored estuary will provide critical rearing habitat to salmonids from the Chinook River as well as salmonids from the entire Columbia River Basin. For this restoration effort to be successful it is necessary to have a comprehensive monitoring plan in place.

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3.2.60 *Native Fish Conservation Policy, Revised September 2003*

Lead: Oregon Department of Fish and Wildlife

The purpose of the Native Fish Conservation Policy is to ensure the conservation and recovery of native fish in Oregon. This policy focuses on naturally produced native fish. The Hatchery Management Policy describes conservation of hatchery produced native fish.

The intent of the Native Fish Conservation Policy is to provide a basis for managing hatcheries, fisheries, habitat, predators, competitors, and pathogens in balance with sustainable production of naturally produced native fish. The policy has three areas of emphasis. The first is defensive to ensure the avoidance of serious depletion of native fish. The second is more proactive to restore and maintain native fish at levels providing ecological and societal benefits. The third ensures that, consistent with native fish conservation, opportunities for fisheries and other societal resource uses are not unnecessarily constrained. This approach will allow Oregon to play a vital role in the recovery of ESA listed species and the prevention of future listings.

The policy embraces the case-by-case application of a wide range of conservation and utilization strategies tailored to individual watersheds and situations. Policy implementation will

likely illustrate a variety of management approaches across the landscape, such as areas focused on hatchery programs complemented with areas where hatchery influences are avoided.

The policy shall be implemented through conservation plans. Plans shall be developed in collaboration with management partners and the public, and will identify the desired and existing status of native fish, key limiting factors, management options to address these factors, and monitoring required to evaluate success. The Oregon Plan for Salmon and Watersheds, as well as other local and regional forums, shall provide the context for development, implementation and coordination of these plans. Existing rules shall guide management until conservation plans are completed

3.2.61 *Ocean Survival of Juvenile Salmonids in the Columbia River Plume (BPA#199801400)*

Lead: U.S. National Marine Fisheries Service, Oregon State University and Oregon Graduate Institute, NW Fisheries Science Center, 1998 to present

This study evaluates the role of the Columbia River plume on growth and survival of juvenile salmon. The study focuses on the hypothesis that variation in the physical and biological conditions of the nearshore environment, particularly that associated with the Columbia River plume, affects overall survival of Columbia River stocks. Primary factors being evaluated include (a) food availability and habits, (b) time of entry, smolt quality, and growth and bioenergetic status at the time of entry and during the first growing season in the ocean, and (c) predation. (A companion study on predation on juvenile salmon is ongoing.) The study proposes to characterize, over a 10-year period, the physical and biological features of the nearshore ocean environment with real-time and modeling projections of the Columbia River plume as it interacts with the coastal circulation regime, and to relate these features, both spatially and temporally, to variation in salmon health, condition, and survival.

3.2.62 *Optimization of Fcrps Impacts on Juvenile Salmonids: Restoration of Lower-Estuary and Plume Habitats (BPA #30002)*

Lead: Oregon Health & Science University, OGI School of Science & Engineering

This project optimizes the interaction of the Federal Columbia River Power System (FCRPS) with the lower Columbia River estuary and plume in support of endangered salmonids. The timing and magnitude of flows released by the FCRPS strongly affect juvenile salmonids as they move through the estuary and plume. Restoration of the properties of the lower estuary and plume that constitute habitat for juvenile salmonids requires advances on several fronts.

Project objectives:

- Define how the lower-estuary and plume interacted historically with coastal currents, how operation of the FCRPS has altered the lower-estuary and plume, and how climate change and the FCRPS will impact the system in coming decades.
- With Action Agencies, define needs and opportunities for science-based input to operational FCRPS management practices, given uncertain climate and coastal circulation forecasts.
- With FCRPS managers, define management scenarios: a) that are based on physical understanding, b) that can be evaluated in terms of habitat opportunity and other constraints

on the system, and c) whose implementation can lead to a qualitative improvement in survival of juvenile salmonids.

- The project will use remote sensing, management science and analyses of numerical model results to achieve the goals of the project, as it moves from research toward provision of definite strategies over the next 6 to 10 years.

A Project Advisory Board (PAB) that includes Action Agency personnel, FCRPS managers and external scientists will be formed to help ensure productive application of the insights achieved. Tight cooperation with work carried out in the estuary and plume by the National Marine Fisheries Service (NMFS) will be facilitated by participation of PIs in this project as well as in two projects proposed by NMFS.

3.2.63 *Oregon Columbia Tributaries West: Watershed Analysis, Columbia River Gorge National Scenic Area, 2001*

Lead: USDA Forest Service, Columbia River Gorge National Scenic Area

This study, completed in 2001 by the USDA Forest Service, is a compilation of prevailing knowledge of the area by various resource specialists. It provides descriptive data about past and present physiological, ecological and cultural conditions. Recommendations drawn from a synthesis of this information provide management guidance for the federal lands located in the watershed. While the study provides analysis and recommendations for desired future conditions, it is not a decision-making document.

3.2.64 *Oregon Spartina Response Plan*

Lead: Oregon Department of Agriculture

This Oregon Spartina Response Plan reviews the biology and historical and current information of Spartina on the west coast and outlines a strategy to prevent, detect, identify, and eradicate the weed in Oregon. The goal of Spartina management in Oregon is to prevent the establishment and spread of any Spartina species in Oregon estuaries and coastal wetlands. It identifies the Oregon Department of Agriculture as the lead agency in this effort, but describes a coordinated approach that requires the cooperation of preserve and refuge managers, mariculturists, state and federal agencies, and those who use Oregon's estuaries to protect them from Spartina damage.

Outreach and education about the threat and management of Spartina and measures to prevent introduction are important elements of the Plan. The many potential pathways to introduction, however, suggest that Spartina is highly likely to invade Oregon estuaries. Therefore, early detection and rapid response are key components of the Plan.

Detection will be done using aerial, boat, and ground surveys. Taxonomic experts that are identified in the Plan will positively identify any suspect plants. The Plan provides a scaled response to the detection of Spartina in Oregon based on the species, size and stage of growth of the infestation, efficacy of various management techniques, and site characteristics. Management options include digging and covering, mowing, and chemical methods. An integrated strategy that includes a combination of management methods is likely to be required.

3.2.65 *Pacific Bald Eagle Recovery Plan, 1986*

Lead: USFWS

The Pacific Bald Eagle Recovery Plan (USFWS, 1986) provides detailed background information on bald eagles and reviews and evaluates their status in the 7-state Pacific recovery area. The Recovery Plan states that the primary objective of the recovery process is, ". . .to provide secure habitat for bald eagles. . . and to increase population levels in specific geographic areas to the extent that the species can be delisted."

The Recovery Plan lists four criteria for delisting:

- a minimum of 800 nesting pairs in the Pacific recovery area;
- average reproductive rate of 1.0 fledged young per pair [5-year average], with an average success rate per occupied site of not less than 65%;
- attainment of breeding population goals in at least 80% of the management zones (Recovery Zones) with nesting potential;
- stable or increasing wintering populations.

The Recovery plan is the basis for the 1990 Working Implementation Plan for Bald Eagle Recovery in Oregon and Washington.

3.2.66 *Pacific Coastal Salmon Recovery Fund (Pcsrf)*

Lead: States of Washington, Oregon, California and Alaska, (NOAA)

The Pacific Coastal Salmon Recovery Fund (PCSRF) was established in FY2000 to provide grants to the states and tribes to assist state, tribal and local salmon conservation and recovery efforts. The PCSRF was requested by the governors of the states of Washington, Oregon, California and Alaska in response to Endangered Species Act (ESA) listings of West Coast salmon and steelhead populations. The PCSRF supplements existing state, tribal and federal programs to foster development of federal-state-tribal-local partnerships in salmon recovery and conservation; promotes efficiencies and effectiveness in recovery efforts through enhanced sharing and pooling of capabilities, expertise and information. The goal of the Pacific Coastal Salmon Recovery Fund is to make significant contributions to the conservation, restoration, and sustainability of Pacific salmon and their habitat.

Recovery of sustainable salmon populations will likely take decades and require a substantial investment over several salmon life cycles. Nonetheless, it is important to track the work accomplished by current investments and measure activities and changes on a regular basis. NMFS has developed a comprehensive performance measurement system for the PCSRF in conjunction with the States and Tribes in response to requests by OMB and Congress for program accountability. The MOUs between NMFS and the States and Tribes, which established criteria and goals for prioritizing PCSRF funds to projects designed to conserve and restore Pacific salmonids, have been amended to include the program-wide Performance Goals and Reporting Metrics developed in May 2003. Aggregation of these project level reporting metrics, combined with larger scale watershed and subbasin assessments and results from monitoring and evaluation efforts, will allow (over the long term) an assessment of program effectiveness in terms of increased numbers of salmon. Progress towards the PCSRF program goal and program achievements on performance goals will be reported annually to Congress commencing with the next annual report in 2004.

3.2.67 *Passage of Juvenile and Adult Salmonids at Columbia and Snake River Dams*

Lead: NMFS Northwest Fisheries Center

This report summarizes the information pertinent to the FCRPS as it is currently configured for each route of passage and life history, and discusses uncertainties associated with the existing database. The reader is referred to Mighetto and Ebel (1994) and Whitney et al. (1997) for historical reviews of studies conducted over the past decades to evaluate the causes of fish loss, various improvements tested, and programs implemented to improve fish condition and survival through the FCRPS.

Development of the Federal Columbia River Power System (FCRPS) on mainstem Snake and Columbia Rivers began with the completion of Bonneville Dam in 1938, and ended with the construction of Lower Granite Dam in 1975 (Fig. 1). Throughout the past six decades, many structural configurations and operational strategies have been tested to improve the survival of juvenile and adult salmonids (Oncorhynchus spp.) passing through the FCRPS.

3.2.68 *Pierce National Wildlife Refuge*

Lead: USFWS, Pierce National Wildlife Refuge

The Pierce National Wildlife Refuge is part of the Ridgefield National Wildlife Refuge in southwest Washington. It consists of 336 acres of river bottomland habitat with riparian areas, wetlands, grasslands and hardwoods. The refuge provides habitat for Canada geese, a variety of other waterfowl and numerous other wildlife species. Hardy Creek supports one of the last remaining chum salmon runs in the lower Columbia River drainage. The south end of the refuge can be viewed from the Beacon Rock trail.

- The refuge development and management efforts aim to:
- Maintain native diversity of wetland habitats for breeding/migrating/wintering waterfowl and other aquatic migratory birds with a special emphasis on Canada geese.
- Provide and enhance habitat for endangered, threatened and sensitive species.
- Enhance wildlife diversity through habitat management.
- Restore natural, dynamic stream/river systems, including their associated in-water and riparian habitats for anadromous fish, breeding neotropical birds and other native fish and wildlife.
- Provide opportunities for quality, wildlife dependent recreation, education and research to enhance public appreciation, understanding and enjoyment of refuge fish, wildlife and habitats.
- Preserve designated cultural resources.

The Ridgefield National Wildlife Refuge Complex is comprised of five refuges located in the southwest part of the state of Washington: Ridgefield north of Vancouver; Conboy in the southcentral part of the state; and Franz Lake, Pierce and Steigerwald Lake all located in the Columbia River Gorge.

3.2.69 *Preliminary Conclusions Regarding the Updated Status of Listed Esus of West Coast Salmon and Steelhead (February 2003, Co-Manager Review Draft)*

Leads: West Coast Salmon Biological Review Team, Northwest Fisheries Science Center, Southwest Fisheries Science Center

This draft report summarizes preliminary scientific conclusions of the NMFS Biological Review Team (BRT) regarding the updated status of 26 ESA-listed Evolutionarily Significant Units (ESUs) of salmon and steelhead (and one candidate species ESU) from Washington, Oregon, Idaho, and California. These ESUs were listed following a series of status reviews conducted during the decade of the 1990s. The status review updates were undertaken to allow consideration of new data that have accumulated over the various time periods since the last updates and to address issues raised in recent court cases regarding the ESA status of hatchery fish and resident (nonanadromous) populations. The draft BRT conclusions in this report should be considered preliminary for two reasons. First, the BRT will not finalize its conclusions until state, tribal, and other federal comanagers have had an opportunity to review and comment on the draft report. Second, some policy issues regarding the treatment of hatchery fish and resident fish in ESU determinations and risk analyses are not resolved at this time.

When finalized, this draft report would represent the first major step in the agency's efforts to review and update the listing determinations for all listed ESUs of salmon and steelhead. By statute, ESA listing determinations must take into consideration not only the best scientific information available, but also those efforts being made to protect the species. After receiving the final BRT report and after considering the conservation benefits of such efforts, NMFS will determine what changes, if any, to propose to the listing status of the affected ESUs.

3.2.70 *Preliminary Estimates of Updated "Indicator Metrics" Applied in the 2000 FCRPS Biological Opinion*

Lead: NOAA Fisheries

As NOAA Fisheries begins the remand of the 2000 FCRPS Biop, it is necessary to update the biological information, including the indicator metrics. Recently, NOAA Fisheries' West Coast Salmon Biological Review Team (BRT) released a draft review of the status of listed ESUs in the Columbia River basin (BRT 2003). This report uses the information assembled by the BRT, along with supplemental analyses, and converts it to "indicator metrics" to provide a preliminary look at how these have changed in response to recent returns since the 2000 FCRPS Biop was issued. Additionally, a supplemental analysis that looks at the sensitivity of choice of time period for "lambda" estimation was included at the request of Federal fisheries managers.

The information in this report was presented in preliminary form to Federal Caucus members on July 23, 2003, and was presented to the Columbia Basin Fish and Wildlife Authority (CBFWA) Anadromous Fish Managers on July 30, 2003.

This exercise of updating the 2000 FCRPS Biop's "indicator metrics" should not be taken as a commitment on NOAA Fisheries' part to employ identical methodology in the new biological opinion. We will be reviewing some of these methods through a process that was specified in the 2000 FCRPS Biop. We will also be reviewing the methods in light of the recent ruling on biological opinion remand.

3.2.71 *Preserve and Restore Columbia River Estuary Islands to Enhance Juvenile Salmonid and Columbian White-tailed Deer Habitat. (BPA #30011, Cre Project 200301800)*

Lead: U.S. Fish and Wildlife Service - Willapa National Wildlife Refuge and Satellites, Columbia Land Trust, USGS - BRD Columbia River Research Laboratory

This project acquires and restores 626 acres of tidal emergent marsh, swamp, slough, and riparian forest habitat on islands in the upper Columbia River Estuary to benefit fish and wildlife. This is a cooperative effort between BPA, USFWS, Columbia Land Trust, USGS, Corps of Engineers, WDFW, and ODFW.

The Columbia Land Trust would acquire 426 acres on Crims Island and 109 acres on Walker Island. USFWS would acquire an additional 90 acres on Crims Island. At Crims Island, the Corps of Engineers would provide funding through Section 1135 of the Clean Water Act to enhance 75 acres of tidal emergent marsh by excavating canary grass wetland and connecting subtidal channels to the mainstem Columbia. In addition, tidal flow would be reestablished to 100 acres of wooded swamp by excavating a man-made plug in a channel and 100 acres of riparian forest would be reestablished on upland areas of the island. These actions would provide productive rearing and foraging habitat for juvenile salmon and increase the export of detrital nutrients to the estuary. A monitoring program would be initiated to measure the response of fish, especially juvenile salmon, and vegetation to these enhancements. Approximately 150 acres of existing tidal emergent marsh on Crims and Walker Islands would be restored by controlling invasive exotic plants, principally purple loosestrife and reed canarygrass. Columbian White-tailed deer would be reintroduced to these and nearby islands to restore this native species to the upper estuary. This action would establish a new subpopulation of the deer on secure habitat to meet the goals of the Columbian White-tailed Deer Recovery Plan. Funding for the reintroduction would be shared between BPA, USFWS, WDFW, and ODFW.

3.2.72 *Re-introduction of Lower Columbia River Chum Salmon into Duncan Creek (BPA 200105300)*

Lead: Pacific States Marine Fisheries Commission, Washington Department of Fish and Wildlife

In this project, a three-pronged approach is being used to once again produce a self-sustaining chum salmon population in Duncan Creek. This approach includes modifying the dam, enhancing spawning habitat, and using local brood stock to reintroduce chum into the basin. Dam modification was accomplished in November 2000, stream restoration was completed in November 2001, and brood stock collection was begun in November/December 2001.

This project addresses the continued collection of brood stock and outlines a comprehensive plan for monitoring and evaluating the Duncan Creek chum reintroduction. To "jump-start" the reintroduction program, eggs are currently being collected from adjacent chum salmon stocks (e.g. Hardy and Hamilton Creeks, and the Ives/Pierce Island complex), incubated at the Washougal Hatchery, and will be liberated into Duncan Creek after hatching. In future years, incubation may occur in streamside incubators as well. Developing embryos will have their otoliths thermally marked during incubation. Otolith marks will be utilized to evaluate the fry-to-adult survival rates of the introduced fish. The occurrence of non-marked adult chum entering the stream will be used to estimate how quickly wild fish are recolonizing the stream.

The physical conditions in the newly renovated stream channels will be monitored as well as the egg-to-fry survival rates of natural spawners.

The principle objectives of this project are to continue the collection of brood stock for use in the Duncan Creek reintroduction, to monitor and maintain the physical conditions necessary for chum salmon spawning in the newly renovated stream channels, and to evaluate the viability of using this approach to chum salmon recovery as a template for future reintroduction projects.

3.2.73 *Research, Monitoring, and Evaluation Plan for the Columbia River Estuary and Plume*

Leads: BPA, USACE, NOAA Fisheries

The Bonneville Power Administration (BPA), in coordination with the U.S. Army Corps of Engineers (COE) and National Oceanic and Atmospheric Administration (NOAA) Fisheries, originated this project (BPA Project No. 2002-077-000; Contract No. 652). Their goal was to provide coordination and facilitation of activities of the estuary/ocean subgroup (EOS) for research, monitoring, and evaluation (RME) arising from the 2000 National Marine Fisheries Service (now called NOAA Fisheries) Biological Opinion (BiOp) on operation of the Federal Columbia River Power System (FCRPS). Specifically, the EOS was tasked with developing the RME plan for the Columbia River estuary and plume (CRE&P) for BiOp Reasonable and Prudent Alternative (RPA) Action 161. The EOS functions under the auspices of the basin-wide RME planning process to implement the FCRPS BiOp, spearheaded by the federal action agencies (BPA, COE, Bureau of Reclamation) and NOAA Fisheries. The EP-RME plan is a stand-alone document, although it eventually will be incorporated into the basin-wide RME plan for BiOp implementation.

The goal of the research, monitoring, and evaluation (RME) program for the Columbia River estuary and plume (CRE&P) is threefold: 1) Status Monitoring -- quantify the status and trends in listed salmon usage and survival in the CRE&P; 2) Action Effectiveness -- quantify the effects of the habitat restoration actions on listed salmon in the CRE&P; and 3) Uncertainties -- resolve uncertainties related to salmon recovery actions in the CRE&P. Thus, RME for the estuary and plume (EP-RME) embodies many of the same elements at Tributary RME, e.g., ecosystem and habitat status monitoring questions. Action effectiveness research in the CRE&P focuses on habitat restoration, as does the uncertainties research.

In the draft basin-wide RME plan (RME Plan 2003), research, monitoring, and evaluation activities are focused on the listed salmon and steelhead species in the hierarchical context of the ecosystems, subbasins, and habitats supporting these populations. The basin-wide plan encompasses RME activities in habitats used by juvenile and adult life stages of salmonids including natal streams and tributaries, the mainstem hydrosystem, the estuary, and the Columbia River plume in the nearshore ocean. As a subset of the basin-wide RME effort, the plan covers BiOp RME in the Columbia River estuary and plume.

3.2.74 *Return to the River 2000*

Lead: Independent Science Group (ISG)

Beginning in 1982, the NWPPC has developed a basin-wide Fish and Wildlife Program to direct fish and wildlife funding by BPA. In the 1992 Fish and Wildlife Program, NWPPC created the Independent Science Group, and in the 1994 Fish and Wildlife program, the Council

directed the ISG to develop an explicit conceptual foundation and conduct a biennial review of the Fish and Wildlife Program.

This report is the result of that directive. The ISG examined the scientific basis for fish and wildlife recovery in the Columbia River and, in the light of continued declines of salmon and other species, developed an alternative conceptual foundation that is grounded in modern scientific thought.

The Council's fish and wildlife program is developed from recommendations submitted by a variety of interested parties, but especially the region's tribal, state, and federal fish and wildlife management agencies. As such, it mirrors the themes of traditional fisheries management in North America. Because of this, the ISG review and development of a conceptual foundation, while focused on the Columbia River and the Council's program, are applicable to a broad spectrum and wider geographic extent of fisheries management problems.

The report is organized into three sections:

Part I. An introduction and background to the salmon problem (Chapter 1), followed by a description of the current conceptual foundation directing salmon restoration and an analysis of the scientific basis for the assumptions and beliefs implied by measures in the Council's Fish and Wildlife Program (Chapter 2), and finally, an explicit description of an alternative ecologically based conceptual foundation for fish and wildlife management (Chapter 3).

Part II. A technical review and documentation of major scientific issues and topics supporting the conceptual foundation (Chapters 4-9).

Part III. A review of the role of monitoring and evaluation in salmon restoration (Chapter 10), and the Independent Scientific Group's conclusions and strategies for restoration from the overall review (Chapter 11).

3.2.75 *Review of Methods, Progress and Cross-Validation Studies Pertaining to Population Trend and Risk Assessment for Columbia River Salmonids*

Lead: NMFS, Northwest Fisheries Science Center

The purpose of this report is to review and discuss methods for estimating and presenting population trends and extinction risks for Columbia River salmonid populations to support management decisions, such as the ESA Section 7 determination in the 2000 FCRPS Biological Opinion and the anticipated 2005 and 2008 check-in tests. This report reviews research since 2000, which tests and validates diffusion approximation methods for estimating population trends and risks. This review summarizes information from the following publications:

Holmes, E. E. 2004. Beyond theory to application and evaluation: diffusion approximations for population viability analysis. In press in Ecological Applications.

Fagan, W. F., E. E. Holmes, J. J. Rango, A. Folarin, J. A. Sorensen, J. E. Lippe, and N. E. McIntyre. 2003. Cross-validation of quasi-extinction risks from real time series: an examination of diffusion approximation methods. Pre-print.

McClure, M., E. Holmes, B. Sanderson, and C. Jordan. 2003. A large-scale, multi-species risk assessment: anadromous salmonids in the Columbia River Basin. Ecological Applications 13: 964-989.

Holmes, E. E. and W. F. Fagan. 2002. Validating population viability analysis for corrupted data sets. Ecology 83: 2379-2386

Holmes, E. E. 2001. Estimating risks in declining populations with poor data. Proceedings of the National Academy of Science 98: 5072-5077.

3.2.76 *Review of Relative Fitness of Hatchery and Natural Salmon (Draft Technical Memorandum)*

Lead: NMFS, Northwest Fisheries Science Center

The objectives of this paper are to summarize the latest information on the relative fitness of hatchery and natural Pacific salmon and steelhead and to determine if there are any general patterns relating the origin and history of hatchery stocks to their relative fitness.

Since NMFS (2000a), numerous additional studies on the relative fitness of hatchery fish have been published in both the peer-reviewed and gray literature. Hatcheries have a variety of purposes, including mitigation for lost habitat, harvest augmentation, supplementation of naturally spawning populations, and conservation of genetic resources. Consequently, broodstock sources, rearing and release practices, and genetic management protocols vary widely. Differences in hatchery broodstock management protocols are likely to affect the relative fitness of hatchery fish. In order to know what typical values of hatchery fish relative fitness are, it is necessary to obtain estimates from a wide variety of program types and species.

We emphasize that we are reviewing studies of the relative fitness of hatchery and natural fish in the natural environment. In some cases, hatchery fish could have high

3.2.77 *Revised Columbia White-Tailed Deer Recovery Plan*

Lead: U.S. Fish and Wildife Service, 1976

The Revised Columbia White-Tailed Deer Recovery Plan outlined methods of re-establishing white-tailed deer near the Columbia River. Land use practices since 1972 via an interim management plan have encouraged the regrowth and reestablishment of permanent cover on many areas of the refuge with a history of heavy grazing. Continuous evaluation of deer responses to land use changes is necessary so that the proper balance between short grass/forb pastures and dense cover is maintained. The integrity of the Columbia River population of Columbia white-tailed deer (CWTD) and their habitat is threatened by a variety of factors, including both natural and man-caused phenomena including:

- Degradation of riparian habitats through logging and brush removal (Crews 1939; Scheffer 1940; Gavin 1978).
- Recent interest in development of riparian zones for beef production, cottonwood and alder harvest and for marina development.
- Automobile collisions.
- Poaching.
- Entanglement in barbed wire fences.
- Competition with livestock.
- Introduction of feral swine on Wallace Island in 1980.
- Major flooding.

- The inundation of over 1,400 acres for nearly 1.5 years due to a dike failure.
- High tides which are a limiting factor on undiked islands of the lower river.
- Disease (foot rot) and parasites (stomach worms), two threats common to the Columbia River population.
- The potential threat of black-tailed deer to CWTD by direct competition for available food sources and by hybridization.
- Presence of Roosevelt elk on the mainland portion of CWTD NWR.

3.2.78 *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: and Evaluation of Limiting Factors*

Lead: NMFS Northwest Fisheries Science Center

The overall purpose of this document is to evaluate and rank candidate limiting factors in the estuary with respect to the potential of each factor to affect population status or suppress population specific recovery. Rankings will be characterized as having a low, moderate, or high potential to improve population status by changing or improving current habitat conditions. The key element of our approach is to evaluate limiting factors from the perspective of overall population viability status and not simply abundance or survival as has traditionally been done.

To define salmon recovery needs, NOAA Fisheries evaluates Viable Salmon Populations (VSP) based on four performance criteria: abundance, population growth rate, spatial structure, and diversity (McElhany et al. 2000). In general, levels of these criteria in aggregate define extinction risk or persistence of the population.

To better understand the role of the Columbia River estuary in population viability, we emphasize the role of the estuary in contributing to the VSP attributes of diversity and spatial structure. We focused on these VSP attributes because as described in a subsequent section, our hypothesis is that a primary role of estuaries in salmon life history and ecology is to contribute to the persistence or viability of populations by contributing to the spatial structure and the range of life history strategies to use these places. The focus of this document is thus on defining potential for improvement in population status from the perspective of how limiting factors in the estuary primarily, but not exclusively, affect these two VSP attributes.

3.2.79 *Reasonable and Prudent Alternatives*

Lead: NOAA Fisheries

Issued by NOAA Fisheries (for salmon and steelhead) and USFW (for bull trout and sturgeon), the BiOps, recommend 199 ways, called “reasonable and prudent alternatives,” to avoid jeopardizing ESA-listed fish. Addressing everything from fish passage and transportation improvements to selective fishing methods, hatchery plans and habitat protection, they set population growth rates for listed fish and performance standards for the hydro system to achieve by 2010, with formal interim evaluations in 2003, ’05 and ’08.

- RPA 158 : Action Plan to Implement the Federal Columbia River Power System Biological Opinion in the Columbia River Estuary (Prepared in response to RPA 158) (ma#23, above)
- RPA 159 and 160: Ecosystem Restoration Plan with Emphasis on Salmonids in the Columbia River Estuary

- RPA 161: Between 2001 and 2010, Corps and BPA to fund a monitoring and research program acceptable to NMFS and closely coordinated with LCREP management plan. Status: Plan being developed – review draft out. To be complete by end of September 2003.
- RPA 162: BPA to work with NMFS to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience.
- RPA 196-197: Relates to funding for research in the estuary and Columbia River plume.

Relationship to other processes: research and monitoring program will be described in the 158 plan. Projects implemented under action 160 will be monitored according to this plan. Monitoring will also include trend analysis. Action 162 (conceptual mode) will provide a framework to support future research undertaken as part of actions 161, 196, and 197.

(These actions fund research and monitoring as proposed in Action 161).

3.2.80 *Salmon and Steelhead Limiting Factors Water Resource inventory Areas 24-28,*

Lead: Washington State Conservation Commission, 2000

Section 10 of the Salmon Recovery Act of 1998 (Engrossed Substitute House Bill 2496), directs the Washington State Conservation Commission, in consultation with local government and treaty tribes to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a Technical Advisory Group (TAG). The purpose of the TAG is to identify habitat limiting factors for salmonids. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." The bill further clarifies the definition by stating "These factors are primarily fish passage barriers and degraded estuarine areas, riparian corridors, stream channels, and wetlands." It is important to note that the responsibilities given to the Conservation Commission in the Salmon Recovery Act do not constitute a full limiting factors analysis. This report is based on a combination of existing watershed studies and knowledge of the TAG participants.

Five WRIAs drain to the Estuary and Lower Columbia subbasins. They include:

- WRIA 25 and 24. Water Resource Inventory Area (WRIA) 25 is located in southwest Washington. The area encompasses 322,582 acres including all of Wahkiakum and portions of Cowlitz, Pacific, and Lewis counties. Located along the Lower Columbia River, the majority of this watershed is in the Coast Range eco-region. All of the drainage's within the WRIA are tributaries to the Columbia River. Although located in WRIA 24, the Chinook River is the western most tributary to enter the Columbia River in Southwest Washington and has been included in this report.
- WRIA 26 is located in southwest Washington within portions of Lewis, Cowlitz, Skamania, Pierce and Yakima Counties, and it includes the Cowlitz River systems and its major tributaries: the Coweeman, Toutle, Tilton and Cispus Rivers. The Cowlitz River enters the Columbia River at RM 68.
- WRIA 27 is located in southwest Washington within portions of Skamania, Clark and Cowlitz Counties, and it includes three major watersheds: the Kalama River, the Lewis River (North Fork) and the East Fork Lewis River. All river systems within WRIA 27 drain to the Columbia River. Six stocks of anadromous salmon and steelhead return to these rivers. For

purposes of this analysis, the WRIA was separated into four subbasins: lower and upper Lewis River (below and above the dams), East Fork Lewis and Kalama.

- WRIA 28 is located in southwest Washington, with boundaries that extend to the western margins of the Wind River to the east, the Columbia River to the south and the East Fork Lewis River to the north. The inventory area includes the southern and eastern portions of Clark County and southwestern Skamania County. For purposes of this report, WRIA 28 was divided into three major subbasins: the Lake River Subbasin, the Washougal River Subbasin and the Bonneville Tributaries Subbasin. These drainages cover approximately 316,365 acres or 494 square miles and enter the Columbia River between river mile (RM) 87.6, at Lake River, and RM 142.3 near Bonneville Dam.

3.2.81 *Salmon at the River's End*

Lead: NMFS, 2001

Salmon at the River's End" is a comprehensive state-of-the-knowledge description of the ecological underpinnings of the Columbia River estuary. This study reviews the historical development of the CRE relative to changes in salmon populations, evaluates alternative conceptual frameworks for evaluating estuarine habitat conditions, assesses the effects of climate and the hydropower system on river flow and sediment transport, tests habitat availability predictions of the most detailed and up-todate hydrodynamic model of the estuary, evaluates biological and bioenergetic factors influencing salmonid rearing capacity, and evaluates population characteristics of juvenile salmon at various periods during the development of the CRE and Columbia River upstream (Bottom et al. 2001).

The Salmon at the River's End assesses the potential impact of flow regulation on juvenile salmon utilization of the estuary. The analyses identified flow regulation and climate effects on hydrology and sediment transport, both of which have likely consequences for the estuarine physical environment. The study evaluated the capacity of the estuary to support salmon, including the effects of flow regulation on this capacity. Six analyses were completed and the results interpreted based on the relationships between habitat and salmon life histories.

The analyses indicated that habitat and food-web changes within the estuary and other factors affecting salmon population structure and life histories have altered the capacity of the estuary to support juvenile salmon. Diking and filling activities in the estuary have likely reduced the rearing capacity for fry and subyearling life histories by decreasing the tidal prism and eliminating emergent and forested wetlands and floodplain habitats adjacent to shore.

The study noted that while the risk of extinction of many Columbia River populations implies the need for immediate recovery action, lack of data on estuarine habitat use by salmon argues that further study may be necessary before we can define appropriate restorative measures. Both of these concerns can be addressed by initiating targeted restoration activities, where there is reasonable confidence in their ecological benefits, and by simultaneously collecting new data to better understand salmon habitat requirements and restoration needs.

3.2.82 *Salmon Steelhead Habitat inventory Assessment Program (SSHIAP)*

Lead: Washington Department of Fish and Wildlife, Northwest Indian Fisheries Commission

With help from partner organizations throughout the Pacific Northwest, SSHIAP collects information about habitat conditions and fish stocks and consolidates it into a single database. Computer-generated maps, based on the data, allow people to view salmon conditions over large areas, or find information on a single stream or tributary.

SSHIAP's growing database currently includes information about fish distribution, barriers to salmon migration (such as impassible culverts) and various habitat conditions throughout western Washington. Future plans include incorporating data on eastern Washington, estuarine conditions, and other information important to salmon recovery efforts.

SSHIAP uses a Geographic Information Systems (GIS) database that contains information on salmon stocks and habitat conditions for Washington's rivers and streams. SSHIAP presents this information in the form of computer- based maps at the 1:24,000-scale, based on data collected for each stream segment.

The Salmon Recovery Act, approved by the Washington State Legislature in 1998, requires that all information regarding habitat preservation and restoration projects be incorporated into the SSHIAP database along with salmon-monitoring data collected by local groups. Baseline information on salmon stocks is derived from the state's Salmonid Stock Inventory (SaSI), a statewide listing of salmon and steelhead stocks.

Managed jointly by the Northwest Indian Fisheries Commission and the Washington Department of Fish and Wildlife, SSHIAP also incorporates data provided by project partners throughout the Pacific Northwest. Protocols are being developed to ensure that data is scientifically sound and easy to access.

3.2.83 *Salmonid Population and Habitat Monitoring in the Oregon Portion of the Columbia Estuary (BPA #30018)*

Lead: Oregon Department of Fish and Wildlife

This project extends the structure and methods employed by the Oregon Plan for Salmon and Watersheds Monitoring Program (Nicholas, 1997a; 1997b; 1999) to Oregon's portion of the Lower Columbia Province (Willamette, Sandy, Lower Columbia Subbasins). This approach, successfully implemented in Oregon's coastal watersheds, applies a rigorous sampling design to answer key monitoring questions, provides integration of sampling efforts, and has greatly improved coordination among state, federal, and tribal governments, along with local watershed groups. This project proposes to monitor the status, trends, and distribution in adult coho and steelhead populations, juvenile salmonids populations, and the habitats they depend on at the Provincial and Subbasin scales. The project is high priority based on the elevated level of emphasis the NWPPC Fish and Wildlife Program and Subbasin Summaries, NMFS 2000 FCRPS Biological Opinion, and the Oregon Plan for Salmon and Watersheds have placed on monitoring and evaluation to provide the real-time data to guide restoration and adaptive management in the region.

3.2.84 *Sandy River Delta Plan and Eis 1996, and Watershed Analysis, 1995*

Lead: US Forest Service, Columbia River Gorge National Scenic Area

The Sandy River Delta was historically a wooded, riparian wetland with components of ponds, sloughs, bottomland woodland, oak woodland, prairie, and low and high elevation

floodplain. It has been greatly altered by past agricultural practices and the Columbia River hydropower system. Restoration of historic landscape components is a primary goal for this land.

The Sandy River Delta comprehensive management plan envisions wetland, riparian forest, shrub-scrub, upland forest, and upland meadow restoration, with moderate recreation and natural resource interpretation. Riparian forest and wetland restoration were identified as first priorities. The long-term objectives are re-establishment of 600 acres of Columbia River bottomland riparian forest (dense stands of black cottonwood, will and ash), and re-establishment of about 200 wetland acres and associated upland habitat. Monitoring will evaluate restoration success. Breaching of levees and dikes can be considered to restore sloughs and backwater channels. Restoration of open upland areas (meadow/prairie) would follow substantial completion of the riparian and wetland restoration.

3.2.85 *Sandy River Watershed Riparian*

Lead: The Nature Conservancy

This project is the second year of a Sandy River watershed-wide, integrated restoration, outreach/education and youth leadership program. Although on-the-ground habitat restoration via removal of the highly invasive and system modifying weed, Japanese knotweed is the central focus, the project is designed to simultaneously increase community knowledge of watershed issues and citizen (especially youth) participation in the solution.

3.2.86 *Scappoose Bay Watershed Assessment*

Lead: Scappoose Bay Watershed Council, 2000

The purpose of this report is to provide a broad foundation for effective restoration of native fish species and their aquatic habitat in the Scappoose Bay watershed. The report follows the guidelines of the Oregon Watershed Enhancement Manual (WPN 1999). The Scappoose Bay Watershed Assessment presents the existing baseline information on watershed conditions (based on available reports and data) and oral history interviews. A Geographic Information System (GIS) was built to display, analyze and store much of the data. Habitat factors for the decline of salmonids are compared, and major protection and restoration opportunities are identified and prioritized. This Phase I assessment does not generally provide the detailed field reconnaissance and comprehensive field studies that are necessary for proceeding with specific protection and restoration projects. Rather, this assessment lays out the groundwork for a second phase of assessment that bridges the gap between identifying major areas for action and conducting specific projects.

Although relatively small in size (85,000 acres), the Scappoose Bay watershed historically supported four of six species of salmon found in the Pacific Northwest. It contained a broad diversity of habitats, ranging from small, steep mountain streams to extended low-gradient stream valleys to the lowland floodplain of the Columbia River estuary. Over the past 150 years, the watershed has been impacted by a broad range of uses: agriculture, forestry, surface mining, and residential and industrial development. The dramatic decline in all species of salmonids in the watershed is not due to one or even several independent habitat-impacting activities, but rather to a complex interplay of activities that have degraded specific habitats used at particular times in the life histories of the fish. Included in this complex scenario is the effect of introduced hatchery fish and fishery management policies, as well as the shift to poor ocean conditions along the Oregon and Washington coasts throughout the 1980s.

3.2.87 *Skipanon, Youngs Bay, Nicolai Wickiup Watersheds Action Plans, May 2003*

Lead: Oregon Watershed Enhancement Board, Skipanon, Youngs Bay, Nicolai Wickiup Watershed Councils

This document represents the final report for the development of Action Plans for the Skipanon, Youngs Bay and Nicolai Wickiup watershed councils. The Action Plan is based on current information contained in the 2000 Skipanon, Youngs Bay, and Nicolai Wickiup Watershed Assessments.

The watershed health and council priority issues identified through the action plan and by utilizing Watershed Assessments include: fish passage, riparian and estuarine habitat, water quality/quantity, watershed monitoring, and education and outreach. The Action Plan recommends ways to enhance watershed conditions through implementation of action opportunities identified in watershed subbasin summaries. The document was submitted to OWEB in May 2003 and was revised to incorporate comments from OWEB

3.2.88 *Status Assessment and Conservation Recommendations for the Caspian Tern (Sterna Caspia) in North America*

Lead: US Fish and Wildife Service - August 2002

Despite recent population increases, the Caspian Tern (Sterna caspia) is of conservation concern in the Pacific Northwest because of the concentration of breeding terns at relatively few sites and fisheries conflicts at the Columbia River estuary, where currently two-thirds of the Pacific Coast and one-quarter of the North American population occurs. Although not listed at the national level, the species currently is listed as threatened or endangered in three states or provinces and is considered of special concern in ten more. The Caspian Tern still occupies most of its historic range and has expanded slightly into new areas.

Historically the Caspian Tern suffered from harvest for the millinery trade, egging, human disturbance, habitat loss at interior wetlands, and, more recently, from contaminants. Historic population numbers are unknown but appear to have been substantially reduced early in the century. Relatively accurate population data for the Caspian Tern in North America were unavailable until the late 1970s, when concerns over coastal habitat modification and offshore oil development prompted national multi-species surveys of colonial nesting waterbirds. Estimates of the U.S. breeding population were roughly 9,454 pairs in the mid-1970s to early 1980s and 20,948 pairs in the late 1980s to late 1990s. Since the late 1970s, the population has increased in four of five major breeding regions in North America, and the continental population is estimated to be a minimum of 32,000 to 34,000 pairs, distributed differentially among regions: Pacific Coast/Western (interior) (45%), Central Canada (28%), Great Lakes (19%), Gulf Coast (7%), and Atlantic Coast (<1%).

Continentwide population increases were fueled initially by the reduction or elimination of some historic pressures (e.g., hunting for millinery trade) but more recently by changes in breeding habitat and prey resources. Occupation of relatively stable artificial habitats (e.g., dredge spoil islands) has greatly concentrated the tern population leaving it more vulnerable to stochastic events, such as disease outbreaks, severe storms, disruption by predators or human disturbance, and oil spills. Caspian Tern population increases in the Pacific region from the mid-1980s to 2001, primarily in the Columbia River estuary, may largely reflect the crucial juxtaposition of stable human-created habitats in conjunction with a predictable food supply.

Human exploitation of native fish communities leading to dominance of small fish species favored by foraging terns appears to be a significant factor in tern increases in the Great Lakes and central Canada.

Conservation efforts will be most effective if focused on multiple fronts including monitoring tern populations, resolving management conflicts with other species by addressing root causes, reducing risks to the tern population by distributing breeding colonies among a greater number of sites, filling gaps in knowledge of biology and threats on migration and the wintering grounds, and educating the public about the value of colonial waterbirds and possible effects of human actions on Caspian Terns.

3.2.89 *Steigerwald Lake National Wildlife Refuge*

Lead: USFWS, Steigerwald Lake National Wildlife Refuge

The Steigerwald Lake National Wildlife Refuge is part of the Ridgefield National Wildlife Refuge Complex located in southwest Washington. It consists of more than 950 acres of historic lakebed and river bottomland habitat with wetlands, riparian areas, grasslands and hardwood forest. The refuge provides habitat for wintering waterfowl and year-round habitat for a variety of wildlife species.

The refuge development and management efforts aim to:

- Restore natural, dynamic stream/river systems, including their associated in-water and riparian habitats for anadromous fish, breeding neotropical birds and other native fish and wildlife.
- Provide wetland and cropland/grassland habitats for feeding and resting by migrating and wintering ducks, geese, cranes and other migratory birds and for reducing crop depredation on private lands.
- Preserve, enhance and protect habitats that support endangered species, threatened species and species of special concern.
- Provide opportunities for quality, wildlife-dependent recreation, education and research to enhance public appreciation, understanding and enjoyment of refuge fish, wildlife and habitats.
- Preserve designated cultural resources.

The Ridgefield National Wildlife Refuge Complex is comprised of five refuges located in the southwest part of the state of Washington: Ridgefield north of Vancouver; Conboy in the southcentral part of the state; and Franz Lake, Pierce and Steigerwald Lake all located in the Columbia River Gorge.

3.2.90 *Support Local Salmon Corps Projects*

Lead: CRITFC

The Salmon Corps receives independent funding from NOAA/NMFS to implement habitat restoration projects funded under the PCSRF. Projects selected by the Salmon Corps will be salmon-related habitat restoration projects in the Lower Columbia River. CRITFC will cost-share with this program to assist in project implementation and inter-agency coordination. Other participants in this program include the Native American Youth Association (NAYA) and the Lower Columbia River Estuary Partnership (LCREP). Two Native American interns will be

hired by CRITFC to coordinate project implementation, collect environmental data and write a monitoring and evaluation report.

3.2.91 *Survival and Growth of Juvenile Salmonids in the Columbia River Plume (BPA # 199801400)*

Lead: National Marine Fisheries Service

This project evaluates the role of the Columbia River plume in survival of juvenile salmon through long-term observations, fine-scale process studies, retrospective assessments, and modeling to assess management of flow to improve habitat opportunity.

The project characterizes, over an extended period, the physical and biological features of the nearshore ocean environment using mesoscale and fine scale oceanographic surveys, develops coupled physical-biological models and performs retrospective assessment of the Columbia River plume as it interacts with coastal circulation. With a new understanding of salmon-plume-coastal circulation interactions, the project will develop a set of hydropower management scenarios that could benefit survival, growth, and health of juvenile salmon by changing the dynamics of the Columbia River plume.

The nearshore ocean environment, particularly that associated with the Columbia River plume, is a critical habitat to outmigrating juvenile salmon. Recent evidence suggests that improvement in survival of the estuarine and early ocean life history phase of Columbia River salmon may be critical to recovery of endangered stocks. In the case of salmonids originating in the Columbia River Basin, survival success hinges on the complex interaction of smolt quality and the abiotic and biotic ocean conditions at the time of entry and during their first year of ocean existence.

This project hypothesizes that variation in the physical and biological conditions of the nearshore environment, particularly that associated with the plume, affects overall survival of Columbia River stocks. It further hypothesizes (a) that primary factors driving the variation in the nearshore and plume environment include oceanographic and land-based (river flow) processes modulated by climatic and anthropogenic factors, (b) that trophic relationships modulated by these physical variations affect growth and survival of juvenile salmon and (c) that management of the hydropower system can be used to regulate the Columbia River plume habitat to benefit salmon growth and survival.

3.2.92 *Washington and Oregon Eulachon (Columbia River Smelt) Management Program*

Lead: Washington and Oregon Departments of Fish and Wildlife

The Washington and Oregon Departments of Fish and Wildlife conduct a small scale program of monitoring sport and commercial eulachon (Columbia River smelt) fisheries and sampling for eulachon eggs and larvae in the mainstem lower Columbia River and tributaries to index run size and to identify the extent and distribution of spawning activity.

Sampling has demonstrated that the number of eulachon returning each year varies and the number of tributaries and portions of the mainstem Columbia River use for spawning also varies from year to year. Occasionally, a portion of the run travels to and sometimes passes above Bonneville Dam, presumably in an attempt to spawn in pre-impoundment spawning sites.

The goal of the Oregon and Washington eulachon management program is to maintain healthy populations of eulachon returning annually to spawn in the mainstem Columbia River and tributaries. The primary strategy involves estimating run size and regulating fisheries to only harvest excess surplus. The magnitude of spawning is indexed through sampling for eulachon eggs and larvae at a small number of selected sites.

3.2.93 *Washougal River: Slough Creek Riparian*

Lead: Washington State Parks

Project funding is for acquisition of high quality salmon rearing habitat and cold-water refuge and spawning beds for steelhead, sea-run cutthroat, chinook and coho salmon along portions of Slough Creek and the Washougal River in Clark County. Approximately 18 acres and 2,800 lineal feet of high quality riparian habitat that is highly threatened by development will be secured through purchase and donation of a conservation easement. Project supporters include WDFW, the Camas-Washougal Wildlife League, and Habitat Partners. Protection of this land will prevent future development and destruction of riparian vegetation and habitat conditions. This property is immediately downstream from over 400 acres and 8,000 lineal feet of high quality habitat that will be acquired and protected by WDFW, ensuring greater protection of this investment.

3.2.94 *Western Washington Columbia River Tributaries Watershed Analysis*

Lead: USDA Forest Service Columbia River Gorge National Scenic Area 2001

This analysis, completed in 2001 by the USDA Forest Service, describes the land uses and management within the Columbia River Gorge National Scenic Area. The Management Plan (CRGNSA) provides a Recreation Intensity Class (RIC) overlay to the underlying land use designations for maximum habitat protection. It explains that in the Columbia River watershed, the Northwest Forest Plan (NFP) applies to the National Forest lands in the CRGNSA and Gifford Pinchot National Forest (GPNF). The NFP describes Land Allocations meant to protect habitat areas.

Land use direction for the Columbia River comes from three management plans: the Columbia River Gorge National Scenic Area Management Plan, the Gifford Pinchot National Forest Land and the Resource Management Plan. The most protective guidelines in the watershed give precedence to fish and wildlife protection.

3.2.95 *Wetlands Functional Assessment, City of Vancouver Marine Park*

Lead: City of Vancouver Water Resources Education Center, 2001

This functional assessment, completed in 2001, summarizes findings and reviews provided by a joint city/community advisory committee and stakeholder forums from neighbors and other citizens. The management plan will specify objectives and address opportunities for wetlands enhancement that continue to protect high habitat values.

The objective is to protect high quality habitat while providing education and passive recreation opportunities compatible with habitat functions.

3.2.96 *White Sturgeon Mitigation and Restoration in the Columbia and Snake Rivers Upstream from Bonneville Dam*

Leads: Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, U.S. Geological Survey

WDFW, ODFW and USGS have been studying impounded white sturgeon populations since 1987. The studies have involved many activities, including sampling for sturgeon eggs, larva, and young-of-the-year (YOY) to measure natural production. Recruitment failures (lack of YOY) were documented during years when hydrosystem operation reduced spring/summer flows. Reduced population productivity has negatively impacted ongoing tribal and sport fisheries. Supplementation experiments were conducted to identify possible mitigation measures, including transporting juvenile white sturgeon from the unimpounded lower Columbia River (the reach within the Lower Columbia Province) upstream to The Dalles and John Day reservoirs

Transporting white sturgeon from the unimpounded lower Columbia River was adopted as a mitigative measure to address the negative impact that hydrosystem operation has had on natural production of impounded populations. The removal of over 26,000 white sturgeon and the planned removal of 5,000-10,000 juvenile fish annually for an unspecified number of years will have an impact on the white sturgeon population residing in the Lower Columbia Province.

The goal of the transport program is to replace small or missing year classes in order to rebuild recruitment to fisheries and to broodstock. Progress is being measured by conducting intensive stock assessments every five years. Annual natural production is being indexed annually.

3.2.97 *Wood's Landing Chum Spawning Site Protection, City of Vancouver (BPA#31006)*

Lead: City of Vancouver

The project will protect the largest Lower Columbia River chum production site between the Grays River near the mouth of the Columbia River and Hardy/Hamilton Creeks just below Bonneville Dam. Federal, state, and regional reports including the Federal Columbia River Power System Biological Opinion and the Lower Columbia Subbasin Summary, have described the importance of good chum spawning habitat in the Lower Columbia.

Through acquisition the project will protect the area, 11.96 acres and 1000 feet of shoreline, above this significant chum spawning habitat on the Columbia River shore in Vancouver, Washington. The properties include tidelands and mostly forested upland areas with very good riparian habitat. The current zoning allows 1 unit per 10,000 square feet (0.23 acres). Such residential development degrades habitat by increasing pollutant loading and bringing people and pets that disturb the spawning chum and their eggs.

Restoration of 350 feet of the Joseph's Creek, which enters the Columbia River immediately downstream of the main stem spawning site, will provide additional spawning habitat. The restoration will include adding spawning gravel, removing invasive plants from the banks, and stabilizing and revegetating the banks.

Partners in the project are Washington Department of Fish and Wildlife, Columbia Land Trust, City of Vancouver and the Wood family members who own the property. All partners share salmon conservation goals. Washington Department of Fish and Wildlife will develop a

management plan in cooperation with the partners. Columbia Land Trust will manage the acquisition and then give the title and easements to Washington Department of Fish and Wildlife. The project provides a unique opportunity within the Lower Columbia subbasin to protect existing, critical, high quality chum salmon habitat in the main stem.

3.2.98 *Wood's Landing Chum Spawning Site Protection, Clt*

Lead: Columbia Land Trust

This acquisition project will protect the largest Lower Columbia River chum production site between the Grays River near the mouth of the Columbia River and Hardy/Hamilton Creeks just below Bonneville Dam. The project will protect 6.78 acres and 600 feet of shoreline, immediately above this significant chum spawning habitat in Vancouver, Washington. The properties are mostly forested with excellent riparian habitat. Without the proposed acquisition, the threat of residential development of the site in the near future is very high.

3.2.99 *Working Implementation Plan for Bald Eagle Recovery in Oregon and Washington, July 1990*

Lead: Bald Eagle Working Team for Oregon and Washington, (of OR-WA Interagency Wildlife Committee, Washington Department of Wildlife)

The purpose of this Implementation Plan is to provide state and federal agencies, private individuals and organizations, and conservation groups with specific guidance to fulfill bald eagle recovery goals within Recovery Zones in Oregon and Washington.

The first section of the Plan describes situations (needs or problems) to be addressed and lists tasks to be accomplished as well as Leaders and Cooperators for each task. The second section includes Tables, Figures, and Appendices which summarize the results of the completed tasks and are devices for guiding and tracking progress towards recovery.

The situations listed are as follows:

- monitoring nesting populations
- monitoring winter populations
- habitat management plans
- acquisition
- research needs: human activities
- research needs: foraging ecology
- research needs: contaminants
- information and education

The Pacific Bald Eagle Recovery Plan (USFWS, 1986) provides detailed background information on bald eagles and reviews and evaluates their status in the 7-state Pacific recovery area. The Recovery Plan is the basis for this Implementation Plan and states that the primary objective of the recovery process is, “. . .to provide secure habitat for bald eagles. . . and to increase population levels in specific geographic areas to the extent that the species can be delisted.”

3.2.100 *Wy-Kan-Ush-Mi Wa-Kish-Wit Spirit of the Salmon the Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes*

Leads: the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes

The Spirit of the Salmon, completed in 1995 by the Columbia River Intertribal Fish Commission, provides a framework to restore the Columbia River salmon, simply stated: put the fish back into the rivers. According to Spirit of the Salmon, past attempts to maintain or restore declining salmon numbers all assumed that technology alone could "fix" the damage caused by disregard for the underlying, interconnected processes of nature which gave rise to and sustained the great salmon runs of the Columbia Basin. Simple solutions could not replace the complexity of nature; naturally these attempts failed. Accomplishing this requires a common understanding of habitat requirements of salmon relative to the present conditions they face in the Columbia River Basin.

Its goals include:

- Restore anadromous fish to the rivers and streams that support the historical, cultural and economic practices of the tribes. (These are generally areas above Bonneville Dam.)
- Emphasize strategies that rely on natural production and healthy river systems to achieve this goal.
- Protect tribal sovereignty and treaty rights.
- Reclaim the anadromous fish resource and the environment on which it depends for future generations.
- Objectives:
- Halt the declining trends in salmon, sturgeon and lamprey populations originating upstream of Bonneville Dam within seven years.
- Increase the total adult salmon returns of stocks originating above Bonneville Dam to 4 million annually and in a manner that sustains natural production to support tribal commercial as well as ceremonial and subsistence harvests within 25 years.
- Increase sturgeon and lamprey populations to naturally sustainable levels that also support tribal harvest opportunities within 25 years.
- Restore anadromous fish to historical abundance in perpetuity.

3.2.101 *Youngs Bay, Nicolai-Wickiup River and Skipanon River Watershed Assessments*

The purpose of these watershed assessments, completed in 1999, is to inventory and characterize watershed conditions of the Youngs Bay, Nicolai-Wickiup and Skipanon River watersheds and to provide recommendations that address the issues of water quality, fisheries and fish habitat, and watershed hydrology. These assessments were conducted by reviewing and synthesizing existing data sets and some new data collected by the watershed council, following the guidelines outlined in the Oregon Watershed Enhancement Board (OWEB) watershed assessment manual (WPN 1999).

4. MANAGEMENT PLAN

4.1 Introduction

As the core of the subbasin plan, the management plan provides the direction in which the subbasin needs to proceed in the future regarding enhancement of aquatic and terrestrial habitats over the next 10-15 years. It provides testable hypotheses, measurable objectives and implementable strategies formulated upon the biological priorities and current conditions provided in the assessment and inventory.

This management plan provides information about two subbasins: the Columbia River Estuary and Mainstem Lower Columbia River. It also covers a subarea that includes the western-most Oregon tributaries. Major tributaries are not included in this analysis because they have been designated as subbasins by the Northwest Power and Conservation Council (NPCC); they are addressed separately in other subbasin plans.

Figure 4-1: Large-scale map of the lower Columbia River mainstem and estuary, depicting major tributaries and population centers (R2 2003).

4.1.1 *Approach*

The project team and Planning Group have recognized that the state of the science relative to ecosystem processes and salmon in the Columbia River estuary is dissimilar to that of the tributaries. In particular, the ability to model productive capacity and predict responses to management action is limited. Focused efforts currently are underway that will further define the limiting factors, research, monitoring and evaluation. Significant progress will be made in these areas during the last half of 2004 and in early 2005.

As such, this plan moves forward with assumptions with or about which the degree of certainty is not always high. While the assumptions in this subbasin plan are derived from currently available information, the project team expects that these will likely need adjustments as new information becomes available.

Because of the likelihood of upcoming modifications, this management plan is built for flexibility. The project team has attempted, whenever possible, to develop and articulate the links between limiting factors, objectives and strategies and explain the logic behind making such links. The project team also attempted to articulate the level of certainty on which assumptions and decisions are based. This transparency should help keep this plan dynamic and allow for adjustments and plan adaptations based on more refined data and information.

A comprehensive diagnostic model of the system, like EDT, could not be developed within the scope of this plan.

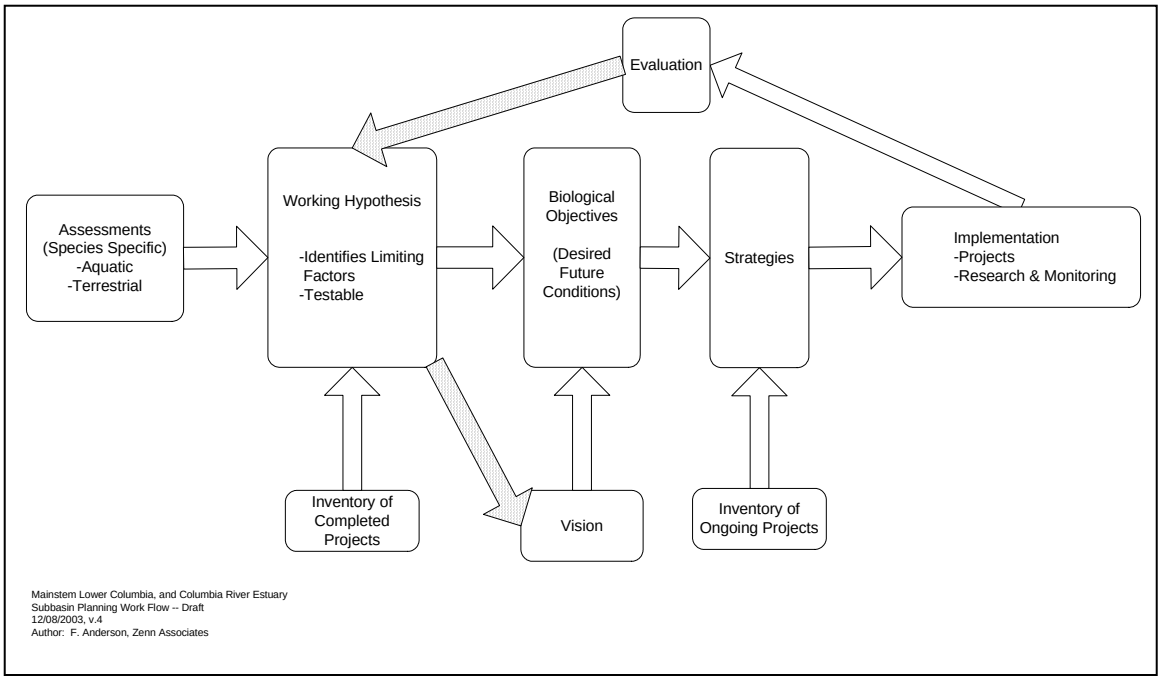

Figure 4-2: Figure 0 3 Process model workflow for development of the Mainstem Lower Columbia River and Columbia River Estuary subbasin plan

This Management Plan builds on information in the assessment and inventory, articulates a subbasin vision and values and examines four major areas of emphasis: working hypotheses, limiting factors, objectives (biological and physical) and strategies (Figure 4-2). Working hypotheses, limiting factors, objectives (biological and physical) and strategies areas are examined at a species level for focal species and other species of interest (ecological interest, management interest and recreational interest). Focal species were selected based on:

- ESA status
- Cultural importance of the species
- Level of information available about species' life histories allowing an effective assessment
- Life histories representative of the *use* of Mainstem Lower Columbia River and Columbia River Estuary subbasin

Table 4-1. Species Selection and Planning Context.

Species	ESA	Ecological[1]	Cultural	Economic[2]	Recreation[3]
Species of Primary Interest (Focal Species)					
Fall Chinook	X	X	X	X	X
Chum	X	X	X	X	X
Spring Chinook	X	X	X	X	X
Winter Steelhead	X	X	X	X	X
Summer Steelhead	X	X	X	X	X
Coho	X	X	X	X	X
Pacific Lamprey	X	X	X		
Bald Eagle	X	X	X		
CWT Deer	X	X[4]	X		
Green Sturgeon		X	X		
White Sturgeon		X	X	X	X
Species of Ecological Significance					
N. Pikeminnow		X		X[8]	X
Shad		X[7]		X	X
River Otter		X[9]			
Eulachon		X	X	X	X
Caspian Tern		X[6]		X	
Osprey		X			
Yellow Warbler		X[10]			
Red-eyed Vireo		X[10]			
Species of Management Interest					
Dusky Canada Goose				X[5]	
Sandhill Crane	X			X[5]	
Species of Recreational Significance					
Walleye		X[7]			X
Smallmouth Bass		X[7]			X
Channel Catfish		X[7]			X

1 May be positive or negative ecological impact; this column only indicates relative significance.

2 May be positive or negative economic impact; this column only indicates relative significance.

3Active recreation potential (e.g., harvest).

4 Likely ecologically important historically.

5 Seasonal crop damage.

6 Historically not present in estuary.

7 Non-native species.

8 Some economic importance for control program.

9 Indicator of ecosystem health.

10 Indicator of habitat type.

From the species level this information was compiled and synthesized for use in decision making. The information from focal species forms the core of the plan supplemented with information from other identified species of interest and from information acquired through the assessment process for the Western Oregon tributaries subarea.

The compilation and synthesis is detailed in this Management Plan; the species-level information is included with the Management Plan Supplement (Chapter 5).

Management Plan Supplementary Information

Because the Mainstem Lower Columbia River and Columbia River Estuary are considered out-of-basin effect for most upstream users, the Planning Group recommended that the plan recognize the needs of stocks that use the estuary for only part of their life history. In setting out the goals of the Mainstem Lower Columbia River and Columbia River Estuary subbasin plan, the Planning Group identified a large number of aquatic and terrestrial species to be in this plan. As such, a large amount of material was generated for all salmonid stocks using the estuary; it was recognized that building a management plan around all of this information would require a significant amount of condensing and summarizing. In an effort to keep the policy considerations as focused as possible, the species-specific information was organized into a Management Plan Supplement (Chapter 5) that accompanies this subbasin plan. This supplement has species-specific limiting factors, working hypotheses, threat identification, physical objectives, strategies and measures.

Vision

The vision provides general guidance and priorities for the long-term future of the subbasin. The vision describes, generally, the desired future condition of the subbasin. The vision reflects the policies, legal requirements and local conditions, values and priorities of the subbasin in a manner that is consistent with the vision described for the Columbia Basin in the Council's program. The vision was drafted by a Planning Group subcommittee, and then approved by the Planning Group. The vision section includes: vision, supporting statements, strategy links and, for each of the species examined, value statements.

Working Hypotheses

The Subbasin Assessment (Chapter 2) examined physical and environmental characteristics of the Mainstem Lower Columbia River and Columbia River Estuary and the Western Oregon tributaries subarea. These assessments culminated in basin-wide working hypotheses that represent the processes and functions that govern how these ecosystems function with respect to focal species and species of interest. These working hypotheses are used to relate limiting factors for each species to physical and biological objectives and to species-specific hypotheses that posit a response to changes in a given physical condition or limiting factor. The species-specific limiting factors, physical objectives and working hypotheses are available in the Management Plan Supplement (Chapter 5).

Table 4-2: Mainstem And Estuary Working Hypotheses

Working Hypotheses – Estuary & Lower Columbia Mainstem	
E.H1.	Complex and dynamic interactions between physical river and oceanographic processes, as modulated by climate and human activities, affect the general features of fish and wildlife habitat in the Columbia River estuary and lower mainstem.
E.H2.	Human activities have altered how the natural processes interact, changing habitat conditions in the Columbia River estuary and lower mainstem.
E.H3.	Rates of obvious physical habitat change in the Columbia River estuary and lower mainstem have slowed in recent years; current physical and biological processes are likely still changing such that habitat conditions represent a degraded state.
E.H4.	Our current understanding of the interrelationships among fish, wildlife, and limiting habitat conditions in the estuary and lower mainstem is not robust and introduces substantial uncertainty in decisions intended to benefit recovery and sustainability of natural resources.
E.H5.	Exotic species are capitalizing on the Columbia River estuary and lower mainstem habitats and they have impacted ecosystem processes and relationships.
E.H6.	Of all fish and wildlife species utilizing the Columbia River estuary and lower mainstem habitat, salmonids appear the most distressed.
E.H7.	The Columbia River estuary and lower mainstem ecosystem is critical to the expression of salmonid life history diversity and spatial structure which support population resilience and production.
E.H8.	Changes in the Columbia River estuary and lower mainstem habitat have decreased the productivity of the ecosystem and contributed to the imperiled status of salmon and steelhead.
E.H9.	Construction and operation of the Columbia River hydropower system has contributed to changes in Columbia River estuary and lower mainstem habitat conditions that have reduced salmonid population resilience and inhibited recovery.
E.H10.	Predation has always been a significant source of juvenile salmonid mortality in the lower Columbia River mainstem and estuary but habitat changes resulting from human activities have substantially altered predator concentration and distribution, particularly Caspian terns and northern pikeminnow.
E.H11.	Density dependent factors affect salmonid productivity in the Columbia River estuary and lower mainstem. However, the relationships of the quantity and quality of habitat in relation to the expression of life history strategies of salmonids requires further clarification.
E.H12	Habitat restoration efforts are capable of significantly improving conditions for fish and wildlife species in the Columbia River estuary and lower mainstem.

Table 4-3: Western Oregon tributaries working hypotheses

Working Hypotheses – Western Oregon Tributaries	
W.H1	If habitat diversity and channel stability in high-priority reaches of the Western Oregon tributaries subarea are protected and restored, salmonids production and abundance will increase.
W.H2	If n-type coho are promoted and restored to the Western Oregon tributaries subarea, then population diversity in the coastal range emographically independent populations (DIPs) will improve.
W.H3.	If habitat diversity is restored in the lower reaches of the Lewis and Clark River, spawning and rearing of all salmonid populations will improve.
W.H4.	If geomorphic behavior of channels in the lower reaches of the Youngs River is restored, and

Working Hypotheses – Western Oregon Tributaries	
	connectivity to the floodplains and estuary is enhanced, spawning and rearing of salmonids will improve.
W.H5.	If access to productive habitat above the Big Creek hatchery is improved and if concerns about disease transmittal at the hatchery can be addressed., the spatial structure of salmonid populations in the coastal DIPs will improve and productivity of coho, steelhead, and Chinook populations will increase.
W.H6.	If habitat diversity and channel stability are restored in the lower reaches of the Klaskanine River, chum spawning and summer rearing opportunities for Steelhead will improve.
W.H7.	If protection measures are applied to key reaches of the Clatskanie River and if channelization, habitat diversity, and water quality attributes are mitigated in its lower reaches, the population and abundance of salmonids, including chum, coho and winter steelhead, will improve.
W.H8.	Habitat conditions in Scappoose Bay are impaired throughout the watershed, and significant impacts in the lower reaches have been observed due to channelization and diking. Protection of the south end of Scappoose Bay should be a priority, as it is one of the few remaining relatively intact portions of the lowland floodplain portion of the watershed; restoration opportunities in Jackson Creek and Joy Creek are possible means of improving habitat conditions; Artficial and natural barriers to fish passage limit access to potentially productive habitat.

Limiting Factors

The limiting factors section includes the applicable species and (for aquatic species) life stage or stages affected. The section also includes all the limiting factors from all of the subbasin focal and non-focal species. The synthesis eliminates duplication and identifies common limiting factors among the species. The result is 39 limiting factors for focal aquatic species, 11 limiting factors for non-focal species and 12 limiting factors for focal terrestrial species.

Biological and physical objectives

The biological objectives (or desired future conditions) were formulated, when possible, to support value statements for each species. The physical objectives were formulated to address limiting factors and then used in evaluating strategies.

The summary of physical objectives is compiled from each of the species-specific sections included in the Management Plan Supplement (Chapter 5). These have been synthesized to eliminate duplication and identify common objectives among the species. This effort resulted in a total of 33 physical objectives.

The physical objectives include species-specific working hypotheses and applicable species life stages. Each of these has been evaluated by: 1) the level of difficulty of addressing objectives, 2) potential benefit and 3) degree of certainty with which these qualitative judgments are applied.

The project's technical staff conducted the initial evaluation, which was then amended or verified based on reviews by species experts and Planning Group members. The evaluation uses the qualitative terms of "high," "medium" and "low" to provide a relative benefit of each identified physical objective.

Strategies

As with the limiting factors and objectives, the subbasin project team compiled all of the species-specific strategies and combined them where commonalities existed to form a single set of master strategies for the subbasins. Each of these master strategies was further examined to identify and articulate the relationships to the biological objectives outlined. At the direction of the Planning Group, the subbasin-wide strategies were reviewed based on:

- ability to address key objectives
- relationship to ESA
- relationship to focal species of the subbasin
- socioeconomic considerations as stated in the vision

Measures

The project team identified measures and activities that may be pursued to implement strategies identified in this chapter. Measures were detailed on a species-specific basis (Chapter 5), then compiled and synthesized to support the broad biological and physical objectives outlined. Measures are not prioritized.

Research Monitoring and Evaluation

A robust and adaptive research, monitoring and evaluation (RME) framework will be critical for weighing progress toward desired future conditions and for making appropriate course adjustments along the way. The subbasin project team recognizes that in the Mainstem Lower Columbia River and Columbia River Estuary and Western Oregon tributaries, RME efforts from a variety of entities will be responding to an array of court-mandated or Northwest Power-Planning-Act-inspired management plans and recovery plans. The RME efforts discussed here with respect to Mainstem Lower Columbia River and Columbia River Estuary subbasin planning recognize the continual evolution of these complementary efforts.

Endangered Species Act & Clean Water Act Consistency

This section briefly describes the subbasin plans Endangered Species Act and Clean Water Act considerations. This subbasin planning effort overlaps broadly with recovery efforts in the region. The Co-lead for the plan, the Lower Columbia Fish Recovery Board (LCFRB), approached its contributions to the plan with recovery in mind. Similarly, federal action agencies represented on the planning committee expressed their desire to ensure that the subbasin plan represented a step toward their recovery planning.

The subbasin plans consistency with Clean Water Act provisions is also discussed. Strategies that address toxins and contaminants will rely on clean water act standards to help achieve environmental benefits for fish and wildlife, as well as human populations.

Artificial Production Consideration

The Estuary and Mainstem Assessment (EMA) and the Western Oregon tributaries identified limiting factors and working hypotheses that led to the setting of biological and physical objectives and the identification of strategies and measures that may affect the desired future conditions. These are detailed in the Management Plan Supplement (Chapter 5) and summarized in this chapter. How these strategies and measures ultimately intersect with artificial production policies in the subbasin is briefly described in the Management Plan;

however, it was beyond the purview of this plan to suggest changes for hatchery and artificial production policies that serve a complicated array of *US v. Oregon* responsibilities, while also serving as mitigation for a variety of other out-of-basin effects.

4.2 Vision

This section provides general guidance and priorities for the long-term future of the subbasin. The vision, generally, describes the desired future condition of the subbasin. The vision is qualitative and reflects the policies, legal requirements and local conditions, values and priorities of the subbasin in a manner that is consistent with the vision described for the Columbia Basin in the Council's program. The vision provides guidance for prioritizing and implementing actions in the future, thereby driving the development of biological objectives and strategies for the subbasin (NPCC 2001).

4.2.1 *Subbasin Vision*

The following vision statement and guiding principles for the Mainstem Lower Columbia River and Columbia River Estuary were developed and approved by the Subbasin Planning Group. In addition to the vision, the Planning Group provided supporting statements, strategy links and, for each of the species examined, value statements.

Fish and wildlife resources and their habitats are maintained at healthy levels; clean, safe water is available for people, fish and wildlife. The lower Columbia River and estuary nourish all communities.

4.2.2 *Supporting Statements*

In developing the vision articulated above, the subbasin Planning Group considered numerous influences, values and perceived challenges in the mainstem lower Columbia River and Columbia River estuary. The group felt that discussions that culminated in the vision needed to be captured as supporting statements that effectively articulate the challenges facing the subbasin and the desired outcomes of management actions. The NPCC guidance for development of the Management Plan suggests that the strategies, which are addressed more fully later in this chapter, should support and respond to the subbasin vision. The alignment of strategies to supporting statements is briefly noted in an abbreviated fashion here. And again in more detail in the Strategies Section 4.4 of this Management Plan.

Supporting Statement (SV1): In the lower Columbia River and estuary, communities recognize that a healthy and well-managed ecosystem supports opportunities for cultural and economic growth.

At Issue: Cultural and Economic Sustainability

The Lower River and estuary provide a rich cultural heritage and economic viability to the human populations of the region and the nation. Degradation of the system puts both at risk. For example, loss of habitat and other impacts of human activity have led to several species of fish

now listed as threatened or endangered. This loss of fish has had a decimating effect on our commercial fishing industry. Figures from Oregon State University Extension Service report that the commercial salmon fishing industry provided $41 million in personal income in 1976-1980; in 1998, it provided just $4 million in personal income. Hundreds of local commercial fisherman now must travel to Alaska and other rivers to compete with local fishers there for their catch. Not only is this difficult for them, but it further depletes investments in the economy of the Pacific Northwest.

Addressed by the following strategies from section 4.4.2 below: S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S15, S18, S19, S20, S23

Supporting Statement (SV2): Integrated, resilient, and diverse biological communities are restored and maintained in the lower Columbia River and estuary. Riverine and oceanic processes are recognized and protected.

At Issue: Biological Integrity

The populations of certain native species in the Lower Columbia River Estuary have declined, and twelve species of Columbia Basin salmon and steelhead that use the lower river are now listed as endangered or threatened. Some ecosystem functions are impaired, decreasing the ability of the river system to support a healthy, adaptive community of plant and animal life. Restoring and maintaining the biological integrity and species diversity of the system is the ultimate goal of the Estuary Program.

Addressed by the following strategies from section 4.4.2 below: S1, S2, S3, S4, S5, S7, S8, S9, S10, S11, S18, S19, S23

Supporting Statement (SV3): In the lower Columbia River and estuary, flow, temperature, turbidity, bacteria, dissolved oxygen, dissolved gas, and other conventional pollutants are managed in a manner that benefits the health of fish, wildlife, and humans.

At Issue: Conventional Pollutants

Pollutants from a variety of sources have negatively affected water quality. Summer temperatures in the lower Columbia River regularly rise above the 68 degree threshold necessary for salmonid viability. High levels of dissolved gas are sometimes present. Standards for bacteria, dissolved oxygen, and pH are exceeded on occasion. Turbidity, flow and sedimentation are also of concern.

Addressed by the following strategies from section 4.4.2 below: S1, S6, S11, S12, S18, S23

Supporting Statement (SV4): Toxic contaminants are not present at levels that impair the health or threaten the future well-being of the lower Columbia River and estuary and the populations they support.

At Issue: Toxic Contaminants

Toxic contaminants have been found in sediment and fish tissue. Levels of PCBs, DDE, and dioxin are high enough that they may be linked to reproductive failure in bald eagles, mink, and river otters. They also pose a threat to human health.

Addressed by the following strategies from section 4.4.2 below: S1, S2, S3, S4, S6, S11, S12, S18, S23

Supporting Statement (SV5): Habitat in the lower Columbia River and estuary supports self-sustaining populations of native plants, fish, and wildlife.

At Issue: Habitat Loss and Modification

Human activities over the last 100 years have significantly altered the estuary and resulted in the loss of more than 50% of the habitat since 1890. Dams, dikes, maintenance dredging, urbanization, agriculture, forestry, and land use practices all contribute to this alteration. Loss of habitat impacts fish and wildlife populations. Economic and recreational activities that depend on these resources are also threatened.

Addressed by the following strategies from section 4.4.2 below: S1, S2, S10, S11, S12, S23

Supporting Statement (SV6): Land uses and land development practices, including results of past practices and population growth, are managed in a way that enhances the quality of life of the biological and human communities.

At Issue: Impacts of Human Activity and Growth

Many past and current human activities have degraded the natural environment. Impervious surface area, paved area that blocks the natural infiltration of water, continues to grow, increasing the polluted runoff to tributaries and the river. As population continues to grow, land use and development practices could result in further pollution, habitat loss and impacts to fish and wildlife.

Addressed by the following strategies from section 4.4.2 below: S1, S2, S3, S4, S5, S6, S10, S11, S17, S18, S20, S23

Supporting Statement (SV7): A coordinated, integrated network exists among all levels of government and other interested organizations that effectively and efficiently protects and manages the lower Columbia River and estuary.

At Issue: Institutional Constraints

Over 160 agencies and organizations of government currently have some jurisdiction or a management role in the lower 146 miles of the Columbia River. This complex and sometimes conflicting network hampers efforts to protect and improve the health of the estuary.

Addressed by the following strategies from section 4.4.2 below: S1, S2, S3, S4, S6, S10, S11, S12, S18, S19, S23

Supporting Statement (SV8): Everyone participates in maintaining and protecting the lower Columbia River and estuary.

At Issue: Public Awareness and Stewardship

There is a continual need to connect ourselves as individual, corporate, and community citizens to our river. Greater understanding of the river will lead to stronger river protection. In a 1997 Estuary Partnership survey, less than half the respondents expressed some "connectedness" to the river. Citizens actions do have a direct impact on the environmental integrity of the Columbia River system.

Addressed by the following strategies from section 4.4.2 below: S7, S10

4.2.3 *Species value statements*

In considering biological objectives for each of the focal species, species of recreational interest, species of management interest and species of ecological interest, members of the subbasin Planning Group noted that setting of these objectives required explanation about how the species are intended to fit into the future architecture of the subbasin. The value statements are intended to address the status of the species, the value the species may provide to the economic, cultural or ecological milieu of the subbasin, and social and ecological objectives. These value statements help direct the desired future conditions identified in the biological and physical objectives sections. For the species-specific limiting factors, biological and physical objectives, and strategies, refer to the Management Plan Supplement (Chapter 5).

4.2.3.1 Chum

Lower Columbia River chum are currently listed as threatened under the Endangered Species Act; additionally, chum salmon are culturally, economically and ecologically important. Juvenile rearing in the estuary and adult spawning in the mainstem are vital life history trajectories for chum salmon. Because chum salmon pass hydroelectric facilities with poor efficiency, it is likely that restoration efforts of chum will achieve the highest success in the lower Columbia mainstem, the estuary and the various tributaries below Bonneville Dam. Therefore, strategies and measures to return selected historic chum populations in these areas to viability are among the highest levels of importance. The restoration goal for lower Columbia chum salmon is to increase the population to a self-sustaining, viable population that can provide for tribal, sport and commercial fishery harvest.

4.2.3.2 Fall Chinook

Lower Columbia River and Snake River fall Chinook are currently listed as threatened under the Endangered Species Act. Additionally, fall Chinook are culturally, economically, and ecologically important. Juvenile rearing in the estuary and adult spawning in the mainstem are vital life-history trajectories for fall Chinook. The restoration goal for lower Columbia fall Chinook is to increase the population to a self-sustaining, viable population that can provide for tribal, sport and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage, it is likely that restoration efforts of fall Chinook will achieve the highest success in the lower Columbia mainstem, the estuary and the various tributaries below Bonneville Dam. However, recovery efforts of upriver fall Chinook have shown some success and should continue to be pursued. Strategies and measures to return

fall Chinook populations to viability throughout the historical distribution are among the highest level of importance.

4.2.3.3 Coho

Lower Columbia River coho salmon are currently a candidate species for listing under the Endangered Species Act; additionally, coho are culturally, economically and ecologically important. Juvenile rearing in the lower mainstem, Western Oregon tributaries, estuary and plume are a vital life history trajectory for coho. The restoration goal for lower Columbia coho is to increase the population to a self-sustaining, viable population that can provide for tribal, sport and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage, it is likely that restoration efforts of coho will achieve the highest success in the lower Columbia mainstem, the estuary and the various tributaries below Bonneville Dam. However, recovery efforts of upriver coho should continue to be pursued. Strategies and measures to return coho populations to viability throughout the historical distribution are among the highest level of importance.

4.2.3.4 Winter Steelhead

Lower Columbia River winter steelhead are currently listed as threatened under the Endangered Species Act. Additionally, winter steelhead are culturally, economically and ecologically important. Juvenile rearing in the lower mainstem, Western Oregon tributaries, estuary and plume are a vital life-history trajectory for winter steelhead. The restoration goal for lower Columbia winter steelhead is to increase the population to a self-sustaining, viable population that can provide for tribal, sport and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage and because winter steelhead were historically destined primarily for tributaries below Bonneville Dam, it is likely that restoration efforts of winter steelhead will achieve the highest success in the lower Columbia mainstem, the estuary and the various tributaries below Bonneville Dam. However, recovery efforts of the few winter steelhead populations above Bonneville Dam should still be pursued. Strategies and measures to return winter steelhead populations to viability throughout the historical distribution are among the highest level of importance.

4.2.3.5 Spring Chinook

Spring Chinook salmon in the Columbia River lower mainstem, Western Oregon tributaries, estuary and plume have threats to both life stages expressed in the combined subbasins and adjacent tributaries. Historically, spring Chinook salmon populations were distributed throughout the Columbia River basin. Within the Lower Columbia River ecologically significant unit, the Cowlitz and Lewis River subbasins likely supported the largest spring Chinook populations, although historical escapement data are limited. Each of these subbasins has undergone development of hydroelectric facilities that have blocked access to a considerable amount of historical spring Chinook spawning habitat. Downstream of Bonneville Dam, juvenile spring Chinook have been affected by low flows, disconnected or lost habitats and predation losses. The period of estuarine residence may be a critical phase in the life history of spring Chinook, and thus it plays a major role in determining the size of the subsequent adult run back to fresh water.

4.2.3.6 Summer Steelhead

Lower Columbia River, Middle Columbia, Upper Willamette, and Snake River steelhead are currently listed as threatened under the Endangered Species Act, while Upper Columbia River steelhead are listed as endangered. Additionally, summer steelhead are culturally, economically and ecologically important. Juvenile rearing in the lower mainstem, Western Oregon tributaries, estuary, and plume is a vital life-history trajectory for summer steelhead. The restoration goal for lower Columbia summer steelhead is to increase the population to a self-sustaining, viable population that can provide for tribal, sport and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage, it is likely that restoration efforts of summer steelhead will achieve the highest success in the lower Columbia mainstem, the estuary and the various tributaries below Bonneville Dam. However, recovery efforts of upriver summer steelhead populations should still be pursued. Strategies and measures to return summer steelhead populations to viability throughout the historical distribution are among the highest level of importance.

4.2.3.7 White Sturgeon

White sturgeon are culturally, economically and ecologically important. The restoration goal for lower Columbia River white sturgeon is to maintain or increase the population to a self-sustaining, viable population that can meet continued cultural, economic and ecological needs. Strategies and measures to maintain the white sturgeon population at viable levels are among the highest importance.

4.2.3.8 Green Sturgeon

Green sturgeon are culturally and economically important, although less so than white sturgeon. The ecological importance of green sturgeon in the lower Columbia River and estuary is unclear. The restoration goal for lower Columbia River green sturgeon is to maintain or increase the population to a self-sustaining, viable population that can meet the continued cultural, economic and ecological needs. Strategies and measures to maintain the green sturgeon population at viable levels are among the highest importance.

4.2.3.9 Pacific Lamprey

Pacific lamprey is culturally and ecologically important. Culturally, they are important to many tribes throughout the Columbia River basin. Ecologically, they are an important food source for many Columbia River estuary and mainstem species (e.g., sturgeon and pinnipeds). Because Pacific lamprey pass hydroelectric facilities with poor efficiency, it is likely that lamprey restoration efforts will achieve the highest success in the lower Columbia mainstem, the estuary and the various tributaries below Bonneville Dam. Therefore, strategies and measures to return selected historic lamprey populations in these areas to viability are among the highest levels of importance. The goal for Columbia River Pacific lamprey is to reverse the decreasing abundance trend and increase the population to a self-sustaining, viable population that can provide for cultural and ecological needs.

4.2.3.10 Bald Eagle

The bald eagle carries significant status both legally and culturally. Bald eagles are an indicator of habitat with large, mature trees. They also serve as indicators for detecting changes in contaminants over time and for evaluating contaminant exposure and toxic impacts in fish-

eating birds and mammals. As such, the goal of the bald eagle plan is to increase the viability of local populations. Successes with regional management planning for bald eagles should not override efforts to improve the reproductive successes of local populations.

4.2.3.11 Columbian White-tailed Deer

The Columbian White-tailed Deer was once abundant in the Willamette and Columbia River valleys. The clearing of riparian lands for agriculture and unrestricted hunting had reduced the population of Columbian White-tailed Deer to a low of 200 to 400 animals early in the 1900's. The Columbian White-tailed Deer thrived under the protection of refuges and were even considered to be candidates for down-listing in 1995. But, in February of 1996, both Tenasillahe Island and the mainland deer refuge experienced severe flooding. As a result of these floods, half of the Washington population of Columbian White-tailed Deer was lost.

The Columbian White-tailed Deer carries both legal and management status. It also carries cultural importance as the largest of 38 subspecies and the western-most subpopulation. As such, the goal for the Columbian White-tailed Deer is to reach and maintain manageable populations (with acceptable level of depredation).

4.2.3.12 Species of Ecological Interest

4.2.3.12.1 Northern Pikeminnow

Northern pikeminnow are a native fish with ecological, cultural and economic importance. With their increased abundance in response to Columbia River habitat alterations, pikeminnow have become an integral part of the Columbia River mainstem ecosystem. Northern pikeminnow are an important predator of juvenile salmonids. The goal for northern pikeminnow in the lower Columbia River is to maintain a viable population while minimizing the number older, larger, predaceous individuals.

4.2.3.12.2 Eulachon

Eulachon are a species with ecological, cultural, economic and fishery management importance. They are an anadromous species that utilizes unique spawning habitat in the estuary and lower mainstem. The goal for eulachon in the lower Columbia River is to maintain or increase annual population to some (currently unknown) carrying capacity level to provide forage value for estuary and lower mainstem species and to provide annual harvest opportunities similar to the historic annual average (i.e., 2 million pounds).

4.2.3.12.3 Caspian Tern

Caspian terns are a colonial nesting species protected under the Federal Migratory Bird Treaty. They are perceived to be a significant predator of juvenile salmonids and have become a significant part of the estuarine ecosystem, based on their abundance and consumptive needs during the breeding season. Salmon recovery efforts should evaluate potential effects on Caspian terns. Goals for the Columbia River estuary population are to maintain population viability region-wide and decrease the population’s vulnerability to catastrophic events, consistent with objectives emerging from the Caspian Tern Working Group and USFWS Environmental Impact Statement process.

4.2.3.12.4 Osprey

Osprey in the lower Columbia River mainstem and estuary are ecologically significant; they are considered an indicator of environmental contaminants. The goal for the estuary and lower mainstem osprey population is to improve population viability by increasing reproductive success.

4.2.3.12.5 Yellow Warbler

Yellow warblers in the lower Columbia River mainstem and estuary are ecologically significant; they are considered an indicator of dense riparian shrub habitat. The goal for the estuary and lower mainstem warbler population is to improve population viability, although little is known about current population abundance and productivity.

4.2.3.13 Species of Management Interest

4.2.3.13.1 Dusky Canada Goose

The dusky Canada goose has ecological, management and potentially negative economic (crop depredation) significance. The dusky Canada goose is classified as a migratory bird by federal regulation and thus protected by the Migratory Bird Treaty Act. It is considered a game bird by Washington rule. The Pacific Flyway and Washington Fish and Wildlife Commission regulate harvest. The goal for dusky Canada geese is to reverse the declining abundance trend and maintain a wintering population in the lower Columbia River, while limiting crop depredation.

4.2.3.13.2 Sandhill Crane

Sandhill cranes have ecological, management and potentially negative economic (crop depredation) significance. They are a Washington state listed species, based partially on concern for the wintering population within the subbasins. Because of their migratory life history, sandhill cranes are protected by the Migratory Bird Treaty Act. The goal for sandhill cranes is to support and maintain a wintering population in the lower Columbia River, while limiting crop depredation.

4.2.3.14 Species of Recreational Interest

Walleye, smallmouth bass and channel catfish are introduced species with fishery management and economic importance; The Washington Department of Fish and Wildlife recognizes the beneficial value of commercial and recreational fisheries of each species. Each species of recreational interest is a top-level predator within the aquatic community; each is perceived to have some predation impact on emigrating juvenile salmonids. The goal for the species of recreational interest is to adaptively manage each population to maintain or reduce current abundance levels and minimize adverse impacts on salmonids and other species of interest.

4.3 Limiting factors summary

The Subbasin Assessment culminated in working hypotheses that described the basin-wide processes, mechanisms and functions that subbasin planners will need to take into consideration as protection, mitigation and enhancement efforts are developed pursuant to the Northwest Power and Conservation Councils Fish and Wildlife Program. The basin-wide working hypotheses were derived from the assessment components and from the Species Technical Foundation (Appendix A), and they hinge on limiting factor identification. A limiting factor analysis for each species considered in the subbasin plan (focal species, species of management interest and species of recreational interest) is detailed in the Management Plan Supplement (Chapter 5). These species-specific limiting factor analyses address the following:

- Factors or conditions that historically led to the decline of each focal species and of associated ecological functions and processes.
- Key factors or conditions that currently inhibit populations and ecological processes and functions relative to their potential.
- Current threats or risks for focal species and their habitats.
- Opportunities that directly reduce these threats.

The summary section includes a compilation and synthesis of the limiting factors derived from the species-specific sections contained in the Management Plan Supplement (Chapter 5). The limiting factors compilation includes the applicable species and (for aquatic species) life stage or stages affected, plus all the limiting factors from all of the subbasin focal and non-focal species. The synthesis eliminates duplication and identifies common limiting factors among the species. The result is 39 limiting factors for focal aquatic species, 11 limiting factors for non-focal aquatic species and 12 limiting factors for focal terrestrial species.

Evaluating impact

The technical staff evaluated the impact of each limiting factor as “high,” “medium” or “low” using the following scale descriptions:

High – The limiting factor currently limits population viability because of effects on mortality rates or productivity. The limiting factor is of primary importance in maintaining current levels of population abundance/productivity, or the limiting factor must be addressed to promote recovery of the species.

Medium – The limiting factor currently affects population viability but, at present impact levels, may not be significantly reducing population abundance or productivity. The limiting factor does affect current levels of population abundance/productivity or recovery of the species; however, addressing this factor will have less impact on overall population viability than the high-impact factors.

Low – The limiting factor exists, but is unlikely to affect the population viability at present impact levels. The limiting factor should be recognized but will likely produce no measurable effects on population viability until the high-and medium limiting factors have improved.

Evaluating degree of certainty

Recognizing the inconsistencies in level of understanding for many of the limiting factors, the technical staff further described the degree of certainty for each evaluation. The qualitative terms of "high," "medium" and "low" were again used and, in the context of certainty, are defined as:

High – Considerable research has been performed on the subject and has repeatedly produced similar results.

Medium – Considerable research has been performed on the subject and results have been inconclusive or contradictory OR some research has been performed on the subject and preliminary results suggest that a relationship exists.

Low – Some research has been performed on the subject and preliminary results are inconclusive or contradictory OR little to no research has been performed on the subject and any relationships are assumed based on other related scientific data or relationships.

The species-limiting factors are organized into three categories: 1) Focal aquatic; 2) Non-focal species of interest and 3) Focal terrestrial species.

4.3.1 *Focal Aquatic Species*

4.3.1.1 Limiting Factors, Aquatic Focal, Salmonids

Table 4-4 below summarizes limiting factors derived from the Estuary and Mainstem Assessment (EMA) and the Western Oregon tributaries subarea assessment. While limiting factors derived from EMA apply across the subbasin, those that were derived from the WOTs assessment are specifically identified.

Table 4-4: Limiting Factors for Focal Salmonids (WOTs-specific factors identified by a "-w" notation)

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
Juvenile Rearing (within and out-of-subbasin populations)	Chum Fall Chinook	**LF.1** Availability of preferred habitat (i.e. shallow water, low velocity, peripheral habitats). Chum salmon are closely associated with peripheral habitats. There has been extensive loss of peripheral wetland and side channel habitat throughout the mainstem and estuary, and in the Western Oregon tributaries (WOTs) as a result of water regulation, dike construction, and urban and agricultural development. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, E.H12, W.H3, W.H4, W.H6, W.H7, W.H8**	High/High

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.2** Microdetritus-based food web. The current microdetritus-based food web is expected to be less productive than the historical macrodetritus-based food web. Loss of wetland and side channel habitat identified above has reduced the local macrodetritus inputs from terrestrial and riparian habitats that supported the historical food web. Present detrital inputs to the food web are dominated by microdetritus from upriver sources and are controlled primarily by reservoir production and flow rates from Bonneville Dam. Further, the microdetritus-based food web is thought to be less available to chum salmon because it is pelagic in nature and may be focused on the spatially-confined estuary turbidity maximum region. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H8, E.H9, E.H11, E.H12, W.H3, W.H4, W.H6, W.H7, W.H8**	High/Medium
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.3** Loss of habitat connectivity. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids. As juveniles grow, they move across a spectrum of salinities, depths, and water velocities. For species like chum salmon that rear in the estuary and in tidally influenced areas of the Western Oregon tributaries for extended time periods, a broad range of habitat types in the proper proximities to one another may be necessary to satisfy feeding and refuge requirements within each salinity zone. For species like fall Chinook that rear in the estuary for extended time periods, a broad range of habitat types in the proper proximities to one another may be necessary to satisfy feeding and refuge requirements within each salinity zone. And research suggest that proximity of feeding and refuge areas for stream-type salmonids may be important for survival and olfactory cues needed for a successful return migration. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, E.H12, WH.1,W.H3, W.H4, W.H5,W.H6, W.H7, W.H8**	High/High

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.4** Predation mortality. Current levels of predation on chum salmon are unknown but are expected to be lower than other salmonids, potentially as a result of lower abundance, smaller size, or spatial segregation from predators. Levels of predation on fall Chinook are unknown but are expected to higher than chum but lower than stream-type salmonids. Current primary sources of predation on stream-type salmonids are substantial (but how current predation levels compare to those experienced historically is unknown). For example, Caspian tern predation is higher for larger emigrating salmonids, such as steelhead. Primary predation sources for stream-type salmonids include Caspian tern and pikeminnow. Also, because chum salmon spawn downstream of Bonneville Dam, emigrating chum do not encounter the known concentration of northern pikeminnow just below Bonneville Dam. **Supported by Working Hypotheses:** **E.H1, E.H4, E.H5, E.H6, E.H8, E.H9, E.H10, E.H11, E.H12.**	Low/Medium
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.5** Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on salmonids. Juvenile chum and fall Chinook salmon are closely associated with peripheral, side channel habitats where contaminants commonly accumulate. Exposure risks to stream-type salmonids are not clear; contaminant uptake may be through contaminated diet items. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H4, E.H5,E.H6, E.H8**	Medium/Medium
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.6** Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on salmonids are unknown but are expected to be negative. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H4, E.H5, E.H6, E.H8, E.H9, E.H10**	High/Low

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.7** Density dependence. Density dependent mechanisms in the lower mainstem, Western Oregon tributaries, estuary, and plume may limit juvenile salmonid survival and productivity, however, the significance is unclear. NOAA Fisheries is currently conducting research intended to clarify this issue. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H8, E.H9, E.H10, E.H11**	Medium/Low
	Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.8** Fitness and timing of juvenile salmonids entering the subbasin. Juveniles entering the subbasin from upriver via barge releases or dam passage experience lower survival than historical mainstem emigration prior to hydrosystem development. **Supported by Working Hypotheses:** **E.H2, E.H6, E.H9, E.H10**	High/High
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.9** Development, as well as agricultural and timber practices have caused a loss of habitat diversity and channel stability throughout the Western Oregon tributaries due to the loss of recruitment of large woody debris (LWD) into the systems throughout the subbasin. Habitat complexity is important for creating rearing opportunities for young-of-the-year coho. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H8, E.H12, WH.1,W.H3, W.H4,W.H6, W.H7, W.H8**	High/High

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
Adult Migration (within and out-of-subbasin populations)	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.10** Dam passage. Chum salmon are often unable or unwilling to migrate through fish ladders or inundated habitats. Thus, Bonneville Dam has blocked most upstream migration of chum salmon to historical spawning areas. Access to historical spawning areas has been blocked in 2 major fall Chinook producing subbasins, the Cowlitz and Lewis, and in key areas of the Western Oregon tributaries. Coho likely experience some mortality and delay associated with mainstem dam passage, however, an average per dam survival rate estimate for coho was not available. For spring Chinook, average per dam survival rate estimate was 89 percent (includes fallback and re-entry). Winter and summer steelhead estimate was 95 percent. **Supported by Working Hypotheses:** **E.H2, E.H6, E.H8, E.H12, W.H4,W.H5, W.H6, W.H8**	Medium/High
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.11** Migration barriers/ lack of resting habitats. Elevated water temperature or high water flow may act as a temporary adult migration barrier. Additionally, high water flow likely reduces available resting habitat for migrating adults. Hatchery weirs, culverts and other passage barriers exist in the Western Oregon tributaries that block access to potentially productive habitat. **Supported by Working Hypotheses:** **E.H2, E.H6, E.H8, E.H12, W.H4,W.H5, W.H6, W.H8**	Low/High
	Chum Fall Chinook Coho Spring Chinook Winter steelhead Summer steelhead	**LF.12** Predation losses. Marine mammals (pinnepeds) prey on adult salmon, but the significance is unclear. **Supported by Working Hypotheses:** **E.H4, E.H5, E.H6, E.H9, E.H10, E.H11**	Low/Medium

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
Adult Spawning (within subbasin)	Chum Fall Chinook	**LF.13** Availability of spawning habitat (i.e. accessibility/ quantity). Chum salmon have been observed spawning in multiple lower mainstem locations between the I-205 Bridge and Bonneville Dam., and in the lower reaches of the Western Oregon tributaries. These spawning aggregations represent an important component of current chum natural production. Fall Chinook have been observed spawning in multiple lower mainstem locations, particularly in the Ives and Pierce Island area. These spawning aggregations are believed to be derived from local hatchery strays, so their importance to ESU recovery is unclear. Water regulation at Bonneville Dam substantially affects water level in these mainstem spawning locations. Low flow may limit access to spawning areas while high flow may decrease the quality of these spawning locations (i.e., depth or velocity too high). **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, E.H12, W.H3, W.H4, W.H6, W.H7, W.H8**	High/High for chum Medium/Low for fall Chinook
	Chum Fall Chinook Coho Winter steelhead	**LF.14** Decreased flows during spawning and incubation. Water regulation at Bonneville Dam substantially effects water flow in these mainstem spawning locations and may also negatively affect flow in the lower reaches of the Western Oregon tributaries. Low flow may decrease the delivery of nutrients and dissolved oxygen to incubating eggs, thereby decreasing survival. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, E.H12, W.H3, W.H4, W.H6, W.H7, W.H8**	High/Medium
	Chum Fall Chinook	**LF.15** Dewatering of redds. Water regulation at Bonneville Dam substantially affects water level in these mainstem spawning locations. Flow reductions to the point of dewatering redds will result in substantial mortality of incubating eggs or pre-emergent alevins. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, E.H12, W.H3, W.H4, W.H6, W.H7, W.H8**.	High/Medium

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	Fall Chinook	**LF.16** Availability of spawning habitat (i.e. accessibility/ quantity) Several historic spawning areas in the Demographically Independent Populations (DIPs) in the Coast Range Stratum have been limited due to barriers such as culverts and hatchery weirs. Lack of access to productive habitat limits recovery potential in these DIPs. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H12, W.H3, W.H4, W.H5, W.H6, W.H8**.	High/High
	Coho	**LF.17** Hatchery impacts on diversity. Early hatchery practices resulted in the proliferation of s-type coho populations, which are not ideally matched with the environmental characteristics of the coast range ecological zone. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H4, E.H5, E.H7, E.H8, E.H11, E.H12, W.H1,W.H2,W.H3, W.H4, W.H5, W.H6, W.H7,W.H8**	Medium/FA

4.3.1.2 Limiting Factors, Aquatic Focal, non-Salmonids

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
Egg Incubation	White Sturgeon Eulachon	**LF.18** Sedimentation of spawning substrates. Deposition of fine sediments in the preferred spawning habitats (i.e. deepwater, rocky substrates for sturgeon and coarse sand for eulachon) results in egg suffocation. Fine sediment sources include adjacent tributary subbasins as well as migration of sediments from mainstem deposits. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H9, E.H12**.	Medium/High for sturgeon High/Low for eulachon
	White sturgeon Eulachon	**LF.19** Egg hypoxia. Hypoxia may have disproportionate negative effects on sturgeon compared to other fish because of their limited capacity to osmoregulate at low dissolved oxygen concentrations. Dissolved oxygen levels may be low for any number of reasons. Delivery of oxygenated water is decreased through sedimentation. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H9, E.H12**.	Medium/High for sturgeon High/Low for eulachon
	White sturgeon	**LF.20** Predation mortality. Demersal white sturgeon embryos are vulnerable to predation. Research on the upper Columbia indicated that 12% of naturally-spawned white sturgeon eggs were subject to predation, although the research suggests that predation was likely underestimated. If predation mortality is substantial, recruitment failure can result. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H9, E.H10, E.H11**	Medium/Medium
	White sturgeon	**LF.21** Direct dredging mortality. Although, white sturgeon prefer to spawn in rocky substrates with sufficient interstitial spaces, spawning has been observed in sands and fine sediments. Additionally, eggs broadcast among rocky substrates may disperse downstream and settle among sands or fine sediments. Dredging activities in areas where embryos are present results in direct mortality. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H9, E.H12**	Medium/Low

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	White sturgeon	**LF.22** Contaminant/parasite exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on development and physiological processes. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H9, E.H12**	Medium/Low
Juvenile Rearing	White sturgeon	**LF.24** Predation mortality. Juvenile white sturgeon losses to predation are probably low because of the protective scutes, benthic habitats, and fast growth. Predation needs to be evaluated. **Supported by Working Hypotheses:** **E.H4, E.H9, E.H10, E.H11**	Low/Low
	White sturgeon	**LF.25** Direct dredging mortality. White sturgeon association with benthic habitats make them susceptible to suction dredging effects. There is speculation that dredging operations may attract white sturgeon, compounding potential losses. Dredging activities in areas where juveniles are present can result in direct mortality. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H9, E.H12**	Medium/Low
	White sturgeon	**LF.26** Contaminant/parasite exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on growth and physiological processes. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H9, E.H12**	Medium/Low
	White sturgeon	**LF.27** Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on white sturgeon are unknown and may be offsetting. For example, shad have become an important food source for adult sturgeon while shad and gamefish may compete for food sources with juvenile sturgeon. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H10, E.H11**	Medium/Low

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
Adult Abundance	White sturgeon Green sturgeon	**LF.28** Fishing mortality. At present, size restrictions in the sport fishery are allowing for sturgeon survival to older ages, thus maintaining adequate abundance of spawning adults. Fishery regulations, fishing effort, harvest levels, and population response needs to be monitored closely to ensure adult spawning abundance is maintained. **Supported by Working Hypotheses:** **E.H4**	Low/High
	White sturgeon Green sturgeon	**LF.29** Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on white sturgeon are unknown and may be offsetting. For example, shad have become an important food source for adult sturgeon while shad and gamefish may compete for food sources with juvenile sturgeon. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H10, E.H11**	Medium/Low
	White sturgeon Green sturgeon	**LF.30** Incidental mortality. Operations at Bonneville Dam, specifically dewatering of turbines, can entrain white sturgeon and result in mortality. Significance of this mortality factor needs to be evaluated. **Supported by Working Hypotheses:** **E.H9**	Low/Low
Juvenile Rearing and Migration	Pacific lamprey	**LF.31** Flow alteration. Juvenile Pacific lamprey are poor swimmers and rely on flow to carry them toward the ocean. Flow alterations in the Columbia River basin (hydrosystem operations, water withdrawal) have decreased peak flows in the lower Columbia River mainstem, as well as created inundated habitats throughout the basin. Flow reductions may delay downstream migration, disrupting the synchrony of physiological development and downstream migration timing. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H9, E.H11**	Medium/Medium

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	Pacific lamprey	**LF.32** Direct dredging mortality. Juvenile Pacific lamprey are closely associated with fine sediments where they burrow and filter feed. Dredging activities in areas where juveniles are present results in direct mortality; an estimated 3-26% of juvenile lamprey passed through a dredge survived. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E. H11**	Medium/Low
	Pacific lamprey	**LF.33** Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on aquatic organisms. Juvenile Pacific lamprey are closely associated with fine sediments where contaminants commonly accumulate. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H9, E.H12**	Medium/Low
	Pacific lamprey	**LF.34** Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on Pacific lamprey are unknown. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H11**	Low/Low
	Pacific lamprey	**LF.35** Predation mortality. Juvenile Pacific lamprey losses to predation are unknown and need to be evaluated. **Supported by Working Hypotheses:** **E.H4, E.H9, E.H11**	Medium/Low
Adult Migration	Pacific lamprey	**LF.36** Dam passage. Pacific lamprey are often unable or unwilling to migrate through fish ladders. Thus, Bonneville Dam, as well as many tributary or other mainstem dams, has limited upstream migration of Pacific lamprey to historical upriver spawning areas. **Supported by Working Hypotheses:** **E.H2, E.H6, E.H9**	High/High
	Pacific lamprey	**LF.37** Predation losses. Because of their high caloric value, Pacific lamprey are an important food source for marine mammals (pinnepeds) and sturgeon (and potentially others) in the lower Columbia River. The significance of predation on Pacific lamprey needs to be quantified. **Supported by Working Hypotheses:** **E.H4, E.H9, E.H11**	Medium/Medium

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	Pacific lamprey	**LF.38** Harvest mortality. Historically, tribes harvested lamprey throughout the Columbia basin for food, ceremonial, medicinal, and trade purposes. Today, harvest is limited primarily to Willamette Falls and Sherars Falls (Deschutes River). Because of limitations on lamprey harvest (i.e., fishing effort, legal gear types, area closures, seasonal restrictions, diel restrictions), harvest may not be a major mortality factor. **Supported by Working Hypotheses:** **E.H4**	Low/High
	Pacific lamprey	**LF.39** Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on Pacific lamprey are unknown. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H11**	Medium/Low

4.3.1.3 Limiting Factors, Non-focal Species.

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
Egg Incubation	Eulachon	**LF.40** Sedimentation of spawning substrates. Deposition of fine sediments in the preferred spawning habitats (i.e., coarse sands) can result in egg suffocation. Fine sediment sources include adjacent tributary subbasins as well as migration of sediments from mainstem deposits. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H12**	High/Low
	Eulachon	**LF.41** Egg hypoxia. Dissolved oxygen levels may be low for any number of reasons. Delivery of oxygenated water is decreased through sedimentation. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H12**	High/Low
	Eulachon	**LF.42** Predation mortality. Eulachon eggs may be vulnerable to predation. Eggs have been documented as an important food item of juvenile sturgeon in the lower mainstem. Eulachon eggs comprised up to 25 percent of stomach contents for sturgeon $\leq$350mm; the percentage increased to 51 percent for sturgeon 351-724mm. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H11, E.H12**	Medium/Med

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	Eulachon	**LF.43** Direct dredging mortality. Dredging activities in areas where eggs or developing larvae are present results in direct mortality. Also, evidence suggests that dredging activity in the vicinity of spawning areas makes the substrate too unstable for egg incubation. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E. H11**	Medium/Low
	Eulachon	**LF.44** Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on development and physiological processes. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H4, E.H5,E.H6, E.H8**	Medium/Low
Juvenile Migration	Eulachon	**LF.45** Predation mortality. Juvenile eulachon losses to predation are unknown and need to be evaluated. Predation could be substantial because juvenile eulachon have poor swimming ability and are at the mercy of river currents. **Supported by Working Hypotheses:** **E.H1, E.H4, E.H5, E.H8, E.H9, E.H11, E.H12.**	High/Low
	Eulachon	**LF.46** Near ocean survival. Mortality upon ocean entry is unknown, but may be substantial. **Supported by Working Hypotheses:** **E.H1,EH2,EH3,EH4,EH9**	High/Low
Adult Abundance	Eulachon	**LF.47** Fishing mortality. At present, fishery regulations, fishing effort and harvest levels appear to be at sustainable levels; population response needs to be monitored closely to ensure population viability. **Supported by Working Hypotheses:** **E.H1,EH2,EH3,EH4,EH9**	Low/High
	Eulachon	**LF.48** Predation mortality. Eulachon are an important food item for many estuary and lower mainstem species. Large congregations of avian predators accompany eulachon runs into spawning areas. Pinnepeds prey on eulachon as they migrate through the estuary; pinnepeds may also follow eulachon runs to spawning areas. **Supported by Working Hypotheses:** **E.H1, E.H4, E.H5, E.H8, E.H9, E.H11, E.H12.**	Medium/High

Life Stage	Applicable Species	Limiting Factors	Impact/Certainty
	Eulachon	**LF.49** Migration barriers. Eulachon do not navigate fish passage structures well, thus the Bonneville Dam restricts access to historical spawning areas. Optimal water temperature for upstream migration is about 40 °F; below this temperature, migration will be delayed. **Supported by Working Hypotheses:** **E.H9**	Medium/High
	Eulachon	**LF.50** Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on eulachon are unknown. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4, E.H8, E.H11**	High/Low

4.3.2 *Terrestrial Species-Focal (Bald Eagle and Columbian White-tailed Deer and others)*

Life Stage	Applicable species	Limiting Factors	Impact/Certainty
N/A	Osprey, Bald Eagle	**LF.51** Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to decrease eggshell thickness, which affects survival. Columbia River osprey eggs contained the highest concentration of DDE reported in North America in the late 1980s and 1990s. The greatest impact to Bald Eagles appears to occur at older breeding territories, which were located predominantly in the lower estuary below river mile 60. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H4, E.H5,E.H6, E.H8**	Medium/High
N/A	Bald Eagle, Osprey	**LF.52** Availability or disturbances to nesting habitat. Bald eagles typically prefer very old Douglas fir or Sitka spruce on shorelines and large cottonwoods or spruce on Columbia River islands. Osprey prefer mature forest habitats with adequate nest and roost trees in close proximity to abundant fish resources. Osprey appear to be adaptable and have been observed nesting on artificial structures such as channel markers or power poles. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4,E.H5, E.H12**	Low/Medium
N/A	Species of Management Interest Winter populations	**LF.53** Availability of overwintering habitat. Urbanization and conversion of agricultural crops to non-preferred forage crops is reducing the acreage of goose and crane overwintering habitat. Continued habitat loss will decrease the number of overwintering birds the subbasins can support. Wildlife refuges within the subbasins provide a vital baseline of winter habitat. **Supported by Working Hypotheses:** **E.H1, E.H2, E.H3, E.H4,E.H5, E.H12**	High/High
N/A	Bald Eagle	**LF54** Persecution (primarily illegal shooting) (USFWS 1978 as cited in Stinson et al. 2001) **Working hypothesis is species specific; no basin-wide working hypothesis**	Medium/High

Life Stage	Applicable species	Limiting Factors	Impact/Certainty
N/A	Columbian White-tailed Deer	**LF.55** Availability of preferred habitat (i.e., riparian habitat, communities that provide both forage and cover). Columbian White-tailed Deer in the lower Columbia use brushy woodlots associated with tidal lowlands that are characterized by cottonwood, willow, alder, spruce and dogwood. Dense forested swamps and tall tidal shrubs are needed for suitable habitat. Deer forage for annuals, forbs, and shrub. There has been extensive loss of riparian habitat throughout the mainstem and estuary as a result of water regulation, dike construction and urban and agricultural development. **Supported by Working Hypotheses:** **E.H2, E.H3, E.H5, E.H12**	High/High
N/A	Columbian White-tailed Deer	**LF.56** High tides in undiked areas or failed dikes. Some of the greatest recent losses of deer have been due to flooding. **Working hypothesis is species specific; no basin-wide working hypothesis**	High/High
N/A	Columbian White-tailed Deer	**LF.57** Lack of continuity between suitable habitats. Much of the habitat is unsuitable or disconnected due to channels and structures. **Supported by Working Hypotheses:** **E.H2, E.H3, E.H12**	High/High
N/A	Columbian White-tailed Deer	**LF.58** Predation mortality. Greatest losses of fawns are due to coyotes. Adult losses from predation are due to poaching. **Working hypothesis is species specific; no basin-wide working hypothesis**	High/High
N/A	Columbian White-tailed Deer	**LF.59** Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on Columbian White-tailed Deer are competition of habitat for breeding and foraging. **Supported by Working Hypotheses:** **E.H2, E.H3, E.H12**	Medium/High
N/A	Columbian White-tailed Deer	**LF.60** Available habitat. Overcrowding has led to higher numbers of parasites and diseases such as foot rot. **Working hypothesis is species specific; no basin-wide working hypothesis**	Unknown/Low
N/A	Columbian White-tailed Deer	**LF.61** Hybridization and competition with black-tailed deer. Direct competition with black-tailed deer affects white-tailed deer resources. **Working hypothesis is species specific; no basin-wide working hypothesis**	Medium/Medium

Life Stage	Applicable species	Limiting Factors	Impact/Certainty
N/A	Columbian White-tailed Deer	**LF.62** Collisions with cars. Losses have been due to automobile collisions. **Working hypothesis is species specific; no basin-wide working hypothesis**	Unknown/Low

4.3.3 *Biological and Physical Objectives Summary*

This section includes a compilation and synthesis of the biological and physical objectives included with the species-specific sections, which are included as a supplement to this management plan.

The biological objectives (or desired future conditions) were formulated, when possible, to support value statements for each species. The physical objectives were formulated to address limiting factors and then used in evaluating strategies.

Biological objectives

For most of the aquatic focal species (chum, fall Chinook, sturgeon and Pacific lamprey) and species of ecological and management interest, numbers are uncertain, given the assumptions in data collection and the variability that governs population dynamics. As a result, the numeric biological objectives for the lower mainstem and estuary should be viewed as "order of magnitude" estimates and interim in nature until more certainty can be achieved in abundance estimates and more specific goals can be quantified. These are listed in Table 4-5.

For Chinook and coho, the project team was unable to develop meaningful biological performance metrics to describe focal species' response to subbasin habitat conditions in terms of productivity, capacity, abundance or life-history diversity. Spring Chinook and coho use the estuary and lower mainstem subbasins primarily for migration, although evidence suggests that juvenile spring Chinook and coho feed as they migrate. It also indicates that the brief mainstem and estuarine residence time is extremely important to the physiological transformation to smolts and to gathering olfactory cues needed for a successful return migration. Thus, actions within the lower mainstem and estuary subbasins (e.g., restored floodplain connectivity or predator management) can affect spring Chinook and coho survival within the subbasins. However, biological performance levels are likely determined by out-of-subbasin effects, such as spawning tributary conditions or mainstem/tributary dam passage success.

Likewise, performance levels of species of recreational interest have not been formulated because no reliable metrics of species abundance or productivity have been estimated for the populations below Bonneville Dam.

Table 4-5: Biological objectives summary

Applicable Species	Metric	Performance Level
Focal Species		
Chum	Mortalityb	Current mortality estimates range from 0.28 to 0.59 and average 0.46. Mortality estimates at population recovery goals range from 0.23 to 0.58 and average 0.42.
	Productivity	>1 recruit per spawner
	Abundancea (estuary/mainstem adult spawning only)	I-205 1,250 Ives Island 6,400 Multnomah Falls 2,300
Fall Chinook	Mortalityb	Current mortality estimates range from 0.29 to 0.38 and average 0.33. Mortality estimates at population recovery goals range from 0.16 to 0.36 and average 0.27. Current mortality estimate for the Lewis River late fall population was 0.39; mortality estimate at population recovery was 0.26.
	Productivity	>1 recruit per spawner
	Abundancea (estuary/mainstem adult spawning only)	Ives and Pierce Islands 12,000
Winter steelhead	Mortalityb	Current mortality estimates range from 0.10 to 0.18 and average 0.14. Mortality estimates at population recovery goals range from 0.10 to 0.18 and average 0.10.
Summer steelhead	Mortalityb	Current mortality estimates range from 0.04 to 0.59 and average 0.16. Mortality estimates at population recovery goals range from 0.04 to 0.59 and average 0.16.
Sturgeon	Productivity	>1 recruit per spawner
	Abundance of 36-72 inch size class	> 400,000; abundance estimates of this size class in the 1990s approached 450,000, which represents modern day record numbers.
	Harvest levels	~ 50,000; manage population to maintain recent harvest levels while maintaining spawner abundance.
Pacific Lamprey	Adult abundance	Minimum of 100,000 adults passing Bonneville Dam annually (represents the 1938-1969 average).

Applicable Species	Metric	Performance Level	
Columbian White-tailed Deer	Abundance	Roseburg, OR	>9,000
		Mainland Refuge	~150
		Tenasillahe Island	~150
Bald eagle	Productivity	>1 young per occupied nest	
Species of Ecological Interest			
Eulachon	Annual harvest level	~2 million pounds, which represents average harvest from 1938-2002.	
Caspian Tern	Breeding colony abundance	~10,000 pairs; maintain regional abundance at current levels.	
Osprey	Young productivity	>1.5 young per active nest (0.8 young per active nest needed for stable population.	
	Breeding population size	>100 active nest sites in lower 410km of Columbia River.	
Shad	Columbia River adult population size	700,000 to 1,000,000	
Species of Management Interest			
Dusky Canada Goose	Winter population abundance	~25,000, which represents the upper bound of abundance estimates of duskys in Washington and Oregon since 1950.	
Sandhill Crane	Winter population abundance	~3000-4000, which is the present WDFW estimate of cranes using the lower Columbia River and associated uplands for overwintering or as a migratory stopover.	

Physical Objectives

The summary of physical objectives is compiled from each of the species-specific sections included in the supplement to this management plan. These have been synthesized to eliminate duplication and identify common objectives among the species. From this effort, we have 15 physical objectives for aquatic species.

The physical objectives include working hypotheses and applicable species life stages. Each of these has been evaluated by: 1) the level of difficulty of addressing objectives, 2) potential benefit and 3) degree of certainty with which these qualitative judgments are applied.

The technical staff conducted the initial evaluation, which was then amended or verified based on reviews by species experts and Planning Group members. Although the physical objectives are not ranked based on this evaluation, this information assists in evaluating strategies in Section 4.4

The evaluation used the qualitative terms of “high,” “medium” and “low” to provide a relative benefit of each identified physical objective. It is important to note that, because of the subjective nature of this evaluation, no two scientists will likely qualify each physical objective

in precisely the same manner. The purpose of the evaluation is to identify those physical objectives that address the most important limiting factors for each species. Thus, achieving those physical objectives would most likely result in the greatest benefit for the species population. In the context of species-specific physical objectives, the terms are defined as:

High – The physical objective addresses a limiting factor that currently limits population viability because of effects on mortality rates or productivity. Achieving the physical objective is of primary importance in maintaining current levels of population abundance/productivity or in promoting recovery of the species.

Medium – The physical objective addresses a limiting factor that currently affects population viability but, at present impact levels, may not be significantly reducing population abundance or productivity. Achieving this physical objective will have less impact on overall population viability than the high benefit objectives.

Low – The physical objective addresses a limiting factor that exists, but likely does not affect population viability at present impact levels. Achieving the physical objective is not likely to produce measurable effects on population viability until the high- and medium benefit physical objectives are implemented.

The physical objectives benefit level is further qualified based on the current level of certainty that the objective will successfully address limiting factor. The qualitative terms of "high," "medium" and "low" are defined similarly to the certainty terms applied to the limiting factors.

Physical Objective	**Applicable Species and life stage**	**Difficulty**	**Benefit/ Certainty**
PO1 Protect existing rearing and spawning habitat to ensure no further net degradation. *Hypothesis Statement:* If current spawning and rearing habitat is protected, then salmonid adult spawning and juvenile rearing capacity and productivity in the lower mainstem, Western Oregon tributaries, estuary, and plume can be maintained. For white sturgeon, productivity and population recruitment in the estuary and mainstem can be maintained. *Justification;* Protection and maintenance of existing spawning and rearing habitat will provide a base level of salmonid production and diversity. For white sturgeon, protection and maintenance of existing deepwater, rocky substrate spawning habitat will maintain the current level of embryo survival and population productivity. (Sedimentation and dissolved oxygen delivery are two important concerns with developing embryos; concerns are minimized in rocky substrates. Further, protection of existing habitat is often more cost effective then restoration of former habitat.	salmonid/ juvenile salmonid/ adult White sturgeon/ egg incubation	Med Med Med	High/High High/High High/Med
PO2 Increase shallow water peripheral and side channel habitats toward historic levels. *Hypothesis Statement;* If shallow water habitat is increased, then juvenile rearing capacity in the estuary and mainstem will increase. *Justification;* Rearing juvenile fall Chinook and chum are closely associated with shallow water habitats in the estuary and lower mainstem.	salmonid/ juvenile	High	High/High

Physical Objective	Applicable Species and life stage	Difficulty	Benefit/ Certainty
PO3 Restore connectivity between river and floodplain, as well as in-river habitats. *Hypothesis Statement;* If connectivity with floodplain is restored, then juvenile salmonid productivity in the estuary and lower mainstem will increase. For Columbian White-tailed Deer openings were likely associated with the wet areas, accreting lands or lands having recently experienced a scouring flood. *Justification;* Connectivity with the floodplain will restore macrodetrital inputs and alter the current food web. A macrodetritus-based food web will increase productivity and support greater life history diversity. For CWTD, reducing damage due to floods will reduce mortality and out migration of deer due to floods.	salmonid/ juvenile Columbian White-tailed Deer	High High	High/High High/Med
PO4 Reduce predation mortality: For aquatics on developing embryos, emigrating juveniles and migrating adults. For Columbian White-tailed Deer, on fawns. *Hypothesis Statement:* If predation on emigrating salmonid juveniles, salmonid and Pacific lamprey migrating adults and white sturgeon embryos is reduced, then survival in the estuary and lower mainstem will increase. For CWTD, if predation on fawns is reduced, then Columbia White-tailed Deer survival in the estuary and mainstem will increase. *Justification;* Predation on salmonid juveniles in the lower Columbia River and estuary has increased as a result of increased predator populations, such as northern pikeminnow and Caspian terns. Marine mammal predation on adult salmonids has been observed. Marine mammal and sturgeon prey on adult lampreys. Predation on white sturgeon embryos has been observed at about 12% in the upper Columbia River, current levels of predation in the lower Columbia River is unknown. Although predation on fall Chinook and chum may be lower then other salmonids, predation mortality may be significant. Predation mortality in all cases may be significant and needs to be quantified. For CWTD, predation on fawns in the lower Columbia River and estuary has increased as a result of increased predator populations, such as coyotes. Predation on Columbia White-tailed Deer mortality may be significant and needs to be quantified.	salmonid/ juvenile salmonid/ adult White sturgeon/ egg incubation Pacific lamprey/ adult	Med High Med High	Med/High Low/High Med/Med Med/Med
PO5 Reduce contaminant exposure of emigrating salmonid and Pacific lamprey juveniles and white sturgeon eggs and juveniles. *Hypothesis Statement;* If contaminant exposure is reduced then salmonid juvenile, Pacific lamprey juvenile and white sturgeon embryo survival in the estuary and mainstem will increase. *Justification;* Contaminants have been shown to have detrimental effects, such as delayed development or disrupted physiological processes. In juvenile salmonids these may be decreased immune function, and generally reduced fitness. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on	salmonid/ juvenile White sturgeon/ egg incubation White sturgeon/ juvenile	High High High	Med/Med Med/Low Med/Low

Physical Objective	Applicable Species and life stage	Difficulty	Benefit/ Certainty
aquatic organisms. Fall Chinook and chum may be particularly susceptible to contaminant exposure because they are closely associated with peripheral, shallow water habitats where contaminants are known to accumulate. And Pacific lamprey juveniles may also be particularly susceptible because they are associated with fine sediments.	Pacific lamprey/ juvenile	High	Med/Low
PO6 Document the interaction between emigrating salmonid juveniles, white sturgeon adults/juveniles and Pacific lamprey adults/juveniles and introduced species; Minimize negative interactions. *Hypothesis Statement*; If introduced species continue to thrive, then salmonid juvenile, white sturgeon adult/juveniles, and Pacific lamprey adult/juvenile survival in the lower mainstem, Western Oregon tributaries, estuary, and plume may be negatively affected. *Justification*; Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystem. Effects on native species are generally unknown, may be significant and need to be quantified.	salmonid/ juvenile White sturgeon/ adult White sturgeon/ juvenile Pacific lamprey/ adult Pacific lamprey/ juvenile	High High High High High	High/ Low Med/Low Med/Low Med/ Low Low/Low
PO7 Develop an understanding of emigrating juvenile salmonid life history diversity, white sturgeon spawning characteristics, and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement*; If our understanding of salmonid, white sturgeon spawning and lamprey integration with the ecosystem increases, then management and recovery actions will proceed with greater certainty. *Justification*; Our current understanding of life history diversity and interaction for salmonids and Pacific lamprey with the lower mainstem, Western Oregon tributaries, estuary, and plume is limited. As is our understanding of known spawning sites and specific spawning habitat characteristics for white sturgeon. Research is needed to increase our knowledge and reduce uncertainty.	salmonid/ juvenile White sturgeon/ egg incubation Pacific lamprey/ adult	High High High	High/Med Med/Med High/Low
PO8 Evaluate/improve survival of upriver juvenile salmonid emigrating via barge or dam passage. *Hypothesis Statement;* If survival and fitness of emigrating upriver salmonids improves, then these fish will be better prepared for emigration through the lower mainstem, Western Oregon tributaries, estuary, and plume. *Justification;* Current survival/fitness of upriver fish is lower than historical conditions. This lower fitness may predispose fish to predation as they enter the subbasin, delay attainment of threshold size needed for smoltification, or disrupt physiological processes that control smoltification.	salmonid/ juvenile (except chum)	High	High/High

Physical Objective	Applicable Species and life stage	Difficulty	Benefit/ Certainty
PO9 Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Hypothesis Statement;* If extreme water flows or temperatures exist; during incubation, then egg mortality will be unacceptably high, during spawning, then salmonids may not have access to current spawning areas, or during migration, then spawning may be delayed or averted. *Justification;* Extreme (i.e. both high and low) water flow and temperature can; 1 decrease egg to fry survival (high flow can cause bed scour and subsequent egg loss. Low flow reduces nutrient and oxygen transport to developing eggs; extreme low flow can result in redd dewatering. High temperature can increase egg mortality. Low temperature delays emergence and subsequent emigration. Each of these scenarios often results in decreased juvenile fitness.) 2 serve as a migration barrier and prevent access to current spawning areas (or decrease the quality of existing spawning habitat) or 3 during migration result in; delayed arrival to spawning grounds, spawning activity in less then desirable locations or no spawning. Each of these scenarios often results in decreased juvenile fitness and productivity.	salmonid/ egg incubation (chum and fall Chinook) salmonid/ juvenile salmonid/ adult	Med Med Med	High/High High/Med Med/High
PO10 Avoid direct dredging mortality. *Hypothesis Statement;* If suction dredging activities occur in the presence of white sturgeon embryos, juveniles or Pacific lamprey juveniles, then direct mortality will result. *Justification;* White sturgeon embryos, white sturgeon juveniles and Pacific lamprey juveniles are closely associated with sand and fine sediments as a result of dispersal mechanisms and/or benthic existence. Suction dredging of these sands and fine sediments results in entrainment and mortality. Dredge operations should avoid known areas of developing white sturgeon embryos, juveniles and areas of burrowing juvenile Pacific lamprey.	White sturgeon/ egg incubation White sturgeon/ juveniles Pacific lamprey/ juveniles	Low Low Low	Med/Low Med/Low Med/Low
PO11 Develop an understanding of white sturgeon juvenile and adult and Pacific lamprey habitat use in the lower mainstem and estuary. *Hypothesis Statement;* If our understanding of white sturgeon and Pacific lamprey integration with the ecosystem increases, then management actions will proceed with greater certainty. *Justification;* Our current understanding of white sturgeon and Pacific lamprey interaction with the lower mainstem and estuary ecosystem is limited; research is needed to increase our knowledge and reduce uncertainty.	White sturgeon/ juvenile White sturgeon/ adult Pacific lamprey/ adult	High High High	Med/Low Med/Low High/Low
PO12 Protect population for overexploitation. *Hypothesis Statement;* If current fisheries are properly maintained, then adult white sturgeon spawning abundance in the estuary and mainstem can be maintained. And impacts to lamprey can be minimized. *Justification;* Longevity, slow growth and delayed maturation make sturgeon susceptible to fishery overexploitation. Fishery	White sturgeon/ adult Pacific lamprey/ adult	Med Med	High/High Low/High

Physical Objective	Applicable Species and life stage	Difficulty	Benefit/ Certainty
restrictions (such as size limits) and constant population monitoring can help maintain the current level of spawner abundance. At present levels of fishing effort and fishery restrictions, Pacific lamprey harvest is relatively low and unlikely a major limiting factor.			
PO 13 Avoid incidental operations and maintenance mortality at Bonneville Dam. *Hypothesis Statement;* If Bonneville Dam operations are properly managed, then white sturgeon incidental mortality can be minimized. *Justification:* Turbine dewatering operations at Bonneville Dam have been observed to entrain white sturgeon and result in mortality. This, and other operations at Bonneville and elsewhere in the subbasins, needs to be monitored to determine the significance to the lower Columbia white sturgeon population.	White sturgeon/ adult	Med	Low/Low
PO 14 Restore spring peak flows in lower Columbia River. *Hypothesis Statement:* If peak flows are restored, then juvenile lamprey physiological development and downstream migration timing will remain synchronized. *Justification:* Restoration and maintenance of historical peak flows will provide a consistent mechanism for juvenile lamprey downstream migration.	Pacific lamprey/ juvenile salmonid/ juvenile	High High	Med/Med High/Med
PO15 Improve dam passage. *Hypothesis Statement:* If dam passage conditions are improved, then lamprey will benefit basin-wide. *Justification:* Adult Pacific lamprey, navigate hydrosystem dams with poor efficiency. Thus, lamprey access to historical spawning and rearing areas has been limited.	Pacific lamprey/ adult salmonid/ adult (particul-arly chum)	High High	High/High High/High
PO16 Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery derived stocks.	salmonid/ adult	Med	High/High
PO 17 Eliminate and mitigate access barriers for migrating adults, creating additional spawning and rearing habitat. *Hypothesis Statement:* If access to high quality habitat within the historic range of fall Chinook, winter steelhead and coho is restored, abundance will be improved. *Justification:* Restoration of access to productive habitat will improve population diversity and spatial structure of DIPs within the coastal stratum	salmonid/ WOT (fall Chinook, coho, and winter steelhead)	Med	High/High
PO18 Seek methods for restoring historic run timing to coastal stratum, including the Western Oregon Tributaries. *Hypothesis Statement;* If late-run type of coho were returned to the Western Oregon tributaries, viability of the population would be improved. *Justification;* The physical and environmental characteristics of	salmonid/ WOT (coho)	High	High/ Unknown

Physical Objective	Applicable Species and life stage	Difficulty	Benefit/ Certainty
watersheds in the coastal range ecological zone are suited to support a late-run (n-type) coho population. Restoration of this population would add needed diversity to these DIPs.			
PO 19 Restore spawning and rearing habitat in the Western Oregon tributaries. *Hypothesis Statement;* If adult spawning habitat in priority reaches in the Coastal stratum are restored then productivity in the subbasin will be enhanced. *Justification:* Restoration of historically utilized spawning habitat in the Western Oregon tributaries will improve the diversity and spatial structure of the coast range DIPs.	salmonid/ WOT (fall Chinook, and coho)	Med	High/High
PO20. Protect existing over-wintering habitat to insure no future net degradation. *Hypothesis Statement:* If current winter habitat is protected, then population abundance in the estuary and mainstem can be maintained.	species of manage-ment interest	Med	High/High
PO21. Encourage use of public lands over private lands. *Hypothesis Statement*: If geese and cranes primarily use public lands such as wildlife refuges, then over-winter survival in the estuary and mainstem can be maintained or increased.	species of manage-ment interest	High	High/Med
PO22. Increase the availability of over-wintering habitat on public lands. *Hypothesis Statement*: If winter habitat availability is increased, then population abundance in the estuary and mainstem can be maintained or increased.	species of manage-ment interest	High	High/High
PO23. Limit crop depredation. *Hypothesis Statement*: If foraging of agricultural crops continues, then economic losses from crop depredation will be substantial.	species of manage-ment interest	High	High/High
PO24. Manage populations to maintain or decrease current level of abundance. *Hypothesis Statement*: If populations are maintained at present low abundance levels, then negative impacts to salmonids and other focal species can be minimized.	species of recreat-ional interest	Med	High/Med
PO25. Encourage breeding colony distribution among multiple breeding sites, preferably in locations where non-salmonid food sources are plentiful. *Hypothesis Statement*: If the Caspian tern colony is more widely distributed, then the tern colony will be less vulnerable to disturbance.	species of manage-ment interest	Med	High/High
PO26. Protect existing foraging habitat to insure no further net degradation. *Hypothesis Statement:* If current foraging habitat is protected, then breeding, rearing, and foraging capacity and productivity in the estuary and mainstem can be maintained. *Justification:* Protection and maintenance of existing riparian habitat will provide a base level of Columbia White-tailed deer	Columbia White-tailed Deer	Low	High/High

Physical Objective	Applicable Species and life stage	Difficulty	Benefit/ Certainty
production and genetic diversity. Further, protection of existing habitat is often more cost effective than restoration of former habitat.			
PO27. Increase forested areas in lowlands and floodplain with hardwood and some coniferous riparian species. *Hypothesis Statement:* If forested habitat is increased, then fawn rearing capacity in the estuary and mainstem will increase. *Justification:* Columbia White-tailed viable populations are closely associated with forested habitats in the estuary and lower mainstem.	Columbia White-tailed Deer	High	High/High
PO28. Increase availability of habitat including pasture and woodlots *Hypothesis Statement:* Increased acreage of habitat will increase survival rate and population size of Columbia White-tailed Deer and will decrease instances of parasites and disease. If less habitat is lost to home construction, then habitat and in turn Columbian White-tailed Deer will have a greater survival in the estuary and mainstem during uncontrollable floods and the population increase. *Justification:* The greatest single man-caused threat and natural threat to Columbia White-tailed deer is the continued degradation of habitat. Overcrowding has been linked to the presence of parasites and foot-rot disease in Columbia White-tailed Deer. Floods, such as the 1996 flood, have claimed some of the highest moralities of adult deer populations in protected areas.	Columbia White-tailed Deer	High	High/High
PO29. Artificially reintroduce deer. *Hypothesis Statement:* Reintroducing deer to suitable habitat will increase survival and population numbers. *Justification:* Deer cannot easily pioneer new habitat. Therefore, deer have to be artificially reintroduced for range expansion to occur.	Columbia White-tailed Deer	High	Unknown/ Med
PO30. Minimize disturbance during breeding and rearing season *Hypothesis Statement:* Minimizing disturbance during breeding season will increase survival and population will increase. *Justification Statement:* Columbia White tailed Deer occasionally exhibit low productivity. Minimizing disturbance during breeding and rearing season, mid November to Mid December and June 1 to July 15, respectively, will increase chances of fawn survival, decreases stresses to does, and may prevent mortality of fawns due to automobiles.	Columbia White-tailed Deer	Low	Unknown/ Med
PO31. Identify and Protect existing nesting and foraging areas to ensure no population declines. *Hypothesis Statement:* If current bald eagle habitats are protected, then Bald Eagle recovery in the estuary and mainstem can be maintained. *Justification:* During the early stages of breeding activity and incubation, bald eagles are very sensitive to disturbances such as approaching humans or boats, which can cause nest abandonment of	Bald Eagle	Medium	High/High

Physical Objective	Applicable Species and life stage	Difficulty	Benefit/ Certainty
their nest and loss of young. Enormous recreational and development pressures, if not managed carefully, threaten to undermine recovery progress			
PO32. Continue to and reduce, monitor and understand contaminant sources in the Lower Columbia River *Hypothesis Statement:* If bioaccumulative contaminants in the Bald Eagle become less prevalent in the Eagle food sources, successful reproduction efforts will increase over time. *Justification:* Productivity at new breeding sites is much higher than at old breeding sites suggesting that pairs at the older sites (particularly those in the lower 60 miles of the river) or impacted by contaminants to a greater level. Although the number of Bald eagles nesting along the river is increasing, continued foraging on contaminated prey form the LCR and subsequent bioaccumulation of contaminants could limit future productivity of some newer pairs as the chemical bioaccumulate in the adult birds with age.	Bald Eagle	Medium	Med/High
PO33. Reduce threats from physical hazards and persecution *Hypothesis Statement:* If these hazards are reduced, population will remain stable or increase *Justification:* Though significantly less than 30 years ago, death caused by electrocution and injuries caused by power lines, lead poisoning and shooting remain as problems for Bald Eagles.	Bald Eagle	Medium	Med/High
PO34: Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery derived stocks. *Hypothesis*: Continuation of Select Area (terminal) fishing opportunities in the lower Columbia River will support productive sport and commercial fisheries on harvestable stocks without negatively affecting rebuilding efforts directed at weak stocks. *Justification:* Commercial and recreational harvest in the lower Columbia River has the potential to negatively impact salmonid stocks, if not managed and directed. Harvesters are generally agreeable to targeting specific hatchery stocks, and the technology exists to manage fisheries with selectivity in the estuary without negatively impacting biological diversity and genetic integrity of wild stocks.	Salmonid / Adult	Low	High/High

4.4 Management Strategies and Priorities Summary

4.4.1 *Strategies Overview*

As with the limiting factors and objectives, the subbasin project team compiled all of the species-specific strategies, then combined them where commonalities existed to form a single set of master strategies for the subbasins. Each of these was further examined to identify and articulate the relationships to the biological objectives outlined in the previous chapter.

At the direction of the Planning Group, the subbasin-wide strategies were reviewed based on their:

- ability to address key objectives
- relationship to ESA
- relationship to focal species of the subbasin
- socio-economic considerations as stated in the vision

Through this synthesis, the project team has identified 23 strategies covering aquatic focal species, species of interest, terrestrial species and the Western Oregon tributary subbasin.

The Planning Group established an upper tier of strategies based on the criteria above. Eight strategies rise to an upper tier through their extensive coverage of physical objectives and emphasis on socio-economic priorities. These strategies include:

Strategy 1: Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Strategy 2: Strive to understand, protect, and restore habitat-forming processes in the Columbia River Columbia River lower mainstem, Western Oregon tributaries, estuary and plume.

Strategy 3: Avoid large-scale habitat changes where risks to salmonids, white sturgeon and Pacific lamprey are uncertain.

Strategy 4: Mitigate small-scale local habitat impacts such that no net loss occurs.

Strategy 10: Our understanding the relationships between salmonids, white sturgeon, Pacific lamprey and the lower mainstem, Western Oregon tributaries, estuary and the plume ecosystems needs to be improved.

Strategy 11: Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Strategy 23: Assess the mainstem lower Columbia River and the Columbia River estuary by discreet geographic reaches for restoration and protection priorities, and develop approach for determining expected outcomes of research, monitoring and evaluation activities.

Strategy 15: Manage Columbia River fisheries at sustainable levels, maintaining a viable population through adequate spawner abundance and directing harvest away from depressed stocks.

The other strategies include:

Strategy 5: Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Strategy 6: Utilize a combination of active and passive habitat restoration measures to provide near-term and long-term benefits.

Strategy 7: Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Strategy 8: Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introduced species.

Strategy 9: As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Strategy 12: Limit the effects of toxic contaminants in the Columbia River estuary, lower mainstem and nearshore ocean.

Strategy 13: Evaluate the level of predation mortality during the embryo and juvenile life states to determine the extent of predation related recruitment failure for white sturgeon and during juvenile and adult migration of Pacific lamprey.

Strategy 14: Avoid incidental mortality of embryos and juveniles during dredging operations.

Strategy 16: Avoid incidental operations and maintenance mortality at Bonneville Dam.

Strategy 17: Evaluate and improve downstream and upstream lamprey passage conditions at mainstem and tributary dams. In doing so, ensuring no negative effects on salmonid passage.

Strategy 18: Open access to productive habitat by removing or mitigating passage barriers.

Strategy 19: Promote management actions that support sufficient life-history diversity to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes.

Strategy 20: Protect and restore habitat diversity and channel stability attributes in Western Oregon tributaries to complement salmonid life-history requirements.

Strategy 21: Minimize physical crop losses and economic effects from lost agricultural production.

Strategy 22: Investigate and minimize competition among shad and ESA-listed salmonids.

Strategy 23: Assess the mainstem lower Columbia River and the Columbia River estuary by discrete geographic reaches for restoration and protection priorities, and develop approach for determining expected outcomes of RM&E activities.

Notably, both terrestrial focal species—Bald Eagle and Columbian White-tailed Deer—have long-standing master plans, which have brought their respective populations to a point of consideration for delisting. Because of this success, Strategy 11 **(**Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures) provides the overriding strategy for these terrestrial focal species recognizing the continued importance of these plans and deferring to them, at this point, for future direction.

The logic path behind these selections is outlined in the details listed with each strategy. These details provide:

- an explanation of the strategy
- ranking justification
- physical objectives satisfied by the strategy
- possible measures that address this strategy

These upper-tier strategies are placed first in the list of subbasin the master list of subbasin strategies and details below. The details under each strategy below provide the logic behind the selection.

4.4.2 *Prioritized Focal Strategies*

Protect and Restore Habitat

Strategy 1: Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Explanation: Important habitats in the Columbia River lower mainstem, Western Oregon tributaries, estuary, plume and riparian areas that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving. The strategy responds to the following vision-supporting statements: SV1, SV2, SV5, SV6

Strategy ranking justification: This strategy addresses the following physical objectives rated high for benefit and incorporates ESA-listed species.

Physical objectives satisfied by Strategy 1	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
High Benefit/ High Difficulty	
PO2	Increase shallow water peripheral and side-channel habitats toward historic levels. *Species/life stage affected: fall Chinook and chum juveniles.*

Physical objectives satisfied by Strategy 1	
High Benefit / Lower to Medium Difficulty	
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles, Columbian White-tailed Deer*
PO7	Develop an understanding of emigrating juvenile salmonid life history diversity, white sturgeon spawning characteristics and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation, species of ecological interest and species of recreational interest.*
PO8	Evaluate/improve survival of upriver juvenile salmonid emigrating via barge or dam passage. *Species/life stage affected: salmonid juveniles*
PO14	Restore spring peak flows in lower Columbia River. *Species/lifestage affected: salmonid juveniles.*
PO15	Improve dam passage. *Species/lifestage affected: Pacific lamprey and species of ecological interest.*
PO27	Increase forested areas in lowlands and floodplain with hardwood and some coniferous riparian species. *Species/lifestage affected: Columbian White-tailed Deer*
PO28	Increase availability of habitat including pasture and woodlots. *Species/lifestage affected: Columbian White-tailed Deer.*

Measures that address Strategy 1		
Description of Measure		**Applicable Species**
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M3	Maintain adequate water flows throughout spawning, incubation and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead,

Measures that address Strategy 1		
Description of Measure		**Applicable Species**
		winter steelhead.
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, Columbian White-tailed Deer, species of ecological interest.
M5	Protect and restore riparian and wetland habitat condition and function.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Columbian White-tailed Deer, species of ecological interest.
M7	Mitigate channel dredging activities in the Columbia river estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Columbian White-tailed Deer, species of ecological interest.
M18	Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.	white sturgeon

Understanding, protection and restoration of habitat-forming process

Strategy 2: Strive to understand, protect and restore habitat-forming processes in the Columbia River lower mainstem, riparian areas, Western Oregon tributaries, estuary and plume.

Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat-forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

The strategy responds to the following vision-supporting statements: SV1, SV2, SV5, SV6,SV8

Strategy ranking justification: This strategy addresses the following physical objectives rated high for benefit and incorporates ESA-listed species.

Physical objectives satisfied by Strategy 2	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Species/life stage affected: salmonid incubation, juvenile, adult.*
High Benefit/ High Difficulty	
PO2	Increase shallow water peripheral and side-channel habitats toward historic levels. *Species/life stage affected: fall Chinook and chum juveniles.*
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles, Columbian White-tailed Deer.*
PO7	Develop an understanding of emigrating juvenile salmonid life-history diversity, white sturgeon spawning characteristics and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest and species of recreational interest.*

Measures that address Strategy 2		
Description of Measure		**Applicable Species**
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M3	Maintain adequate water flows throughout spawning, incubation and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, Columbian White-tailed Deer, species of ecological interest.
M5	Protect and restore riparian and wetland habitat condition and function.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer.
M6	Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M7	Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Columbian White-tailed Deer, species of ecological interest.

Large-scale habitat impact mitigation

Strategy 3: Avoid large-scale habitat changes where risks to salmonids, white sturgeon, Pacific lamprey, Columbian White-tailed Deer, and bald eagles are uncertain.

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but efforts must be made to ensure that habitat does not further degrade.

The strategy responds to the following vision-supporting statements: SV2, SV5, SV6

Strategy ranking justification: This strategy addresses the following physical objectives rated high for benefit and incorporates ESA-listed species.

Physical objectives satisfied by Strategy 3	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
High Benefit/ High Difficulty	
P07	Develop an understanding of emigrating juvenile salmonid life-history diversity, white sturgeon spawning characteristics and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary and plume. *Species/lifestage affected; salmonid juvenile and adults, sturgeon egg incubation, species of ecological interest and species of recreational interest.*

Measures that address Strategy 3		
Description of Measure		**Applicable Species**
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Measures that address Strategy 3		
Description of Measure		**Applicable Species**
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M3	Maintain adequate water flows throughout spawning, incubation and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer
M6	Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M7	Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Columbian White-tailed Deer, species of ecological interest.
M9	Implement regulatory, control, and education measures to prevent additional species invasions.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, species of recreational interest.
M14	Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M15	Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Measures that address Strategy 3		
Description of Measure		**Applicable Species**
M18	Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.	white sturgeon

Small-scale habitat impact mitigation

Strategy 4: Mitigate small-scale local habitat impacts such that no net loss occurs.

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with onsite rather than offsite efforts.

The strategy responds to the following vision-supporting statements: SV1, SV2, SV5, SV6

Strategy ranking justification: This strategy addresses the following physical objectives rated high for benefit and incorporates ESA-listed species.

Physical objectives satisfied by Strategy 4	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
PO30	Minimize disturbance to Columbian White-tailed Deer during breeding and rearing season. *Species/life stage affected: Columbian White-tailed Deer*
High Benefit/ High Difficulty	
PO7	Develop an understanding of emigrating juvenile salmonid life-history diversity, white sturgeon spawning characteristics and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation, species of ecological interest and species of recreational interest.*

Measures that address Strategy 4		
Description of Measure		**Applicable Species**
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Measures that address Strategy 4		
Description of Measure		**Applicable Species**
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M3	Maintain adequate water flows throughout spawning, incubation and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer
M6	Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M7	Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, , Columbian White-tailed Deer species of ecological interest.
M8	Limit the effects of toxic contaminants on salmonid, white sturgeon, Pacific lamprey, and bald eagle fitness and survival in the Columbia River estuary, lower mainstem and nearshore ocean.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, bald eagle, species of ecological interest.
M9	Implement regulatory, control and education measures to prevent additional species invasions.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, species of recreational interest.
M14	Continue to manage predation by Caspian terns to avoid increases in salmon predation while	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter

Measures that address Strategy 4		
Description of Measure		**Applicable Species**
	also protecting the viability of the tern population.	steelhead, species of ecological interest.
M18	Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.	white sturgeon

Species / Ecosystem understanding

Strategy 10: Improve the understanding of the relationships between salmonids, white sturgeon and Pacific lamprey with the lower mainstem, Western Oregon tributaries, estuary and the plume ecosystems.

Explanation: Emerging research about how physical processes affect habitat conditions in the estuary and mainstem will provide promising tools in the near future. Future research is needed to develop an understanding about how physical processes affect habitat conditions in the estuary and mainstem and understanding about how salmonids, white sturgeon and Pacific lamprey populations use the existing and changing habitats in the estuary and lower mainstem. Additionally, future research should also focus on establishing clear relationships between salmonids, white sturgeon, Pacific lamprey and the various predators or introduced species in the estuary and mainstem.

The strategy responds to the following vision-supporting statements: SV1, SV2, SV3 SV4, SV5,SV6,SV8

Strategy ranking justification: This strategy addresses the following physical objectives rated "High" for "Benefit" and incorporates ESA-listed species.

Physical objectives satisfied by Strategy 10	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Species/life stage affected: salmonid incubation, juvenile, adult.*
PO12	Protect population from overexploitation. *Species/life stage affected: sturgeon adult, lamprey adult.*
High Benefit/ High Difficulty	
PO2	Increase shallow water peripheral and side-channel habitats toward historic levels. *Species/life stage affected: fall Chinook and chum juveniles.*
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles, Columbian White-tailed Deer*

Physical objectives satisfied by Strategy 10	
PO6	Document the interaction between emigrating salmonid juveniles, white sturgeon adults/juveniles and Pacific lamprey adults/juveniles and introduced species; minimize negative interactions. *Species/life stage affected: salmonid juveniles, sturgeon juvenile and adult, lamprey juvenile and adult.*
PO7	Develop an understanding of emigrating juvenile salmonid life-history diversity, white sturgeon spawning characteristics and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation, species of ecological interest and species of recreational interest.*
PO8	Evaluate/improve survival of upriver juvenile salmonid emigrating via barge or dam passage. *Species/life stage affected: salmonid juveniles.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage). *Species/life stage affected: salmonid incubation, juvenile, adult.*
PO10	Avoid direct dredging mortality. *Species/life stage affected: sturgeon egg incubation, juveniles, lamprey juveniles.*
PO11	Develop an understanding of white sturgeon juvenile and adult and Pacific lamprey habitat use in the lower mainstem and estuary. *Species/life stage affected: sturgeon juveniles, lamprey adult.*
PO15	Improve dam passage. *Species/lifestage affected: Pacific lamprey and species of ecological interest.*

Measures that address Strategy 10		
Description of Measure		**Applicable Species**
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.

Measures that address Strategy 10		
Description of Measure		**Applicable Species**
M3	Maintain adequate water flows throughout spawning, incubation and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, Columbia White-tailed Deer, species of ecological interest.
M5	Protect and restore riparian and wetland habitat condition and function.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer
M6	Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M7	Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M8	Limit the effects of toxic contaminants on salmonid, white sturgeon, Pacific lamprey and bald eagle fitness and survival in the Columbia River estuary, lower mainstem and nearshore ocean.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, bald eagle, species of ecological interest.
M9	Implement regulatory, control and education measures to prevent additional species invasions.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, species of recreational interest.
M10	Establish a moratorium on intentional introductions of aquatic species and importation of high-risk	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon,

Measures that address Strategy 10		
Description of Measure		**Applicable Species**
	species.	pacific lamprey, species of ecological interest.
M11	Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures and the impacts on different life stages of white sturgeon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, species of ecological interest.
M12	Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M13	Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M14	Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M15	Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M16	Improve understanding of interrelationships among fish, wildlife and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological, management and recreational interest
M17	Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival and migration patterns of various salmonid, white sturgeon and Pacific lamprey populations	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of management interest, species of recreational interest.

Measures that address Strategy 10		
Description of Measure		**Applicable Species**
M18	Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.	white sturgeon
M19	Evaluate gamefish predation or competition risks to sturgeon and Pacific lamprey; avoid management or enhancement of introduced gamefish populations that pose significant threats to sturgeon and lamprey.	white sturgeon, pacific lamprey, species of ecological interest.
M20	Identify predators of sturgeon embryos and juveniles, juvenile and adult Pacific lamprey; reduce predation mortality.	white sturgeon, Pacific lamprey.

Use of existing processes and programs

Strategy 11: Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection, habitat restoration and recovery measures is currently in place across the overlapping. For terrestrial focal species, this includes successful efforts under the bald eagle and Columbian White-tailed Deer management plans.

The strategy responds to the following vision-supporting statements: SV7

Strategy ranking justification: This strategy addresses the following physical objectives rated high for benefit and incorporates ESA-listed species.

Physical objectives satisfied by Strategy 11	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Species/life stage affected: salmonid incubation, juvenile, adult.*
PO12	Protect population for overexploitation. *Species/life stage affected: sturgeon adult, lamprey adult*
High Benefit/ High Difficulty	
PO2	Increase shallow water peripheral and side channel habitats toward historic levels. *Species/life stage affected: fall Chinook and chum juveniles.*
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles, Columbia White-tailed Deer*
PO6	Document the interaction between emigrating salmonid juveniles, white sturgeon adults/juveniles and Pacific lamprey adults/juveniles and introduced species; Minimize negative interactions. *Species/life stage affected: salmonid juveniles, sturgeon juvenile and adult, lamprey juvenile and adult.*

Physical objectives satisfied by Strategy 11	
PO7	Develop an understanding of emigrating juvenile salmonid life history diversity, white sturgeon spawning characteristics, and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest and species of recreational interest.*
PO8	Evaluate/improve survival of upriver juvenile salmonid emigrating via barge or dam passage. *Species/life stage affected: salmonid juveniles.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Species/life stage affected: salmonid incubation, juvenile, adult.*
PO10	Avoid direct dredging mortality. *Species/life stage affected: sturgeon egg incubation, juveniles, lamprey juveniles.*
PO11	Develop an understanding of white sturgeon juvenile and adult and Pacific lamprey habitat use in the lower mainstem and estuary. *Species/life stage affected: sturgeon juveniles, lamprey adult*
PO12	Protect population for overexploitation. *Species/life stage affected: sturgeon adult, lamprey adult*
PO15	Improve dam passage. *Species/lifestage affected: Pacific lamprey and species of ecological interest.*
PO14	Restore spring peak flows in lower Columbia River. *Species/lifestage affected: salmonid*

Measures that address Strategy 11

Description of Measure		Applicable Species
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.

Measures that address Strategy 11		
Description of Measure		**Applicable Species**
M3	Maintain adequate water flows throughout spawning, incubation, and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, Columbian White-tailed Deer, species of ecological interest.
M5	Protect and restore riparian and wetland habitat condition and function.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer
M6	Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M7	Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M8	Limit the effects of toxic contaminants on salmonid, white sturgeon, Pacific lamprey and Bald Eagle fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Bald eagle, species of ecological interest.
M9	Implement regulatory, control, and education measures to prevent additional species invasions.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, species of recreational interest.

Measures that address Strategy 11		
Description of Measure		**Applicable Species**
M10	Establish a moratorium on intentional introductions of aquatic species and importation of high risk species	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M11	Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures and the impacts on different life stages of white sturgeon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, species of ecological interest.
M12	Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M13	Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M14	Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M15	Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M16	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological, management and recreational interest

Measures that address Strategy 11		
Description of Measure		**Applicable Species**
M17	Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid, white sturgeon, and Pacific lamprey populations.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of mgmt interest, species of rec interest.
M18	Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.	white sturgeon.
M19	Evaluate gamefish predation or competition risks to sturgeon and Pacific lamprey; avoid management or enhancement of introduced gamefish populations that pose significant threats to sturgeon and lamprey.	white sturgeon, pacific lamprey, species of ecological interest.
M20	Identify predators of sturgeon embryos and juveniles, juvenile and adult Pacific lamprey; reduce predation mortality.	white sturgeon, pacific lamprey.

More-specific geographic assessment

Strategy 23: Assess the mainstem lower Columbia River and the Columbia River estuary by discreet geographic reaches for restoration and protection priorities, and develop approach for determining expected outcomes of RM&E activities

Explanation; A problem exists in the information systems of resource planners who are unable, today, to accurately inventory where protection and restoration work has been completed or is ongoing, and where additional work is needed. Throughout the subbasin planning process, an urgent need was identified to develop a "desktop" triage tool to identify where measures should be applied, or where mitigation steps might be needed in response to some natural or anthropogenic system disturbance. A systematic way of identifying the protection and restoration potential of specific areas within the subbasin needs to be developed. Such a system could then provide a means for prioritizing actions.

The strategy responds to the following "vision supporting statements": SV2,SV5,SV6,SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 23	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Species/life stage affected: salmonid incubation, juvenile, adult.*
High Benefit/ High Difficulty	
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles*
PO4	Reduce predation mortality on developing embryos, emigrating juveniles and migrating adults. *Species/life stage affected: salmonid juveniles, sturgeon, lamprey, species of ecological interest.*
PO5	Reduce contaminant exposure of emigrating salmonid and Pacific lamprey juveniles and white sturgeon eggs and juveniles. *Species/life stage affected: salmonid juveniles, sturgeon, lamprey, species of ecological interest.*
PO11	Develop an understanding of emigrating juvenile salmonid life history diversity, white sturgeon spawning characteristics, and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Species/lifestage affected: salmonid*

Physical objectives satisfied by Strategy 23	
	juvenile and adults, sturgeon egg incubation and species of ecological interest and species of recreational interest.
PO2	Increase shallow water peripheral and side channel habitats toward historic levels. *Species/lifestage affected: salmonid juvenile*

Measures that address Strategy 23

Description of Measure		Applicable Species
M36	Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Columbia River lower mainstem and estuary and assessing possible outcomes of actions in the planning area.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.

Sustainable fisheries

Strategy 15: Manage Columbia River fisheries at sustainable levels, maintaining a viable population through adequate spawner abundance, and directing harvest away from depressed stocks

Longevity, slow growth, and delayed maturation make sturgeon susceptible to fishery overexploitation. Columbia River sturgeon fisheries should continue to be managed in such a way as to insure sufficient abundance of fish attaining older ages, thus maintaining adequate spawner abundance. Pacific lamprey fisheries should continue to be managed in such a way as to maintain a viable population. Salmonid stocks can benefit from select area fisheries management.

The strategy responds to the following "vision supporting statements": SV1,SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated "High" for "Benefit"; does not incorporates ESA listed species.

Physical objectives satisfied by Strategy 15	
High Benefit/ Medium-Low Difficulty	
PO34	Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery derived stocks. *Species/life stage affected: Salmonid adult.*
High Benefit/ High Difficulty	
PO12	Protect population for overexploitation. *Species/life stage affected: sturgeon adult, lamprey adult.*

Measures that address this strategy		
Description of Measure		**Applicable Species**
M21	Closely monitor Columbia River fisheries harvest levels to maintain sturgeon spawner abundance and Pacific lamprey population viability.	white sturgeon, pacific lamprey.
M37	Continue the Select Area Fisheries Project	fall Chinook, spring Chinook, chum, coho, winter steelhead

Restoration activity efficiency

Strategy 5: Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Explanation: Salmonid recovery is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will require some restoration of areas that are substantially degraded but also provides significant flexibility in where habitat restoration efforts are distributed among and within subbasins.

The strategy responds to the following "vision supporting statements": SV6, SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 5	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
High Benefit/ High Difficulty	
PO2	Increase shallow water peripheral and side channel habitats toward historic levels. *Species/life stage affected: fall Chinook and chum juveniles*.
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles, Columbia White-tailed Deer*

Measures that address Strategy 5		
Description of Measure		**Applicable Species**
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M3	Maintain adequate water flows throughout spawning, incubation, and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer
M6	Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M7	Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Columbian White-tailed Deer, species of ecological interest.
M16	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, spring Chinook, chum, c oho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological, management and recreational interest
M37	Develop desktop “triage” tool for determining	fall Chinook, spring Chinook, chum,

Measures that address Strategy 5		
Description of Measure		**Applicable Species**
	restoration and protection potential of distinct geographic areas within the Columbia River lower mainstem and estuary and assessing possible outcomes of actions in the planning area.	coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.

Active and passive habitat restoration measures

Strategy 6: Utilize a combination of active and passive habitat restoration measures to provide near-term and long-term benefits.

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but effects are rarely lasting unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures in the riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions).

The strategy responds to the following "vision supporting statements": SV2, SV5, SV6

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 6	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Species/life stage affected: salmonid incubation, juvenile, adult.*
High Benefit/ High Difficulty	
PO2	Increase shallow water peripheral and side channel habitats toward historic levels. *Species/life stage affected: fall Chinook and chum juveniles.*
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles, Columbia White-tailed Deer*

Measures that address Strategy 6	
Description of Measure	**Applicable Species**

Measures that address Strategy 6		
Description of Measure		**Applicable Species**
M19	Evaluate gamefish predation or competition risks to sturgeon and Pacific lamprey; avoid management or enhancement of introduced gamefish populations that pose significant threats to sturgeon and lamprey.	white sturgeon, pacific lamprey, species of ecological interest.
M37	Develop desktop “triage” tool for determining restoration and protection potential of distinct geographic areas within the Columbia River lower mainstem and estuary and assessing possible outcomes of actions in the planning area.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.

Salmon significance

Strategy 7: Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Explanation: Salmon are an integral component of both the freshwater and marine ecosystem of which they are a part. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the status of salmon. Many significant salmon predators including bull trout, eagles, and grizzly bears have declined concurrent with salmon declines, albeit for a variety of reasons. Large numbers of salmon returning to spawn streams also introduce significant amounts of marine-derived nutrients into freshwater systems. These nutrients may stimulate primary and secondary productivity when other appropriate habitat conditions exist; this increased productivity increases food for juvenile salmon as well as other species. Finally, salmon actually affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

The strategy responds to the following "vision supporting statements": SV2

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 7	
High Benefit / High Difficulty	
PO7	Develop an understanding of emigrating juvenile salmonid life history diversity, white sturgeon spawning characteristics, and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest and species of recreational interest.*

Measures that address Strategy 7		
Description of Measure		**Applicable Species**
M8	Limit the effects of toxic contaminants on salmonid, white sturgeon, Pacific lamprey and Bald Eagle fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Bald eagle, species of ecological interest.
M9	Implement regulatory, control, and education measures	fall Chinook, spring Chinook, chum, coho, summer steelhead,

Measures that address Strategy 7		
Description of Measure		**Applicable Species**
	to prevent additional species invasions.	winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, species of recreational interest.
M10	Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M11	Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures and the impacts on different life stages of white sturgeon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, species of ecological interest.
M12	Manage or avoid enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M13	Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M14	Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M15	Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M16	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological,

Measures that address Strategy 7		
Description of Measure		**Applicable Species**
		management and recreational interest
M17	Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid, white sturgeon, and Pacific lamprey populations.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of management interest, species of recreational interest.
M19	Evaluate gamefish predation or competition risks to sturgeon and Pacific lamprey; avoid management or enhancement of introduced gamefish populations that pose significant threats to sturgeon and lamprey.	white sturgeon, pacific lamprey, species of ecological interest.

Introduced species

Strategy 8: Control, mitigate, or manage introduced species. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introducing species.

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often co-adapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

The strategy responds to the following "vision supporting statements": SV2, SV5, SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 8	
High Benefit/ High Difficulty	
PO6	Document the interaction between emigrating salmonid juveniles, white sturgeon adults/juveniles and Pacific lamprey adults/juveniles and introduced species; Minimize negative interactions. *Species/life stage affected: salmonid juveniles, sturgeon juvenile and adult, lamprey juvenile and adult.*

Measures that address Strategy 8		
Description of Measure		**Applicable Species**
M9	Implement regulatory, control, and education measures to prevent additional species invasions	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, species of recreational interest.

Measures that address Strategy 8		
Description of Measure		**Applicable Species**
M10	Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M11	Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures and the impacts on different life stages of white sturgeon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, species of ecological interest.
M12	Manage or avoid enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M16	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological, management and recreational interest
M13	Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration	Fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M19	Evaluate gamefish predation or competition risks to sturgeon and Pacific lamprey; avoid management or enhancement of introduced gamefish populations that pose significant threats to sturgeon and lamprey.	White sturgeon, pacific lamprey.

Exacerbation of predation

Strategy 9: As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

The strategy responds to the following "vision supporting statements": SV2, SV5

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 9	
Medium Benefit/ High Difficulty	
PO4	Reduce predation mortality on developing embryos, emigrating juveniles and migrating adults. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and lamprey adult.*

Measures that address Strategy 9		
Description of Measure		**Applicable Species**
M12	Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M13	Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Measures that address Strategy 9		
Description of Measure		**Applicable Species**
M14	Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, species of ecological interest.
M15	Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M16	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological, management and recreational interest

Species / Ecosystem understanding

Strategy 10: Our understanding the relationships between salmonids, white sturgeon, Pacific lamprey and the lower mainstem, Western Oregon tributaries, estuary and the plume ecosystems needs to be improved.

Explanation: Emerging research and understanding about how physical processes affect habitat conditions in the estuary and mainstem are promising tools in the near future. Future research is needed to develop an understanding about how physical processes affect habitat conditions in the estuary and mainstem and understanding about how salmonids, white sturgeon, Pacific lamprey populations use the existing and changing habitats in the estuary and lower mainstem. Additionally, future research should also focus on establishing clear relationships between salmonids, white sturgeon, Pacific lamprey and the various predators or introduced species in the estuary and mainstem.

The strategy responds to the following "vision supporting statements": SV1, SV2, SV3 SV4, SV5,SV6,SV8

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 10	
High Benefit / Lower to Medium Difficulty	
PO1	*Protect existing rearing and spawning habitat to ensure no further net degradation Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
PO9	*Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) Species/life stage affected: salmonid incubation, juvenile, adult.*
PO12	*Protect population from overexploitation. Species/life stage affected: sturgeon adult, lamprey adult*
High Benefit/ High Difficulty	
PO2	Increase shallow water peripheral and side channel habitats toward historic levels. *Species/life stage affected: fall Chinook and chum juveniles.*
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles, Columbia White-tailed Deer*

Physical objectives satisfied by Strategy 10	
PO6	Document the interaction between emigrating salmonid juveniles, white sturgeon adults/juveniles and Pacific lamprey adults/juveniles and introduced species; Minimize negative interactions. *Species/life stage affected: salmonid juveniles, sturgeon juvenile and adult, lamprey juvenile and adult.*
PO7	Develop an understanding of emigrating juvenile salmonid life history diversity, white sturgeon spawning characteristics, and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest and species of recreational interest.*
PO8	Evaluate/improve survival of upriver juvenile salmonid emigrating via barge or dam passage. *Species/life stage affected: salmonid juveniles.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage), *Species/life stage affected: salmonid incubation, juvenile, adult.*
PO10	Avoid direct dredging mortality. *Species/life stage affected: sturgeon egg incubation, juveniles, lamprey juveniles.*
PO11	Develop an understanding of white sturgeon juvenile and adult and Pacific lamprey habitat use in the lower mainstem and estuary. *Species/life stage affected: sturgeon juveniles, lamprey adult*
PO15	Improve dam passage. *Species/lifestage affected: Pacific lamprey and species of ecological interest.*

Measures that address Strategy 10		
Description of Measure		**Applicable Species**
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.

Measures that address Strategy 10		
Description of Measure		**Applicable Species**
M3	Maintain adequate water flows throughout spawning, incubation, and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, Columbian White-tailed Deer, species of ecological interest.
M5	Protect and restore riparian and wetland habitat condition and function.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer
M6	Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M8	Limit the effects of toxic contaminants on salmonid, white sturgeon, Pacific lamprey and Bald Eagle fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Bald eagle, species of ecological interest.
M9	Implement regulatory, control, and education measures to prevent additional species invasions.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, species of recreational interest.
M10	Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.

Measures that address Strategy 10		
Description of Measure		**Applicable Species**
M11	Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures and the impacts on different life stages of white sturgeon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, species of ecological interest.
M12	Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M14	Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M15	Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M16	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological, management and recreational interest
M17	Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid, white sturgeon, and Pacific lamprey populations.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of management interest, species of recreational interest.
M18	Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.	white sturgeon.
M19	Evaluate gamefish predation or competition risks to sturgeon and Pacific lamprey; avoid management or enhancement of introduced gamefish populations that pose significant threats to sturgeon and lamprey.	white sturgeon, pacific lamprey, species of ecological interest.

Measures that address Strategy 10		
Description of Measure		**Applicable Species**
M20	Identify predators of sturgeon embryos and juveniles, juvenile and adult Pacific lamprey; reduce predation mortality.	White Sturgeon, Pacific Lamprey.

Use of existing processes and programs

Strategy 11: Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection, habitat restoration, and recovery measures are currently in place across the overlapping.

The strategy responds to the following "vision supporting statements": SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated "High" for "Benefit"; incorporates ESA listed species.

Physical objectives satisfied by Strategy 11	
High Benefit / Lower to Medium Difficulty	
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Species/life stage affected: salmonid incubation, juvenile, adult.*
PO12	Protect population for overexploitation. Species/life stage affected*: sturgeon adult, lamprey adult*
High Benefit/ High Difficulty	
PO2	Increase shallow water peripheral and side channel habitats toward historic levels. *Species/life stage affected: fall Chinook and chum juveniles.*
PO3	Restore connectivity between river and floodplain, as well as in-river habitats. *Species/life stage affected: salmonid juveniles, Columbia White-tailed Deer*
PO6	Document the interaction between emigrating salmonid juveniles, white sturgeon adults/juveniles and Pacific lamprey adults/juveniles and introduced species*; Minimize negative interactions. Species/life stage affected: salmonid juveniles, sturgeon juvenile and adult, lamprey juvenile and adult.*

Physical objectives satisfied by Strategy 11	
PO7	Develop an understanding of emigrating juvenile salmonid life history diversity, white sturgeon spawning characteristics, and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest and species of recreational interest.*
PO8	Evaluate/improve survival of upriver juvenile salmonid emigrating via barge or dam passage. *Species/life stage affected: salmonid juveniles.*
PO9	Maintain favorable water flow and temperature throughout mainstem incubation, spawning and migration periods. (August through March depending on life stage.) *Species/life stage affected: salmonid incubation, juvenile, adult.*
PO10	Avoid direct dredging mortality. *Species/life stage affected: sturgeon egg incubation, juveniles, lamprey juveniles.*
PO11	Develop an understanding of white sturgeon juvenile and adult and Pacific lamprey habitat use in the lower mainstem and estuary. *Species/life stage affected: sturgeon juveniles, lamprey adult*
PO12	Protect population for overexploitation. *Species/life stage affected: sturgeon adult, lamprey adult*
PO14	Restore spring peak flows in lower Columbia River. *Species/lifestage affected: salmonid*
PO14	Improve dam passage. *Species/lifestage affected: Pacific lamprey and species of ecological interest.*

Measures that address Strategy 11		
Description of Measure		**Applicable Species**
M1	Restore tidal swamp and marsh habitat in the estuary and idal freshwater portion of ht elower Columbia River.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M2	Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.

Measures that address Strategy 11		
Description of Measure		**Applicable Species**
M3	Maintain adequate water flows throughout spawning, incubation, and migration periods.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M4	Restore connectedness between river and floodplain.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, Columbian White-tailed Deer, species of ecological interest.
M5	Protect and restore riparian and wetland habitat condition and function.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer
M6	Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M7	Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, Columbian White-tailed Deer
M8	Limit the effects of toxic contaminants on salmonid, white sturgeon, Pacific lamprey and Bald Eagle fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Bald eagle species of ecological interest.
M9	Implement regulatory, control, and education measures to prevent additional species invasions.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest, species of recreational interest.
M10	Establish a moratorium on intentional introductions of	fall Chinook, spring Chinook,

Measures that address Strategy 11		
Description of Measure		**Applicable Species**
	aquatic species and importation of high risk species.	chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, species of ecological interest.
M11	Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures and the impacts on different life stages of white sturgeon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, species of ecological interest.
M12	Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M13	Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M14	Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, species of ecological interest.
M15	Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.
M16	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall and spring Chinook, chum, coho, summer and winter steelhead, white sturgeon, pacific lamprey, species of ecological, management and recreational interest.
M17	Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid, white	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon,

Measures that address Strategy 11		
Description of Measure		**Applicable Species**
	sturgeon, and Pacific lamprey populations.	pacific lamprey, species of management interest, species of recreational interest.
M18	Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.	white sturgeon.
M19	Evaluate gamefish predation or competition risks to sturgeon and Pacific lamprey; avoid management or enhancement of introduced gamefish populations that pose significant threats to sturgeon and lamprey.	white sturgeon, pacific lamprey, species of ecological interest.

Toxins

Strategy 12: Limit the effects of toxic contaminants in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on fish or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes. Juvenile lamprey may be particularly susceptible to contaminant effects because of their sediment burrowing habits. Bald Eagles are a top level predator, and the impact of contaminants, needs to be monitored and understood

The strategy responds to the following "vision supporting statements": SV2,SV3,SV4

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 12	
Medium Benefit/ High Difficulty	
PO5	Reduce contaminant exposure of emigrating salmonid and Pacific lamprey juveniles and white sturgeon eggs and juveniles. *Species/life stage affected: salmonid juvenile and adults, sturgeon egg incubation and lamprey juveniles; eagle.*

Measures that address Strategy 12		
Description of Measure		**Applicable Species**
M8	Limit the effects of toxic contaminants on salmonid, white sturgeon, Pacific lamprey and Bald Eagle fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Bald eagle, species of ecological interest.

Sturgeon and lamprey predation

Strategy 13: *Evaluate the level of predation mortality* d*uring the embryo and juvenile life stages of white sturgeon and the juvenile and adult migration stages of Pacific lamprey to determine the extent of predation-related recruitment failure.*

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist. The strategy responds to the following "vision supporting statements": SV2

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 13	
High Benefit/ High Difficulty	
PO6	Document the interaction between emigrating salmonid juveniles, white sturgeon adults/juveniles and Pacific lamprey adults/juveniles and introduced species; Minimize negative interactions. *Species/life stage affected: salmonid juveniles, sturgeon juvenile and adult, lamprey juvenile and adult.*
PO7	Develop an understanding of emigrating juvenile salmonid life history diversity, white sturgeon spawning characteristics, and Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon egg incubation and species of ecological interest and species of recreational interest.*

Measures that address this Strategy 13		
Description of Measure		**Applicable Species**
M16	Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey.

M20	Identify predators of sturgeon embryos and juveniles, juvenile and adult lamprey; reduce predation mortality.	white sturgeon, pacific lamprey.

Incidental dredging mortality

Strategy14: Avoid incidental mortality of white sturgeon embryos and juveniles and Pacific lamprey juveniles during dredging operations.

Explanation: Developing embryos or juvenile white sturgeon and Pacific lamprey may be present among sand or fine substrates throughout the lower Columbia River. Suction dredging in these areas results in direct mortality. Dredge operations should avoid areas of known white sturgeon or Pacific lamprey presence.

The strategy responds to the following "vision supporting statements": SV1,SV6,SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 14	
Medium Benefit/ Low Difficulty	
PO10	Avoid direct dredging mortality.*Species/lifestage affected; White sturgeon egg incubation, white sturgeon adult, Pacific lamprey juvenile.*

Measures that address Stategy 14		
Description of Measure		**Applicable Species**
M7	Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.	fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, pacific lamprey, Columbian White-tailed Deer, species of ecological interest.

Incidental operation and maintence mortality at Bonneville

Strategy 16: Avoid incidental mortality as a result of Bonneville Dam operations and maintenance.

Explanation: Dewatering of turbines at Bonneville Dam has been documented to entrain white sturgeon, resulting in mortality. Operations at Bonneville, and elsewhere in the subbasins, need to be evaluated to minimize sturgeon mortality.

The strategy responds to the following "vision supporting statements": SV6,SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated "Low" for "Benefit"; does not incorporates ESA listed species.

Physical objectives satisfied by Strategy 16	
Medium Benefit/ Low Difficulty	
PO13	Avoid incidental operations and maintenance mortality at Bonneville Dam. *Species/lifestage affected: White sturgeon adult.*

Measures that address Strategy 16		
Description of Measure		**Applicable Species**
M23	Evaluate and mitigate Bonneville Dam operations that result in direct sturgeon mortality.	white and green sturgeon

Lamprey passage

Strategy 17: Evaluate and improve downstream and upstream passage conditions at mainstem and tributary dams, insuring no negative effects on salmonids.

Explanation: Adult Pacific lamprey have difficulty in dam passage and juveniles migrating downstream do not appear to benefit from juvenile salmonid passage systems.

The strategy responds to the following "vision supporting statements": SV1,SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit but does not incorporates ESA listed species.

Physical objectives satisfied by Strategy 17	
High Benefit/ High Difficulty	
PO15	Improve dam passage. *Species/lifestage affected: Pacific lamprey and species of ecological interest.*

Measures that address Strategy 17		
Description of Measure		**Applicable Species**
M24	Modify passage structures at dams to improve juvenile and adult passage efficiency.	pacific lamprey
M25	Determine olfactory capabilities and site fidelity of returning Pacific lamprey adults.	pacific lamprey.

Minimize physical crop losses

Strategy 21: *Crop depredation by geese and cranes can be substantial, creating economic losses to many local farmers and affecting the region's agricultural industry. Alternate overwintering habitat in the region should be sought to decrease the abundance of geese and cranes on private lands.*

This species category was developed because of the significant management interest in the Columbia River mainstem and estuary ecosystem. Future research is needed to develop an understanding about how physical processes affect habitat conditions in the estuary and mainstem as they relate to the species of management interest. Also needed are additional understanding about how species of management interest use the existing and changing habitats in the estuary and lower mainstem. The strategy responds to the following "vision supporting statements": SV1,SV2,SV5,SV6

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit

Physical objectives satisfied by Strategy 21	
High Benefit / High Difficulty	
PO23	Limit crop depredation. *Species/lifestage affected:* species of management interest.
PO21	Encourage use of public lands over private lands. *Species/lifestage affected:* species of management interest.
Medium Benefit/ High Difficulty	
PO20	Protect existing over-wintering habitat to ensure no future net degradation. *Species/lifestage affected:* species of management interest.

Measures that address Strategy 21		
Description of Measure		**Applicable Species**
MI.M4	Minimize geese and crane use of private lands in the estuary and tidal freshwater portion of the lower Columbia River, with no net loss of winter population	Dusky Canada goose

Measures that address Strategy 21		
Description of Measure		**Applicable Species**
	abundance.	
MI.M5	Investigate options to limit crop depredation	Dusky Canada goose
MI.M6	Improve understand of interrelationships among fish, wildlife, and habitat conditions in the estuary and lower mainstem	Dusky Canada goose

Shad competition with salmonids

Strategy 22: Investigate and minimize competition among American shad and ESA-listed salmonids.

Explanation; Evidence indicates there is habitat use and diet overlap of juvenile shad and juvenile salmonids, suggesting potential competition effects. It is not clear whether perceived competition between shad and salmonids is limiting salmonid recovery efforts. Additionally, the timing and abundance of American shad creates crowding at fish ladders during salmonid return migration timing, which can create competition for space and cause delays in salmonid upstream migration.

The strategy responds to the following "vision supporting statements": SV1,SV2,SV7,SV8

Strategy ranking justification: This strategy addresses affects ESA listed species.

Physical objectives satisfied by Strategy 22	
Unknown Benefit / High Difficulty	
PO6	Document the interactions between emigrating salmonid juveniles, white sturgeon and Pacific lamprey adults and juveniles and introduced species; minimize negative interactions. *Species/lifestage affected: salmonid juvenile and adults, sturgeon, lamprey, species of ecological interest and species of recreational interest.*
PO7	Develop an understanding of emigrating salmonid juvenile life history diversity and habitat use, white sturgeon spawning habitat characteristics and Pacific lamprey use in the lower mainstem, the Western Oregon tributaries, the estuary and the plume. *Species/lifestage affected: salmonid juvenile and adults, sturgeon, lamprey, species of ecological interest and species of recreational interest.*

Measures that address Strategy 22		
Description of Measure		**Applicable Species**
M11	Consider the potential opposite impacts of American shad on the Columbia River lower mainstem, estuary, and plume ecosystem; evaluate possible shad management programs.	American shad, juvenile salmonids, adult salmonids, species of ecological interest
M16	Improve understanding of interrelationships among fish, wildlife, and habitat conditions in the estuary and lower mainstem.	American shad, juvenile salmonids, adult salmonids, lamprey, pecies of ecological interest

4.4.3 *Western Oregon tributaries specific strategies*

As discussed previously, the prioritized focal strategies outlined in this management plan may generally be applied regardless of geographic range, including a substantial portion of the Western Oregon tributaries. Strategies and measures were proposed to address physical objectives of our focal species that may also be applied to the WOTs subbarea, in many instances. Evaluation of the WOTs working hypotheses, limiting factors, and biological assessment produced a few strategies that, while not limited to WOTs, are of particular interests.

Barriers to productive spawning and rearing habitat

Strategy 18: Open access to productive habitat by removing or mitigating passage barriers

Explanation: Tide gates, culverts, hatchery weirs, and other barriers have impeded or severed access to habitat that was historically productive, and which could yet provide additional spawning and rearing habitat for salmonids that are currently limited by the amount of available productive habitat. In some cases around hatcheries, barriers have been been erected to prevent potentially disease infected fish from spawning upstream of the water intake for the hatchery and transferring disease to fish being raised at the hatchery. One of the recovery plan strategies for some salmonid populations is to to provide adult passage at several of these locations, consistent with the likelihood of gains in natural production and not unduly compromising the hatchery rearing environment in terms of disease. The strategy responds to the following "vision supporting statements": SV3,SV5,SV6

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 18	
High Benefit/ Medium-High Difficulty	
PO16	Open access to productive habitat by removing or mitigating passage barriers *Species/life stage affected: salmonid juvenile and adults*.
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/life stage affected: salmonid juvenile*
PO2	Increase shallow water peripheral and side channel habitats toward historic levels. *Species/life stage affected: salmonid juveniles*
PO3	Restore connectivity between tributary deltas and the estuary, the river and the , floodplain, as well as in-river habitats *Species/life stage affected: salmonid juveniles, Columbia White-tailed Deer*

Measures that address Strategy 18		
Description of Measure		**Applicable Species**
M22	Implement mitigation and enhancement measures to assess, prioritize,and provide access to productive spawning and rearing habitat that could be achieved through addressing fish passage	coho, fall Chinook, winter steelhead

Life history diversity

Strategy19: Promote management actions that support sufficient life-history diversity to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes.

Explanation: Viable salmonid population parameters suggest that sufficient life-history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. Metrics and benchmarks for evaluating the diversity of a population should be evaluated over multiple generations and should include a substantial proportion of the diversity of a life-history trait(s) that existed historically, gene flow and genetic diversity similar to historical (natural) levels and origins, successful utilization of habitats throughout the range, and resilience and adaptation to environmental fluctuations. The strategy responds to the following "vision supporting statements": SV2,SV5,SV7

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 19	
High Benefit/ High Difficulty	
PO18	Seek methods for restoring historic run timing to coastal stratum, including the Western Oregon tributaries. *Species/life stage affected: salmonid juvenile and adults*

Measures that address Strategy 19		
Description of Measure		**Applicable Species**
M28	Restore n-type coho to Western Oregon tributaries	coho

Address channel stability and habitat diversity in Western Oregon tributaries

Strategy 20: Protect and restore habitat diversity and channel stability attributes in Western Oregon tributaries to compliment salmonid life-history requirements

Explanation: Reaches of the Western Oregon tributaries are significantly challenged by channelization, and modifications to the historic flow regimes; signicifcant degredation is observed in the lower reaches. For example, flows in the estuary and a lack of spring freshets resulting from hydropower operation have modified conditions in the lower reaches of these tributaries in important ways. Additionally, the lack of large woody debris LWD and channelization has simplified habitat, reducing refugia and resting areas. Recruitment of can be enhanced through upstream improvements in riparian conditions and forest practices.The strategy responds to the following "vision supporting statements": SV2,SV5,SV6

Strategy ranking justification: This strategy addresses the following Physical Objectives rated high for benefit and incorporates ESA listed species.

Physical objectives satisfied by Strategy 20	
High Benefit/ Medium-High Difficulty	
PO3	Restore connectivity between tributary deltas and the estuary, the river and the, floodplain, as well as in-river habitats *Species/lifestage affected: Salmonid juvenile.*
PO19	Restore spawning and rearing habitat in the Western Oregon tributaries. *Species/lifestage affected: Salmonid juvenile, adult.*
PO1	Protect existing rearing and spawning habitat to ensure no further net degradation. *Species/lifestage affected: Salmonid juvenile, adult, White sturgeon egg incubation.*
PO14	Restore spring peak flows in the lower Columbia. *Species/lifestage affected: Salmonid juvenile, Pacific lamprey juvenile.*
PO16	Eliminate or mitigate access barriers for migrating adults, creating additional spawning and rearing habitat. *Species/lifestage affected: Salmonid adult.*

Measures that address Strategy 20		
Description of Measure		**Applicable Species**
M5	Protect and restore riparian and wetland habitat condition and function.	fall Chinook, chum, coho, winter steelhead
M1	Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.	fall Chinook, chum, coho, winter steelhead
M3	Maintain adequate water flows throughout spawning, incubation, and migration periods.	fall Chinook, chum, coho, winter steelhead
M4	Restore connectedness between river and floodplain.	fall Chinook, chum, coho, winter steelhead
M6	Restore impaired sediment transport processes affecting the Columbia River lower mainstem, Western Oregon tributaries, estuary and the plume.	fall Chinook, chum, coho, winter steelhead
M22	Implement mitigation and enhancement measures to provide access to productive	fall Chinook, chum, coho, winter

Measures that address Strategy 20		
Description of Measure		**Applicable Species**
	spawning and rearing habitat	steelhead

4.5 Measures summary

This section is a compilation and synthesis of the measures derived from the species-specific sections contained in this management plan's supplement. The synthesis eliminates duplication and identifies common measures among the species. The result is 39 measures that carry benefits for more than one focal species and species of interest. Additional measures that are specific to individual species can be found in the Management Plan Supplement (Chapter 5).

The measures include the applicable species, list of strategies addressed, duration of implementation expected, program gap analysis, potential to contribute to biological objectives (with a ranking) and barriers to success. Also included is a reference to programs and projects currently addressing the measures.

Strategy-derived, habitat-related measures can be framed in any number of perspectives. For instance, they can be based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry or hydropower activities) or programmatic remedies (regulations, incentives, restoration). Sorting into categories is complicated because alternatives exist on several scales and often produce interacting effects.

The measures identified in this compilation represent a partial list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction is needed to develop implementation plans. Additional focus on measures in areas of concern may emerge from upcoming studies related to the Biological Opinion.

4.5.1 Description of Measures

M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Explanation: Loss of tidal swamp and marsh habitat has respectively resulted in an estimated 77% and 43% loss of these habitat types from 1870 to 1983. The substantial acreage loss of the tidal swamp and tidal marsh habitat types has important implications on juvenile salmonid survival in the estuary because evidence suggests salmonids, particularly ocean-type salmonids, depend on these habitats for food and cover requirements. Additionally, although ocean-type salmonids are typically associated with shallow water, peripheral habitats, evidence suggest that steam type salmonids also use these habitats.

Variables	Context
Strategies addressed	S1, S2, S3, S4, S5, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective

Variables	Context
	for restoration of tidal and marsh habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of tidal marsh and swamp habitats would have a high benefit because they may increase food web productivity and provide resting habitat for stream-type salmonids.
Barriers to success	*Explanation:* Tidal marsh and swamp habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid, white sturgeon and Pacific lamprey emigration, and restores tidal channel complexity in the estuary.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, white sturgeon, Pacific lamprey.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging and channelization have significantly modified lower mainstem, Western Oregon tributaries and estuary and plume habitats and have resulted in changes to circulation, sediment transport and biological processes. Establishing flows in the lower mainstem, Western Oregon tributaries, estuary and the plume that emulate a more natural regime will help improve habitat conditions for salmonids, white sturgeon and other resident fish and wildlife species and improve emigration conditions for juvenile Pacific lamprey.

Variables	Context
Strategies addressed	S1,.S2, S3, S4,.S5, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit.
Barriers to success	*Explanation:* An annual allocation of water for salmonids will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

M3. Maintain adequate water flows throughout spawning, incubation, and migration periods.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Explanation: Prevents dewatering and decreased flows in redds during spawning and incubation, as well as increasing the potential spawning sites available for fall Chinook and chum adults. Prevents migration barriers, high temperatures in late summer, lack of resting habitats and predation losses for all salmonids. Facilitates juvenile movement through the mainstem to the estuary.

Variables	Context
Strategies addressed	S1, S2, S3, S4.S5, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for maintaining water flows during spawning, incubation, and migration. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High for ocean type salmonids Medium for stream type salmonids *Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit for ocean type salmonids. Maintenance of water flows during migration would have a medium benefit because of the significance of the subbasins as a migratory pathway and for juvenile rearing/smoltification for stream type salmonids.
Barriers to success	*Explanation:* An annual allocation of water for salmonids will be possible through the modification of current water uses, which at present seems questionable. Maintenance of water flows during migration will be possible through the modification of current water uses, which at present seems possible if current water budget is only modified for brief periods. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

M4. Restore connectedness between river and floodplain.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon, Columbian White-tailed Deer.

Explanation: Restoring the access to the floodplain increases juvenile salmonid access to shallow water, low velocity and peripheral habitats. Further, connection of the river and floodplain begins to restore the historical macrodetritus-based food web which is expected to be more productive than the present day microdetrius-based food web.

Variables	Context
Strategies addressed	S1, S2, S3, S4,.S5, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

M5. Protect and restore riparian and wetland habitat condition and function.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, Columbian White-tailed Deer.

Explanation: Riparian zones are critical habitats for many species. This measure incorporates a variety of tools including, local land use regulatory actions, acquisition, and restoration activities. This measure is inherently linked with measures 1 and 4.

Variables	Context
Strategies addressed	.S1, S2, S3,.S4,S5, S10, and S11
Short vs. long term implementation	<25 years

Variables	Context
(<25 years or >25 years)	
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective for protecting wetland and riparian habitats. The current programs cannot be expected to attain the physical objective for restoring wetland and riparian habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of riparian habitats would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web and because of the close association of juvenile chum and fall Chinook with these habitats.
Barriers to success	*Explanation:* Riparian and wetland habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

M6. Restore impaired sediment transport processes affecting the Columbia River lower mainstem, Western Oregon tributaries, estuary and the plume.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon.

Explanation: Sediment dynamics are a critical component of the lower mainstem, Western Oregon tributaries, estuary and the plume habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	S1,.S2, S3,.S4, S5, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective

Variables	Context
	for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

M7. Mitigate channel dredging activities in the Columbia River lower mainstem, Western Oregon tributaries, estuary and the plume that alter habitat forming processes, reduce salmon population resilience, inhibit recovery and result in direct sturgeon and Pacific lamprey mortality.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon, Pacific lamprey, Columbian White-tailed Deer.

Explanation: Channel dredge activities affect the quality of the various lower mainstem, Western Oregon tributaries, estuary and plume salmonid habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Indirectly, wakes from large ships increase erosion and can cause stranding of juvenile salmonids located along the shoreline. Suction dredging activities in the presence of sturgeon embryos or juveniles and Pacific lamprey juveniles results in direct mortality. Measures to mitigate impacts resulting from dredging activities should be identified and implemented. The altering of habitat-forming processes may also contribute to flooding events harmful to Columbian White-tailed deer.

Variables	Context
Strategies addressed	S1, S2, S3, S4, S5, S10, S11, and S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for mitigating dredging activity effects. The primary reason is that the sole purpose of the Channel Deepening Biological Assessment and resulting BiOp focus is to protect ESA-listed salmonids and

Variables	Context
	their habitat while allowing dredging activity to proceed. Dredging effects on white sturgeon and Pacific lamprey have not been adequately addressed.
Potential to contribute to biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects throughout the channel deepening process and beyond. However, there remains uncertainty as to the short- and long-term effects of channel modification on flow dynamics, sediment transport, and habitat forming processes.

M8. Limit the effects of toxic contaminants on salmonid, white sturgeon, Pacific lamprey and Bald Eagle fitness and survival in the Columbia River estuary, lower mainstem, and near-shore ocean.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon, Pacific lamprey, bald eagle.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on salmonids, resident fish, or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	Context
Strategies addressed	S4, S7, S10, S11 and S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and estuary, as well as uncertainty in exposure risks to salmonids, sturgeon and lamprey.

Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

M9. Implement regulatory, control, and education measures to prevent additional species invasions.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon, Pacific lamprey.

Explanation: Hundreds of aquatic non-indigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	S3, S4, S7, S8, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of non-indigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of non-indigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

M10. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon, Pacific lamprey.

Explanation: Intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	S7, S8, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the

Variables	Context
	authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of non-indigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of non-indigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

M11. Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures and the impacts on different life stages of white sturgeon.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon by-catch. The impacts of shad on the lower Columbia River mainstem and estuary ecosystem are unclear but the large shad population biomass has the potential for significant impacts. Elimination or control of shad is not a silver bullet for salmon recovery but the significance of interactions and opportunities for management warrant closer consideration. Additionally, juvenile shad may consume similar food items as juvenile sturgeon, thus introducing some potential level of competition. Conversely, returning adult shad may be a substantial food source for sub-adult and adult white sturgeon.

Variables	Context
Strategies addressed	S7, S8, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing shad management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of

Variables	Context
	shad. There are currently no programs and/or projects focused on evaluating shad effects on sturgeon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

M12. Manage or avoid enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Explanation: Established populations may be managed to shape fishery benefits as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. Walleye fisheries can be managed with size regulations for instance to shape fishery benefits with no effect on salmonids.

Variables	Context
Strategies addressed	S7, S8, S9, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing gamefish management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of gamefish.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

M13. Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikemnnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

Variables	Context
Strategies addressed	S7, S9, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for

Variables	Context
	managing pikeminnow predation on juvenile salmonids. Currently, there are no plans to discontinue the pikeminnow management program.
Potential to contribute to biological objectives	High for stream type salmonids. Low for ocean type salmonids. *Explanation*: Continued management of pikeminnow predation will minimize predation effects on juvenile salmon. Pikeminnow predation on juvenile chum and fall Chinook are thought to be low, thus, pikeminnow management will have minor effects on chum and fall Chinook.
Barriers to success	*Explanation:* The current pikeminnow management program has been successful at removing the large, predaceous pikeminnow from the population, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

M14. Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where salmon predation might pose added risks.

Variables	Context
Strategies addressed	S3, S4, S7, S9, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing Caspian tern predation on juvenile salmonids. Currently, there are no plans to discontinue the Caspian tern relocation program.
Potential to contribute to biological objectives	High for stream type salmonids. Low for ocean type salmonids. *Explanation*: Caspian tern predation in the past has been substantial, thus, continued tern management will minimize predation effects on juvenile salmon. Caspian tern predation on juvenile chum and fall Chinook is thought to be low, thus tern management

Variables	Context
	will have minor effects on chum and fall Chinook.
Barriers to success	*Explanation:* The current Caspian tern relocation program has been successful at relocating the tern colony from Rice to East Sand Island, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

M15. Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead.

Explanation: Only after adoption of the U.S. Marine Mammal Protection Act have seals and sea lions begun to recover from historical low levels. Populations have expanded greatly and significant numbers now occur in the lower Columbia River.

Variables	Context
Strategies addressed	S7,.S9, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* There are currently no programs in place that are intended to quantify the amount and significance of pinniped predation on adult salmonids.
Potential to contribute to biological objectives	*Explanation*: The significance of pinniped predation on adult salmonids is unclear but expected to be somewhat low.
Barriers to success	*Explanation:* Establishing regulatory control of pinnipeds to limit predation on adult salmonids is challenged by pinniped protection under the Marine Mammal Protection Act, however, some level of management is possible if warranted for salmon recovery.

M16. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary and the plume.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon, Pacific lamprey.

Explanation: Our current understanding of causal relationships between salmonids, white sturgeon, Pacific lamprey, other resident fish, and wildlife species is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	S2, S3, S5, S7, S8, S9, S10, S11and S13
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for understanding the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary and the plume in the short term. The primary reason is that these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

M17. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid, white sturgeon, and Pacific lamprey populations.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, White sturgeon, Pacific lamprey.

Explanation: Use of the Columbia River estuary and lower mainstem by ocean- and stream-type salmonids, sturgeon and lamprey is poorly understood. The use of monitoring studies, tagging and other marking studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	S7, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years

Variables	Context
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for understanding salmonid behavior and habitat use in the lower mainstem and estuary in the short term. The primary reason is that these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships. There are currently no programs and/or projects focused on evaluating sturgeon behavior and habitat use. The Pacific lamprey Research and Restoration Project, evaluating lamprey behavior and habitat use is currently inactive.
Potential to contribute to biological objectives	High. *Explanation*: Understanding salmonid life history diversity and mainstem/estuary/plume habitat use will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

M18. Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Applicable species; White sturgeon.

Explanation: Spawning substrate used by white sturgeon varies considerably, although they appear to prefer deepwater, rocky habitats with sufficient interstitial spaces to provide adequate water flow and predator protection during embryonic development. At present, there is limited information as to the available acreage of preferred sturgeon habitat or as to whether acreage of this habitat type is increasing or decreasing. Based on the recent productivity of the white sturgeon population, there is currently no indication that white sturgeon are spawning habitat limited. However, because of our present lack of information regarding the lower Columbia population, an inventory of white sturgeon spawning locations, habitat characteristics and habitat availability would be beneficial.

Variables	Context
Strategies addressed	S1, S2, S3, S4, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* There are currently no known programs and/or projects addressing the physical objective for maintenance of spawning habitats.
Potential to contribute to biological objectives	High. *Explanation*: Current levels of sturgeon spawning habitat appear to be sufficient for maintaining high population productivity, thus, maintenance of existing spawning habitats will maintain current productivity and abundance.
Barriers to success	*Explanation:* There is no indication that spawning habitat acreage is decreasing, thus habitat may be maintained through no action. Although, little is known about sturgeon spawning habitats and locations, and an inventory is necessary.

M19. Evaluate gamefish predation or competition risks to sturgeon and Pacific lamprey; manage or avoid enhancement of introduced gamefish populations that pose significant threats to sturgeon and lamprey.

Applicable species; White sturgeon, Pacific lamprey.

Explanation: The effects of gamefish (such as walleye, smallmouth bass, or channel catfish) on white sturgeon and Pacific lamprey are unknown and need to be evaluated. Juvenile gamefish may compete with juvenile sturgeon for food or habitat. Adult gamefish may prey on juvenile sturgeon and juvenile lamprey. Gamefish may be a prey item of sub-adult or adult sturgeon. These, and other sturgeon/gamefish and lamprey/gamefish relationships, need to be clarified.

Variables	Context
Strategies addressed	S6, S7, S10, and S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating gamefish effects on sturgeon or lamprey.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish

Variables	Context
	management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency. Gamefish/sturgeon interactions are essentially unknown and considerable research is needed to define any relationships.

M20. Identify predators of sturgeon embryos and juveniles, juvenile and adult Pacific lamprey; reduce predation mortality.

Applicable species; White sturgeon, Pacific lamprey.

Explanation: Predators of sturgeon embryos and juveniles and juvenile lamprey in the lower Columbia River are unknown and need to be identified. Elsewhere in the Columbia River, substantial predation on sturgeon embryos has been observed. The potential for predation-related recruitment failure exists. Additionally adult lamprey are considered important food items for sturgeon and pinnepeds, other potential adult lamprey predators need to be evaluated.

Variables	Context
Strategies addressed	S10, S11, and S13
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating predator effects on sturgeon or lamprey.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating predator effects on sturgeon and lamprey are high based on the limited knowledge of current relationships; significant predation can result in recruitment failure.
Barriers to success	*Explanation:* Predator effects on sturgeon and lamprey are unknown and considerable research is needed to define any relationships.

M21. Closely monitor Columbia River fisheries harvest levels to maintain sturgeon spawner abundance and Pacific lamprey population viability.

Applicable species; White sturgeon, Pacific lamprey.

Explanation: Current fishery regulations, particularly size limits, have allowed sturgeon to survive to older ages, thereby maintaining the spawning portion of the population. For Pacific lamprey, current fishery restrictions and level of effort to maintain harvest at relatively low levels. Harvest levels and fishery regulations should be closely monitored to insure that adequate spawning adult abundance is maintained for sturgeon and population viability is maintained for lamprey.

Variables	Context
Strategies addressed	S15
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the objective for managing sturgeon and lamprey fisheries. Current fishery management has been successful and there is currently no reason to believe this will not continue in the future.
Potential to contribute to biological objectives	High. *Explanation*: Fishery management actions have successfully maintained population productivity levels in conjunction with harvest; continued fishery management can maintain current levels of population productivity and abundance.
Barriers to success	*Explanation:* Fishery management efforts have resulted in high sturgeon harvest and angler effort, while maintaining high spawner abundance. Fishery management regulations have resulted in low lamprey harvest while maintaining population viability. Successful fishery management is expected to continue.

M22. Implement mitigation and enhancement measures to provide access to productive spawning and rearing habitat

Applicable species; fall Chinook, coho, winter steelhead, chum

Explanation: Watershed Assessments in the Western Oregon tributaries include in many cases fish passage surveys. Culverts and other passage barriers have been inventoried and prioritized.

Variables	Context

Strategies addressed	Co.S-W7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* While many passage barriers can be address through systematic review of passage barrier inventories, the current programs and/or projects cannot be expected to attain the physical objective for providing additional habitat. The primary reason is uncertainty on the best means for protecting against spreading disease past hatchery wiers.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of providing additional access to potentially productive habitat are significant, however uncertainty remains on the best means of protecting against disease.
Barriers to success	*Explanation:* Hatchery policies that manage the risk of spreading disease; financial means to address barriers in a systematic way

M23. Evaluate and mitigate Bonneville Dam operations that result in direct sturgeon mortality.

Applicable species; White sturgeon.

Explanation: Dewatering of turbines at Bonneville Dam can result in direct sturgeon mortality through entrainment. The degree and significance of this mortality factor needs to be identified. Measures to mitigate impacts resulting from these activities should be identified and implemented.

Variables	Context
Strategies addressed	S16
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* There are currently no known programs and/or projects focused on evaluating Bonneville Dam operations effects on sturgeon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating Bonneville Dam operations effects on sturgeon are high; there is a lack of information regarding current mortality levels.

Variables	Context
Barriers to success	*Explanation:* Sturgeon mortality resulting from Bonneville Dam operations need to be defined; there is limited focused effort to define any relationships.

M24. Modify passage structures at dams to improve juvenile and adult passage efficiency.

Applicable species; Pacific lamprey.

Explanation: Pacific lamprey access to historical spawning and rearing habitats has been limited because of their inability to navigate fish ladders designed for salmonid passage. Additionally, juvenile lamprey do not appear to benefit from juvenile salmonid passage systems. Passage modifications need to proceed with caution; negative effects on salmonid passage need to be prevented.

Variables	Context
Strategies addressed	S17
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	none
Program Gap Analysis	*Analysis:* There are currently no known programs and/or projects focused on improving dam passage for lamprey.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of improving lamprey passage are high, based in their inability to access historical spawning areas.
Barriers to success	*Explanation:* Because of differing swimming abilities of lamprey and salmonids, it may be difficult to improve lamprey passage without affecting salmonids.

M25. Determine olfactory capabilities and site fidelity of returning Pacific lamprey adults.

Applicable species; Pacific lamprey.

Explanation: Homing capabilities and site fidelity of lamprey is poorly understood. Future research can significantly improve our limited understanding and improve management decisions and recovery efforts.

Variables	Context
Strategies addressed	S10, and S17
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The Pacific lamprey Research and Restoration Project evaluated lamprey migration, Other one-time studies have investigated adult lamprey migration capabilities.
Potential to contribute to biological objectives	High. *Explanation*: Understanding lamprey migration will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Lamprey migration capabilities in the lower mainstem, Western Oregon tributaries, estuary, and plume are poorly understood and considerable research is needed to define any relationships. At present, future research effort levels are uncertain.

M26. Rectify difficulties in Pacific lamprey abundance estimates because of repeated up and downstream movement at mainstem counting facilities.

Applicable species; Pacific lamprey.

Explanation: Standard dam counts are not a reliable index of Pacific lamprey abundance and are complicated by repeated up and downstream movement of adult lamprey. Electrofishing and radiotelemetry methods have been evaluated as possible abundance estimation tools. Both methods show promise, but have not yet been refined to a level of replacing historical dam counts. These methods may be used in the development of a correction factor for the historical dam counts that could prove useful in estimating lamprey abundance.

Variables	Context
Strategies addressed	S10
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The Pacific lamprey Research and Restoration Project acknowledged this abundance estimation challenge. Other sampling efforts have attempted to calibrate dam counts.
Potential to contribute to biological objectives	High. *Explanation*: Accurately estimating lamprey

Variables	Context
	abundance will have a high benefit, given our current level of difficulty in estimating lamprey abundance with methods applicable to other fishes.
Barriers to success	*Explanation:* Lamprey abundance is poorly understood and considerable research is needed to establish accurate abundance estimators. At present, future research effort levels are uncertain.

M27. Take action to restore n-type coho to the DIPS of the coastal stratum

Applicable Species: Coho

Explanation: (information on this measure was not available as of the draft publishing date)

Variables	Context
Strategies addressed	S19
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	Lower Columbia River Coho Endangered Species Management Plan
Program Gap Analysis	(information not as of draft publishing date)
Potential to contribute to biological objectives	(information not as of draft publishing date)
Barriers to success	(information not as of draft publishing date)

M28. Maintain preferred spawning, breeding, or nesting habitat of species of ecological interest in the estuary and tidal freshwater portion of the lower Columbia River.

Applicable Species; species of ecological interest.

Explanation: Spawning substrate used by eulachon is characterized by coarse sand substrate. River otter prefer shallow, tidal influenced backwater, slough, and stream habitats. Caspian terns prefer flat, sandy, non-vegetated mid-channel island habitats. Opsrey prefer mature forest habitat with adequate nest/roost trees. Yellow warbler prefer riparian shrub habitat characterized by a dense deciduous shrub layer 1.5-4 m, with edge and with small patch size. Red-eyed vireo prefer forested riparian habitat characterized by tall, closed canopy deciduous forests, with a deciduous understory, forest stand sizes larger than 50 acres, and riparian corridor widths greater than 50 m. At present, there is limited information as to the available acreage of preferred habitats or as to whether acreage of these habitat types is increasing or decreasing. Because of our present lack of information regarding the lower Columbia populations, an inventory of spawning, breeding, or nesting locations, specific habitat characteristics, and habitat availability would be beneficial.

Variables	Context

Strategies addressed	EI.S1, EI.S2, EI.S3, EI.S4, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The existing programs and/or projects cannot be expected to attain the physical objective for maintenance of preferred habitats. The main reason is lack of funds to acquire lands, and land availability.
Potential to contribute to biological objectives	High. *Explanation*: Maintaining preferred spawning, breeding, or nesting habitat will help to maintain current levels of abundance and productivity.
Barriers to success	*Explanation:* Little is known about the trends in preferred habitat acreage or the location of habitats. Inventories are necessary and will require considerable effort.

M29. Evaluate shad predation on juvenile salmonids; minimize salmonid predation mortality.

Applicable Species; species of ecological interest.

Explanation: Recent shad returns have reached record high abundance levels near 4 million fish. Shad can live to be 11 years old and are capable of spawning multiple times. Adult shad in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume may be a substantial predator of juvenile salmonids; this relationship needs to be evaluated and quantified.

Variables	Context
Strategies addressed	EI.S7, EI.S8, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to explain shad predation effects, primarily because the relationships are complex and more focused effort is needed.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating shad predation effects are high; there is currently limited knowledge of shad effects.
Barriers to success	*Explanation:* Shad predation effects are largely unknown and considerable research is needed to define any relationships.

M30. Maintain preferred over-wintering habitat of species of management interest in the estuary and tidal freshwater portion of the lower Columbia River.

Applicable species; species of management interest.

Explanation: Geese and cranes are attracted to open lands with high quality forage and adequate roost sites that provide early detection of predators. Agricultural lands provide these functions and are often preferred by geese and cranes. Habitat assessments indicate that acreage of agricultural lands have substantially increased in the subbasins from historical (1850) to current (1999) conditions. However, there is limited information as to whether this trend in agricultural land availability has continued to the present day. In recent years, the establishment of national wildlife refuges within the subbasins has secured a base level of winter habitat for geese and cranes, however, considerably more winter habitat is needed to increase winter population abundance, particularly in the face of potential losses of agricultural lands to urban development.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The existing programs and/or projects cannot be expected to attain the physical objective for maintenance of preferred habitats. The primary reason is lack of adequate funds to acquire lands, as well as

Variables	Context
	land availability.
Potential to contribute to biological objectives	High. *Explanation*: Protection and maintenance of winter habitat is vital to continued over-wintering of geese and cranes.
Barriers to success	*Explanation:* Floodplain habitat with quality forage and adequate roost sites is limited; availability of floodplain habitat to convert to geese and crane winter habitat is also limited.

M31. Acquire preferred winter habitat of species of management interest in the estuary and tidal freshwater portion of the lower Columbia River, where the primary land use is to provide a wildlife sanctuary.

Applicable species; species of management interest.

Explanation: Geese and cranes are attracted to open lands with high quality forage and adequate roost sites that provide early detection of predators. In recent years, the establishment of national wildlife refuges within the subbasins has secured a base level of winter habitat for geese and cranes, however, considerably more winter habitat is needed to increase winter population abundance, particularly in the face of potential losses of agricultural lands to urban development. Geese and crane winter habitats on public lands are preferred over private lands because the likelihood of disturbance is reduced.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The existing programs and/or projects cannot be expected to attain the physical objective for acquisition of preferred habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Acquisition of quality winter habitat is vital to continued over-wintering of geese and cranes.
Barriers to success	*Explanation:* Floodplain habitat with quality forage and adequate roost sites is limited; availability of floodplain habitat to convert to geese and crane winter habitat is also limited.

M32. Minimize geese and crane use of private lands in the estuary and tidal freshwater portion of the lower Columbia River, with no net loss of winter population abundance.

Applicable species; species of management interest.

Explanation: This measure is inherently linked with measures 1 through 3 and is likely only possible with some success of these previous measures. Geese and cranes are attracted to agricultural lands; this can cause conflicts in land use. Discouragement of geese and crane use of these private lands can eliminate land use conflicts, however, geese and cranes using these private lands need alternate habitats or population abundance may decline. In recent years, the establishment of national wildlife refuges within the subbasins has secured a base level of winter habitat for geese and cranes, however, considerably more winter habitat on public lands is needed to accommodate geese and cranes that formerly used private lands.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S5, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The existing programs and/or projects cannot be expected to attain the physical objective for transferring geese and cranes from private to public lands. The primary reason is that winter habitats on private lands, outweighs that of public lands and there is limited land availability to acquire sufficient public land.
Potential to contribute to biological objectives	High. *Explanation*: Minimizing private land use will minimize crop depredation and geese/crane conflicts with private landowners.
Barriers to success	*Explanation:* Floodplain habitat with quality forage and adequate roost sites is limited; availability of floodplain habitat to convert to geese and crane winter habitat is also limited.

M33. Investigate options to limit crop depredation.

Applicable species; species of management interest.

Explanation: Geese and cranes are attracted to agricultural lands because of the high quality forage and presence of roost sites. Land use conflicts may result, often with substantial economic impacts to local landowners or the region's agricultural industry. Short of excluding geese and cranes from these agricultural lands, practices need to be developed that allow geese and crane use of agricultural lands while minimizing crop depredation and economic losses.

Variables	Context

Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S5, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of limiting crop depredation.
Potential to contribute to biological objectives	High. *Explanation*: Minimizing private land use will minimize crop depredation and geese/crane conflicts with private landowners.
Barriers to success	*Explanation:* At present, it is easier to discourage geese and crane use of private lands when land use conflicts arise than it is to find solutions that allow multiple land uses with minimal conflicts. Considerable effort is needed to manage for both agriculture and geese and crane winter habitat.

M34. Evaluate the potential impacts of species of recreational interest on the Columbia River lower mainstem and estuary ecosystem.

Applicable species; species of recreational interest.

Explanation: Species of recreational interest have capitalized on the creation of favorable reservoir habitats but their abundance remains limited in the free-flowing section of the river below Bonneville Dam. The impacts of species of recreational interest on the lower Columbia River mainstem and estuary ecosystem are unclear and need to be evaluated.

Variables	Context
Strategies addressed	RI.S1, RI.S2, RI.S3, and RI.S4
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to explain species of recreational interest ecosystem effects, primarily because the relationships are complex and more focused effort is needed.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating species of recreational interest ecosystem effects are high because of our current limited knowledge.
Barriers to success	*Explanation:* Species of recreational interest ecosystem effects are largely unknown and considerable research is needed to define any

Variables	Context
	relationships, although the level of future focused research on recreational interest species is unknown.

M35. Evaluate predation or competition risks to native species; minimize predation- or competition-related mortality of native species.

Applicable species; species of recreational interest.

Explanation: Competition or predation effects of species of recreational interest on native fish are unknown and need to be evaluated.

Variables	Context
Strategies addressed	RI.S1, RI.S2, RI.S3, and RI.S4
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25years
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to explain species of recreational interest predation or competition effects, primarily because the relationships are complex and more focused effort is needed.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating species of recreational interest interaction with native species are high because of limited knowledge of current interaction levels.
Barriers to success	*Explanation:* Species of recreational interest interaction with native species are unknown and considerable research is needed to define any relationships, although the level of future focused research on recreational interest species is unknown.

M36. Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Mainstem Lower Columbia River and Columbia River Estuary, and assessing possible outcomes of actions in the planning area.

Applicable species; fall Chinook, spring Chinook, chum, coho, summer steelhead, winter steelhead, sturgeon, Pacific lamprey, species of ecological interest, species of recreational interest.

Explanation: Identifying priority habitat for protection and restoration within the Mainstem Lower Columbia River and Columbia River Estuary should be a priority. The approach should be the development of both a tool and a process that could be used iteratively to

provide an adaptive management framework for resource planners. The challenge will be to develop a tool that reflects the importance of the estuary for species that use it for important but non-productive portions of their life history. In the Columbia basin tributaries, Ecosystem Diagnostic and Treatment (EDT) has provided planners with a quantitative method for determining priorities and for modeling likely outcomes. Such a tool has been difficult to apply to the estuary because many species with use the estuary for critical life stages do not reproduce in the estuary. However, as upstream subbasin assign "out-of-basin" effects to the estuary, it is important to understand how RM&E in the estuary can positively benefit upriver stocks.

Variables	Context
Strategies addressed	PO1,PO3,PO4,PO5,PO7,PO9,
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 4-6
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are insufficient for determining where to target protection and restoration activities, although our understanding of the habitat forming processes and relationships between species and habitat attributes is growing significantly. The Lower Columbia River Estuary Partnership (LCREP) is currently planning a habitat restoration strategy that will address some of these issuess; implementation of this plan will be aided by resolution of key "uncertainties" though the RME plan which identifies key research needed to develop an understanding of how the ecosystem functions. However, a process for projecting likely outcomes and (both in-basin and out-of basin)impacts is still lacking; and research focus tends to be heavily weighted towards salmonids
Potential to contribute to biological objectives	High. *Explanation*: While measures and strategies intended to effect positive change in the Mainstem Lower Columbia River and Columbia River Estuary are becoming clear, knowing where to apply these measures is uncertain. Tools that help target resources will increase all other measures chances of being successful.
Barriers to success	*Explanation:* A key goal of any desktop management goal tool should be to provide a means of predicting outcomes of restoration and protection activities, but standard measures of performance, for example production and abundance, are likely to occur out-of-basin, making expected outcomes difficult to quantify.

M37. Measure: Continue the Select Area Fisheries Project

Applicable species; fall Chinook, spring Chinook, coho, chum, summer steelhead, winter steelhead

Explanation: The project primarily utilizes existing hatchery facilities to spawn, hatch, and conduct initial rearing of juvenile salmonids for subsequent out planting to net pen facilities at each of the select area sites. Hatcheries providing production are South Fork Klaskanine (CEDC); Big Creek, Bonneville, Cascade, Gnat Creek, North Fork Klaskanine, Oxbow, Sandy, South Santiam, and Willamette (all ODFW); Cowlitz, Elochoman, and Gray's River (all WDFW), and Eagle Creek (USFWS).

The Clatsop Count Economic Development Council (CEDC) Fisheries Project operates estuarine net-pen sites in Youngs Bay, Tongue Point, and Blind Slough. The Washington Department of Fish and Wildlife has net-pen sites at Deep River and Steamboat Slough. Fish are grown and released from these pens under varying management and grow-out regimes including two-week acclimation, over-winter, and full term net pen rearing. Annual releases for 2000-2003 have averaged 3.8 million coho, 1.0 million spring Chinook, and 1.0 million select area bright fall Chinook (includes ODFW's Restoration and Enhancement production). Ex-vessel values of 2000-2003 SAFE commercial fisheries were $408,000-$787,000, with state-level personal income impacts of $1.4 - $3.1 million dollars for al l regional fisheries combined.

Variables	Context
Strategies addressed	15
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 4-6 (CEDC Fisheries)
Program Gap Analysis	*Analysis:* The current programs in the mainstem Lower Columbia River and Columbia River Estuary are sufficient for directing harvest of commercial and recreational fishers to targeted stocks of hatchery stocks of summer Chinook, fall Chinook, and Coho
Potential to contribute to biological objectives	High. *Explanation*: The Terminal Fisheries project has been demonstrated to be effectives for addressing the following objectives: Supports a healthy Columbia basin, Maintains biological diversity, Maintains genetic integrity, Increases run sizes or populations As these objectives are addressed by the measure, the wants, needs, and desires of the fishers can be met.
Barriers to success	*Explanation:* Barriers to success are very low, as most of the logistical and technical problems have been addressed. The project has addressed concerns about juvenile interactions, predation, and straying. The major barrier is that the program is not self-

Variables	Context
	sustaining

M38. Measure: Address issues of disease control at hatcheries, where concerns of contamination may prevent opening access to new productive habitat.

Applicable species; fall Chinook, coho, winter steelhead

Explanation: The project primarily utilizes existing hatchery facilities to spawn, hatch, and conduct initial rearing of juvenile salmonids for subsequent out planting to net pen facilities at each of the select area sites. Hatcheries providing production are South Fork Klaskanine (CEDC); Big Creek, Bonneville, Cascade, Gnat Creek, North Fork Klaskanine, Oxbow, Sandy, South Santiam, and Willamette (all ODFW); Cowlitz, Elochoman, and Gray's River (all WDFW), and Eagle Creek (USFWS). The Clatsop Count Economic Development Council (CEDC) Fisheries Project operates estuarine net-pen sites in Youngs Bay, Tongue Point, and Blind Slough.

The Washington Department of Fish and Wildlife has net-pen sites at Deep River and Steamboat Slough. Fish are grown and released from these pens under varying management and grow-out regimes including two-week acclimation, over-winter, and full term net pen rearing. Annual releases for 2000-2003 have averaged 3.8 million coho, 1.0 million spring Chinook, and 1.0 million select area bright fall Chinook (includes ODFW's Restoration and Enhancement production). Ex-vessel values of 2000-2003 SAFE commercial fisheries were $408,000-$787,000, with state-level personal income impacts of $1.4 - $3.1 million dollars for al l regional fisheries combined.

Variables	Context
Strategies addressed	15
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 4-6 (CEDC Fisheries)
Program Gap Analysis	*Analysis:* The current programs in the mainstem Lower Columbia River and Columbia River Estuary are sufficient for directing harvest of commercial and recreational fishers to targeted stocks of hatchery stocks of summer Chinook, fall Chinook, and Coho
Potential to contribute to biological objectives	High. *Explanation*: The Terminal Fisheries project has been demonstrated to be effectives for addressing the following objectives: Supports a healthy Columbia basin, Maintains biological diversity, Maintains genetic integrity, Increases run sizes or populations As these objectives are addressed by the measure, the wants, needs, and desires of the fishers can be met.

Variables	Context
Barriers to success	*Explanation:* Barriers to success are very low, as most of the logistical and technical problems have been addressed. The project has addressed concerns about juvenile interactions, predation, and straying. The major barrier is that the program is not self-sustaining

4.5.2 *Existing Programs as they relate to measures*

Table 4-6: Existing programs and their connection to recovery measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired 916 acres of land.	1, 4, 5, 29, 31, 32
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; collaboration with these efforts is vital. Including Eco Restoration Study, leading to ecosystem restoration projects. Also protected funding with a 35% State/Local match required.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14, 16, 17, 29, 31, 32
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level. (Comprehensive requirements only apply to Clark County, WA).	2, 4, 5, 6, 9, 16, 17, 22, 31, 32
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	4, 5, 6, 16, 22, 29, 31, 32
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	4, 5, 16, 29, 31, 32
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	4, 5, 6, 8, 16, 17, 22, 29, 31, 32
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	4, 6, 16, 22, 29, 31, 32
Stormwater Control Ordinance	The Department of Ecology (DOE) has updated its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	4, 6, 16, 22, 29, 31, 32
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the scenic area and regulates development along wetlands and other water bodies.	4, 5, 6, 16, 22, 29, 31, 32
Water Resource Inventory Areas (Watershed Planning; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect in-stream flows for fish, and provide for the economic well-being of the citizenry and communities. Watershed plan may also address water quality and habitat needs.	2, 3, 4, 6, 16, 22, 29, 31, 32, 34
Washington State Conservation Commission/ Conservation Districts	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information and implement projects.	1, 2, 4, 6, 16, 17, 22, 29, 31, 32

Program Name and Affiliation	Program Description	Measures Addressed
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 2, 4, 5, 6, 7, 8, 11, 16, 17, 22, 29, 31, 32
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 4, 5, 6, 16, 22, 29, 31, 32
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development.	1, 4, 5, 6, 7, 16, 22, 29, 31, 32
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	2, 3, 4, 6, 8, 16, 22, 29, 31, 32
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services during consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and water quality. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 2, 4, 5, 6, 8, 16, 18, 22, 29, 31, 32
WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington. Hydraulic project approvals.	1, 4, 5, 6, 8, 9, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 25, 26, 29, 30, 31, 32, 33, 34, 35, 36

Program Name and Affiliation	Program Description	Measures Addressed
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) and NOAA that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	1, 4, 5, 6, 16, 22, 29, 31, 32
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 2, 4, 5, 6, 8, 16, 17, 22, 29, 31, 32, 33, 34
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	The goal of the SRFB is to protect and restore salmon habitat. The board provides grant funds to protect or restore salmon habitat and assist related activities; it works closely with local watershed groups. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SRFB administers Pacific Coastal Sanctuary funds targeted for salmon recovery activities and projects.	1, 4, 5, 6, 1622, 29, 31, 32
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 1113, 14, 15, 16, 17, 18, 19, 20, 22, 25, 26, 29, 30, 31, 32, 35, 36
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	4, 8, 16, 31, 32
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	1, 4, 5, 6, 16, 22, 31, 32
Partners for Fish and Wildlife Program – USFWS	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote	1, 4, 5, 6, 16, 22, 29, 31, 32

Program Name and Affiliation	Program Description	Measures Addressed
	watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	4, 6, 16, 22, 29, 31, 32
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 1516, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 29, 30, 31, 32, 33, 34, 35 36
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, re-channelization, or any other modification of navigable water of the United States, and applies to all structures.	4, 6, 7, 8, 16, 22, 31, 32
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and sub-aqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	4, 5, 6, 7, 8, 11, 16, 22, 31, 32
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic non-indigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic non-indigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	9, 10, 16, 19
Pikeminnow Management	The goal of the program is to manage annual pikeminnow predation on juvenile salmonids. The program pays rewards to anglers for harvesting	13, 16

Program Name and Affiliation	Program Description	Measures Addressed
Program	pikeminnow over a prescribed size, thus providing an incentive to remove the large, predaceous pikeminnow from the population.	
Caspian Tern Relocation Project	The goal of the project was to relocate terns to another location in the estuary where tern predation on juvenile salmonids would be reduced but the viability of the tern population would be maintained.	14
Caspian Tern Working Group	Task force dedicated to establishing the needs of the Columbia River Caspian tern breeding population while minimizing negative effects on ESA-listed species.	14, 16
Caspian Tern Environmental Impact Statement	The purpose of the EIS is to explore options to reduce the level of tern predation on Columbia River salmonids while insuring the protection and conservation of Caspian terns in the Pacific Coast/Western region (California, Oregon, Washington, Idaho, and Nevada).	14, 16
Pacific Lamprey Research and Restoration Project	Funded in the late 1990s, the project was a cooperative effort of the Confederated Tribes of the Umatilla Indian Reservation, Columbia River Inter-Tribal Fish Commission, and Oregon State University designed to investigate the status and biology of Pacific lamprey in the Columbia River basin.	16, 17, 25, 26
Columbia Basin Pacific Lamprey Technical Work Group	This multi-agency workgroup was established in 1996 at the request of the Northwest Power Planning Council too coordinate lamprey research projects and prioritize lamprey research needs.	1, 7, 8, 9, 10, 13, 16, 17, 19, 20, 21, 24, 25, 26
Radiotelemetry of Adult Pacific Lamprey in LCR	The study evaluated passage of radio-tagged adults above and below Bonneville Dam. Additionally, lab studies were conducted to evaluate upstream movement through simulated fishway structures.	17, 24, 25
Characteristics of Pacific Lamprey Upstream Migration	The study evaluated maturation and physiology of adult lamprey collected at Bonneville Dam.	17, 24
Effects of Swimming and Exhaustive Stress in Pacific Lamprey	The study evaluated swimming performance, metabolic condition, and exhaustive stress to assess efficacy of Bonneville Dam upstream passage facilities.	17, 24
Tagging Techniques for Juvenile Lamprey	The study evaluated juvenile survival and tag retention of visible implant and PIT tags in juvenile Pacific lamprey.	17, 24
Aging Techniques for Juvenile Lamprey	The study compared statolith-based aging techniques among laboratory and wild lamprey samples.	17
Pacific Lamprey Genetic Analysis	The study served as a baseline for genetic data.	17
Lower Columbia River Estuary Partnership; Habitat Restoration Program	In Action 160 of the Reasonable and Prudent Alternative of the FCRPS BiOp, NMFS stated, "The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10, 000 acres of tidal wetlands and other key habitats…Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts..." This program is funding and implementing diverse restoration programs in the estuarine ecosystem as mandated in RPA Action 160. An effort to develop an ecosystem based approach to protecting existing habitat and restoring altered habitat has been initiated by the Estuary Partnership in association with the Columbia River Estuary Study Task	4, 16, 17, 31, 32

Program Name and Affiliation	Program Description	Measures Addressed
	Force (CREST). The outcome of this project will be a coordinated, ecosystem based habitat restoration program focused on increasing the survival of juvenile salmonids and monitoring habitat project success over time. The specific objectives of this project are to: (1) establish a habitat restoration program for the lower Columbia River and estuary (Bonneville Dam to mouth of river), and (2) develop monitoring and evaluation protocols for the lower river and estuarine habitats.	
Lower Columbia River Estuary Partnership; Habitat Monitoring Program	Action 161 of the FCRPS BiOp says, "Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion." This project would logically become part of the monitoring program called for in Action 161. Other closely related monitoring projects in the Columbia River Estuary (CRE) include "Estuarine Habitat and Juvenile Salmon – Current and Historical Linkages" by NOAA Fisheries, "Habitat Monitoring in the Lower Columbia River and Estuary" by the Lower Columbia River Estuary Partnership (BPA 2003-007-00), and "Research, Monitoring, and Evaluation Plan for the Columbia River Estuary and Plume" by the Action Agencies and others. The LCREP's habitat monitoring program involves "status monitoring" as outlined in the Action Agencies RME Plan. Status monitoring is the "measurement of environmental characteristics over an extended period of time to determine status or trends in some aspect of environmental quality." The LCREP's CRE Habitat Monitoring Program is consistent with the RME Plan and, in fact, the CRE may be treated as a pilot monitoring subbasin. The funding from BPA covers a three-year program with annual funding increments. The intent of the funding is to develop and establish a habitat monitoring program that can be initiated in year two, and sustained in year three and after. The three parts with their associated goals are as follows: 1. Population/Habitat Status Monitoring – monitoring for trends in the status of juvenile salmon and conditions in the habitats they use, 2. Ecosystem Status Monitoring – habitat classification using remote sensing, and 3. Invasive Species Monitoring – monitoring abundance and distribution of non-indigenous plants and animals.	4, 16, 17, 31, 32
NOAA Fisheries; Evaluating Cumulative Ecosystem Response To Restoration Projects in the Columbia River Estuary	The goal of this study is to develop standardized techniques and protocols that will facilitate evaluation of the performance of salmon habitat restoration actions and support the decision-making process for actions in the CRE aimed at increasing population levels of listed Columbia Basin salmonids. The management implications of this research are two-fold. It will provide techniques; 1. to obtain data to compare project results in order to support decisions regarding what projects to pursue for restoration of the ecosystem, and 2. to evaluate the ecological performance of the collective habitat restoration effort in the CRE and its effects on listed salmonids. The objectives of this study are to: 1. Develop standard monitoring protocols and methods to prioritize monitoring activities that can be applied to CRE habitat restoration activities for listed salmonids; 2. Develop the empirical basis for a cumulative assessment methodology, together with a set of metrics and a model depicting the cumulative effects of CRE restoration projects on key major ecosystem functions supporting listed salmonids; 3. Design and implement field evaluations of the cumulative effects of restoration projects using standard methods, and sensors or remotely operated technologies, to measure the effects on listed salmonids through ecosystem response; and 4. Develop an adaptive management	4, 16, 17, 31, 32

Program Name and Affiliation	Program Description	Measures Addressed
	system including data management and dissemination to support decisions by the Corps of Engineers and others regarding CRE habitat restoration activities intended to increase population levels of listed salmon.	
Pacific Flyway Council, Guidelines for dusky Canada goose management	The management plan for the Dusky Canada goose was developed by USFWS, ODFW, WDFW, OSU, and Pacific Flyway representatives. This group developed harvest, nest survey, management and research tasks with the goal of improving the declining dusky population. If these tasks are funded, then the population of dusky geese will reach a level where special protection is not needed. Funding has been limited recently and many projects are not being implemented as planned.	4, 16, 17, 31, 32, 33
Pacific Flyway Council, NW Oregon/SW Washington Canada goose agricultural depredation control plan	This plan is a list of strategies and tasks to reduce the agricultural depredation committed by geese on private property. The plan was developed by WDFW, ODFW, USFWS, APHIS-WS, OSU, and the Oregon and Washington Farm Bureaus. The funding for this plan is inconsistent and recent reductions have caused landowners to potentially suffer more crop damage. Assistance from agencies to landowners has also declined by lack of funding.	4, 16, 17, 31, 32, 33, 34
Wildlife Area Plan for Vancouver Shillapoo Lake Wildlife Areas	This plan outlines land management practices that will enhance goose habitat and provide a secure resting area for wintering geese. The plan was written by the Wildlife Area manager for WDFW with involvement of a Citizens Advisory Group and review by other biologists. Funding has limited implementation of all the appropriate land practices that could enhance goose habitat and improve population status.	4, 16, 17, 31, 32, 33
USFS , Nest Searches on Copper River Delta	Nest searches are conducted every other year on the Copper River Delta to monitor population trends in the breeding grounds. The effort is coordinated by the USFS at Cordova, Alaska, and assistance is provided by ODFW, WDFW, ADFG, DU and other interested volunteers. Data is used to evaluate harvest quotas and harvest management.	16, 17
ADFG, Banding Operations on dusky Canada geese	Dusky Canada Geese are leg banded and neck collared on a biannual basis. The project is designed to provide data for estimates of the wintering population in Oregon and Washington. The project is coordinated by ADFG and participants include WDFW, USFS, and ODFW. Funding is needed to purchase collars and charter a helicopter to conduct the capture.	16, 17
Agricultural Waterfowl Incentive Program	The program is designed to enhance waterfowl habitat by providing seeds, tubers, graze and invertebrates. In 1998, 49 landowners participated to create 38, 949 ac (15, 769 ha) of waterfowl habitat, a 75% increase from the proceeding year. Enrolled landowners were predominantly rice producers in the northern Central Valley, with only one elsewhere. Much of this flooding is in addition to the 60, 021 ac (24, 300 ha) already being flooded before the program was initiated.	16, 17
Western Oregon Stream Restoration Program.	The WOSRP provides technical assistance to watershed councils, landowners, and conservation groups to apply for grants & permits, design and implement in-stream habitat, fish passage and riparian restoration	1, 4, 5, 6, 22
Riparian Lands Tax Incentive Program	The Riparian Tax Incentive Program offers a property tax incentive to property owners for improving or maintaining qualifying riparian lands. Under this program, property owners receive complete property tax exemption for their riparian property	1, 4, 5, 22, 29, 31
Landowner Incentive Program-	The LIP program provides technical assistance and funds from USFWS to landowner who undertakes voluntary restoration efforts.	1, 4, 5, 22, 29, 31
ODFW Hatchery & Genetic	The Hatchery & Genetic Management plan address operation and impact of hatcheries on native fish population for ODFW hatcheries with measures to	9, 10, 22

Program Name and Affiliation	Program Description	Measures Addressed
Management Plan	.	
Lower Columbia Coho Recovery Plan	This plan address the recovery of lower Columbia river in Oregon tributaries from the mouth to Bonneville Dam.	1, 4, 5, 22
Native Fish Conservation Policy	Native Fish Conservation Policy is designed to prevent the serious depletion of any native fish species by protecting natural ecological communities, conserving genetic resources, managing consumptive and nonconsumptive fisheries, and using hatcheries responsibly so that naturally produced native fish are sustainable.	9, 10
Restoration and Enhancement Program	A comprehensive program to restore state-owned fish hatcheries, enhance natural fish production, expand hatchery production, and provide additional public access to fishing waters.	9, 10, 22
Salmon Trout Enhancement Program	STEP is a volunteer based program within ODFW that seeks to rehabilitate and enhance the populations, habitat, and fisheries of native salmon and trout managed by ODFW through the involvement and education of citizens.	4, 5, 22
Fish Screening and Passage Grant Program	A technical assistance and cost-share funding opportunity through the U.S. Fish and Wildife Service and the Oregon Department of Fish and Wildlife for voluntary fish screening and passage projects associated with water diversions	9, 10, 22
Natural Resources Information Management Program	The Natural Resources Information Management Program is a participant within the regional StreamNet Project, a cooperative venture of federal and state agencies and tribes in the Pacific Northwest to provide information for fish and wildlife planners .	1, 4, 5, 29, 31, 37
Oregon Watershed Ehancement Board (OWEB)	OWEB provides grants to support the capacity of citizen groups to assess watershed health conditions, then to plan, prepare, and undertake successful restoration projects.	1, 4, 5, 22, 29, 31, 32, 33, 37
Oregon Department of Environmental Quality (DEQ)	Oregon Department of Environmental Quality submitted 14 measures as part of the legislatively approved Oregon Plan in 1997, most of which apply in the Mainstem Lower Columbia River and Columbia River Estuary subbasin. Programs include Coastal non-point pollution control; Implementation of Water Quality Standards; Develop and Implement 303(d) List for TMDL Development; Watershed Council Support; Revise Water Quality Standard for Sediment; Implement Antidegradation Water Quality Standard; Apply for Instream Water Rights on TMDL Streams; Review and Revise Water Quality Standards During Triennial Review Process	7, 8, 9
Lower Columbia River Estuary Partnership (LCREP)	LCREP participates in the Oregon Plan through development of a Comprehensive Conservation and Management Plan to serve as the strategic plan for the Lower Columbia River Estuary Partnership. It guides all program activities and annual work tasks for the Partnership. Developing and implementing a Comprehensive Conservation and Management Plan is the primary task of a National Estuary Program.	1, 4, 5, 8, 29, 31, 32, 33, 37
Oregon Department of Land Conservation and Development	The Department of Land Conservation and Development's salmon restoration measures are specifically designed to increase the importance of water quality and aquatic habitat as factors in local land use decisions. In time, DLCD's measures will result in a framework for local land use decisions that differs from the framework which prevailed throughout the decades when salmon populations fluctuated, but steadily declined.	1, 4, 5, 6, 8, 29, 31, 32, 33
Oregon Water	The mission of the Water Resources Division is to serve the public by	1, 2, 3, 6

Program Name and Affiliation	Program Description	Measures Addressed
Resources Department	practicing and promoting wise long-term water management. Its primary work that is of interest to the LCREP involves protecting and restoring streamflows and watersheds, safety of dam construction activities, and appropriation of water rights.	
Oregon Department of Agriculture	The Oregon Legislature has taken steps to establish the Oregon Department of Agriculture (ODA) as the lead state agency working with agriculture to address nonpoint source pollution. Senate Bill 1010, passed in the 1993 legislative session, provided the Department of Agriculture with the authority to develop, implement and enforce agricultural water quality management programs where required by state or federal law. In 1995, the Legislature passed SB 502, which gave the Department of Agriculture exclusive authority to develop any program or rules that directly regulate farming practices for the purposes of protecting water quality.	6, 8, 29, 31, 32, 33
Oregon Economic Development Department	The Economic Development Department has two main type of responsibilities in the implementation of the Coastal Salmon Recovery Initiative. One is to use OEDD's traditional role as a coordinator and funder of projects in communities throughout the state to initiate and facilitate projects which will improve coho recovery. The second is to ensure that projects funded with OEDD lottery funds do not have an adverse impact on coho or coho recovery.	22, 31, 38
Oregon Department of Forestry	The Department of Forestry strives to serve the people of Oregon through the protection, management, and promotion of a healthy forest environment which will enhance Oregon's livability and economy for today and tomorrow. The Department has three areas of concentration that are important to the Lower Columbia River Estuary: forest practices, forest assistance, and protection from fire. Through these three programs, the agency maintains forest productivity, water quality, and fish and wildlife habitat.	5, 6, 29, 31, 32, 33

4.6 Endangered Species Act and Clean Water Act Considerations

This section briefly describes the subbasin plan's Endangered Species Act and Clean Water Act considerations. This subbbasin planning effort overlaps broadly with recovery efforts in the region. The Co-lead for the plan, the Lower Columbia Fish Recovery Board (LCFRB), approached its contributions to the plan with recovery in mind. Similarly, federal action agencies represented on the planning committee expressed their desire to ensure that the subbasin plan represented a step toward recovery planning.

4.6.1 *Endangered Species Act*

The Mainstem Columbia River and Columbia River Estuary Subbasin contains several species listed as threatened or endangered under the Endangered Species Act (ESA). 16 U.S.C. §§ 1531-44. The ESA is a powerful tool in the recovery of endangered species; The ESA commands all federal agencies to "conserve" listed species, and "conservation" is defined very broadly. 16 U.S.C. § 1532(3). Section 9, 16 U.S.C. § 1538, prohibits "taking" by anyone, and that too is broadly defined. 16 U.S.C. § 1532(19). Enforcement of the ESA is delegated to the secretaries of Commerce and Interior, however, the Act specifically allows any person to commence a civil lawsuit on his own behalf in federal district court for violations of the ESA or regulations issued under the authority of the ESA. The prevailing party may be awarded costs of litigation including reasonable attorney and expert witness fees (16 U.S.C. § 1540 (g)(4)).

The following sections of the Endangered Species Act are instrumental in governing recovery efforts in the subbasin

Section 7

Section 7 of the Endangered Species Act [16 U.S.C. 1531 et seq.] outlines the procedures for federal interagency cooperation to conserve federally listed species and designated critical habitats.

Proactive Conservation Efforts by Federal Agencies

Section 7(a)(1) directs the Secretary (Secretary of the Interior/Secretary of Commerce) to review other programs administered by them and utilize such programs to further the purposes of the ESA. It also directs all other federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of species listed pursuant to the ESA.

This section of the ESA makes it clear that all Federal agencies should participate in the recovery of listed stocks. Under this provision, federal agencies often enter into partnerships and memoranda of understanding with the Fish and Wildife Service (FWS) or NOAA Fisheries for implementing and funding conservation agreements, management plans, and recovery plans developed for listed species. The services encourage the development of these types of partnerships and planning efforts to develop proactive approaches to listed species management.

Avoiding Adverse Effects of Federal Actions

Section 7(a)(2) states that each federal agency shall, in consultation with the secretary, insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. In fulfilling these requirements, each agency must use the best scientific and commercial data available. This section of the ESA defines the consultation process. which is further developed in regulations promulgated at 50 CFR §402.

Section l0(a)(l)(B) permits (Conservation Plans)

Permits for incidental take under section 10(a)(l)(B) require a FWS or NOAA Fisheries intra-service consultation. These consultations are conducted in the same manner as under section 7 except that the incidental take statement is governed by section 10(a)(1)(B) to the extent that mitigation, including off-site compensation not directed at the affected individuals, may be considered. The services have developed a handbook for Habitat Conservation Planning and Incidental Take Permit Processing (November 1996), which should be referenced to for further information.

The National Marine Fisheries Service (NOAA Fisheries) listed lower Columbia Chinook, upper Columbia Chinook, Columbia Chum, lower Columbia steelhead and upper Columbia steelhead as threatened in March 1999. Within the mainstem Lower Columbia River and Columbia River estuary, only fall Chinook and chum are mainstem spawners. However in the Western Oregon tributaries, Chinook, chum, and steelhead are present. Coho are a candidate species for listing, and is the subject of recovery planning in the Western Oregon tributaries.

On September 29, 2003, the National Marine Fisheries Service (NMFS) published in the Federal Register an Advanced Notice of Proposed Rulemaking (ANPR) regarding future critical habitat designations for 20 evolutionarily significant units of salmon and steelhead listed under the U.S. Endangered Species Act (ESA) in Washington, Oregon, Idaho, and California As described in a recent court-approved schedule, NMFS intends to publish proposed designations in 2004 followed by final designations in 2005.

(http://www.nwr.noaa.gov/1salmon/salmesa/crithab/anprpg92903.htm).

The US Fish and Wildlife Service and NOAA Fisheries are developing recovery plans for species listed under the ESA. Actions called for in the Mainstem Columbia River and Columbia River Estuary Subbasin Plan should be coordinated, consistent and integrated with these recovery plans and the performance measures of the Federal Columbia River Power System Biological Opinion (FCRPS BiOp, NMFS 2000). The FCRPS BiOp requires certain federal actions to be taken within specific time frames in order to continue to operate the power system without jeopardizing the existence and recovery of listed salmonids.

The Mainstem Columbia River and Columbia River Estuary Planning Group recognizes that NOAA Fisheries intends to use subbasin plans as key building blocks for recovery of Snake River salmon and steelhead species listed as threatened or endangered under the ESA. NOAA Fisheries staff participated on the Planning Group and provided population identification information from the technical recovery team (TRT) for the Western Oregon tributaries; this information was a key component in developing the subarea assessment and associated working hypotheses.

The Willamette/Lower Columbia Technical Recovery Team (TRT) has been tasked by NOAA Fisheries to develop a series of products in support of effective recovery planning. Those products include defining populations within each of the listed ESUs, providing the

region with delisting criteria applicable to the specific populations identified within each ESU, and criteria for use at the ESU level. In addition, the TRT is charged with summarizing key information regarding fish/habitat relationships within a particular ESU and developing a limiting factor/factors driving the decline report. It is envisioned that the TRT will work in coordination with regional technical teams engaged in implementing or refining subbasin planning efforts on the latter tasks.

Table 4-7 Estimated number of populations in different strata in the Willamette/Lower Columbia domain (TRT, 2003, Meyers et. al. 2002)

ESU	Ecological Zone	Run Timing	Historical Populations
Lower Columbia Chinook	Coast Range	Fall	7
	Cascade	Fall	9
		Late Fall	2
		Spring	7
	Columbia Gorge	Fall	4
		Spring	2
Lower Columbia steelhead	Cascade	Summer	4
		Winter	14
	Columbia Gorge	Summer	2
		Winter	3
Columbia chum	Coast Range	Fall	7
	Cascade	Fall	7
	Columbia Gorge	Fall	2
Upper Willamette Chinook	Willamette	Spring	7
Upper Willamette steelhead	Willamette	Winter	4
Total			81

The TRT products and efforts should help in the synthesis of information regarding the relationship between salmon and steelhead viability and the specific factors limiting their productivity in the mainstem Columbia River and Columbia River estuary. This syntheses will help provide a foundation for addressing priority problems in a manner that meets ESA recovery and FCRPS biological opinion needs.

4.6.2 *Clean Water Act*

4.6.2.1 Western Oregon tributaries

In Oregon, state water quality standards have been established and approved by the U.S. Environmental Protection Agency (EPA). These standards, required under the Clean Water Act, are designed to protect, restore and preserve water quality in waterbodies that have designated beneficial uses such as drinking water, contact recreation (e.g. fishing and swimming) cold or warm water aquatic life (salmonids). “Designated uses” have been identified for most, but not

all, water bodies within Oregon. Each use has narrative and/or numeric standards that describe the level of water quality necessary to support the use.

When a lake, river or stream fails to meet the water quality criteria that support its "designated uses", specific actions are required under state and federal law to ensure that the "impaired" waterbody is restored to a healthy, fishable and swimmable condition. In the Western Oregon Tributary portion of the Mainstem Columbia River and Columbia River Estuary Subbasin, 27 sections of rivers and streams encompassing 166.5 stream miles have been identified as impaired. These rivers and streams are part of the Oregon 1998 Clean Water Act §303(d) list. The U.S. Environmental Protection Agency approved DEQ's 2002 303(d) list on March 24, 2003. Additionally, the lower Columbia River, including the estuary, is listed (see 4.6.2.2 below).

The state of Oregon and the EPA have a legal, court-ordered responsibility to ensure that these impaired waters be dealt with in a timely manner. This means that a Total Maximum Daily Load (TMDL) must be written for each impaired waterbody. The TMDL is a quantitative assessment of water quality problems and contributing pollutant sources. It specifies the amount of pollution reduction necessary to meet water quality standards, allocates the necessary pollutant limits among the contributing sources in the watershed, and provides a basis for taking actions needed to restore the waterbody. The Oregon Department of Environmental Quality (DEQ) is responsible for preparing the TMDLs for the Western Oregon tributaries. TMDLs may be set for the following:.

- Aquatic Weeds Or Algae
- Biological Criteria
- Chromium (hex)
- Copper
- Dissolved Oxygen
- Fecal Coliform
- Iron
- Manganese
- Temperature
- Zinc

The Oregon Department of Environmental Quality has a TMDL for fecal chloroform bacteria that impacts North Coast Watersheds. In particular, the Clatskanie River is now operating under a TMDL, approved by the EPA in 2003.

Future project implementation actions to address problems identified by the TMDL process may coincide with aquatic and terrestrial species and habitat implementation actions. Although, because water quality actions are usually implemented first where waterbodies are most impaired, and habitat protection and restoration actions often begin where conditions and populations are healthiest, coincidental implementation may not always occur. Project implementation will be coordinated where water quality and aquatic concerns coincide.

Table 4-8: EPA approved 2002 Oregon §303d list for Western Oregon tributaries

Subbasin	Waterbody Name	River Mile	Parameter	Season	List Date	Listing Status
Lower Columbia-Youngs	Bear Creek	2.5 to 9	Temperature	Summer	2002	303(d) List
Lower Columbia-Youngs	Bear Creek	2.5 to 9	Temperature	September 15 - May 31	2002	303(d) List
Lower Columbia-Youngs	Cullaby Lake/Cullaby Lake	0 to 1.6	Aquatic Weeds Or Algae	Summer	1998	303(d) List
Lower Columbia-Youngs	Gnat Creek	0 to 9.8	Temperature	September 15 - May 31	2002	303(d) List
Lower Columbia-Youngs	Klaskanine River	0 to 2.7	Dissolved Oxygen	Spring/Summer	1998	303(d) List
Lower Columbia-Youngs	Klaskanine River	0 to 2.7	Dissolved Oxygen	Year Around	2002	303(d) List
Lower Columbia-Youngs	Lewis And Clark River	0 to 10.8	Dissolved Oxygen	June 1 - September 14	2002	303(d) List
Lower Columbia-Youngs	Lewis And Clark River	8.6 to 10.8	Temperature	Summer	2002	303(d) List
Lower Columbia-Youngs	Skipanon River	0 to 6.1	Dissolved Oxygen	Spring/Summer	1998	303(d) List
Lower Columbia-Youngs	Skipanon River	0 to 2	Dissolved Oxygen	Year Around	2002	303(d) List
Lower Columbia-Youngs	Smith Lake	0 to 0	Aquatic Weeds Or Algae	Summer	1998	303(d) List
Lower Columbia-Youngs	Unnamed Creek	0 to 0	Chromium (hex)	Year Around	2002	303(d) List
Lower Columbia-Youngs	Unnamed Creek	0 to 0	Copper	Year Around	2002	303(d) List
Lower Columbia-Youngs	Unnamed Creek	0 to 0	Zinc	Year Around	2002	303(d) List
Lower Columbia-Youngs	Unnamed Creek	0 to 3.2	Iron	Year Around	2002	303(d) List
Lower Columbia-Youngs	Unnamed Creek	0 to 3.2	Manganese	Year Around	2002	303(d) List
Lower Columbia-Youngs	Youngs River	9 to 23.2	Temperature	Summer	2002	303(d) List
Lower Columbia – Clatskanie	Beaver Creek	0 to 14	Temperature	Summer	2002	303(d) List
Lower Columbia – Clatskanie	Clatskanie River	0 to 1.9	Dissolved Oxygen	Winter/Spring/Fall	2002	303(d) List
Lower Columbia – Clatskanie	Clatskanie River	0 to 1.9	Temperature	Summer	2002	303(d) List
Lower Columbia – Clatskanie	Clatskanie River	1.9 to 25.5	Temperature	Summer	2002	303(d) List

Subbasin	Waterbody Name	River Mile	Parameter	Season	List Date	Listing Status
Lower Columbia – Clatskanie	Clatskanie River	1.9 to 25.5	Temperature	September 15 - May 31	2002	303(d) List
Lower Columbia – Clatskanie	Clatskanie River	0 to 1.9	Fecal Coliform	Summer	1998	TMDL
Lower Columbia – Clatskanie	Clatskanie River	0 to 1.9	Dissolved Oxygen	Spring/Summer	1998	303(d) List
Lower Columbia – Clatskanie	Little Clatskanie River	0 to 6.2	Temperature	Summer	2002	303(d) List
Lower Columbia – Clatskanie	South Fork Goble Creek	0 to 3.9	Biological Criteria		1998	303(d) List
Lower Columbia – Clatskanie	Tide Creek	0 to 16.1	Temperature	September 15 - May 31	2002	303(d) List

4.6.2.2 Mainstem Lower Columbia River and Columbia River Estuary

The Oregon 1998 §303(d) list identifies the following the most common pollutants impacting the Mainstem Columbia River and Columbia River Estuary subbasin from the mouth of the Columbia to Bonneville Dam (See Table 4-6):

- Bacteria
- Dissolved Oxygen (DO)
- Temperature
- Total Dissolved Gas
- Toxics
- pH
- Temperature

Of these pollutants, Total Maximum Daily Loads (TMDLs) have been issued only for addressing total dissolved gas (TDG) in the mainstem Columbia River from its confluence with the Snake River to its mouth at the Pacific Ocean. The states of Oregon and Washington have both listed multiple reaches of the Lower Columbia River on their federal Clean Water Act 303(d) lists, due to TDG levels exceeding state water quality standards. Oregon and Washington jointly issued this TMDL.

State and federal agencies have been working on a draft TMDL, covering temperature on the lower Columbia. The release of the Draft Columbia/Snake Mainstem Temperature TMDL has been delayed to allow necessary discussions and information exchange. EPA will post a release date on this website in sometime in 2004.

Table 4-9: 2002 updates to 1998 Oregon §303d list for Mainstem Lower Columbia River and Columbia River Estuary

Description	Parameter	Criteria	Season	Supporting Data or Information	Change From 1994/96	TMDL Status
Mouth to Tenasillahe Island	Bacteria	Marine and shellfish growing area (fecal coliform)	Fall-Winter-Spring	WA DOE Data: Greater than 10% of the samples exceeded estuarine fecal coliform standard (43) near Ilwaco, WA (Hallock and Ehinger, 1993); Combined Sewer Overflows are present in Astoria; Listed for Fecal Coliform on WA DOE 303(d) list.	No Change	
Mouth to Tenasillahe Island	Dissolved Oxygen (DO)	Cold-water aquatic life: DO < 8 mg/l or 90% sat.	Summer	Bi-state Data - Task 6: Reconnaissance Report (Tetra Tech, 1993).	No Change	
Mouth to Tenasillahe Island	Temperature		Summer	USGS Data (3 Sites): Temperature standard (68) is exceeded 10%/75%/10% at Bradwood; 25%/75%/10% at Kalama; and 25%/75%/25% at Warrendale for the July/Aug/Sep values with maximums of 72.1, 73.8, 72.0 respectively based on daily mean values between 1969-92.	No Change	Draft TMDL
Mouth to Tenasillahe Island	Total Dissolved Gas		Year Around	1993 Dissolved Gas Monitoring for the Columbia and Snake Rivers (US Army Corp of Engineers, 1993), Fuhrer et al (USGS, 1995).	No Change	
Mouth to Tenasillahe Island	Toxics	Tissue - PCB		Levels of PCBs found in some fish (carp, peamouth, sucker) exceed health criteria, OR/WA Health Depts have issued recommendations regarding fish consumption for particular groups (WSDH/OHD, 96); reduced bald eagle reproduction in LCR noted (USFWS, 96). 6	No Change	

Description	Parameter	Criteria	Season	Supporting Data or Information	Change From 1994/96	TMDL Status
Mouth to Tenasillahe Island	Toxics	Tissue - Pesticides (DDE, DDT)		Levels of DDE/DDT found in some fish (carp, peamouth, sucker) exceed health criteria, OR/WA Health Depts have issued recommendations regarding fish consumption for particular groups (WSDH/OHD, 96); reduced bald eagle reproduction in LCR noted (USFWS, 96).	No Change	
Mouth to Tenasillahe Island	Toxics	Arsenic (Water)	Year Around	USGS date from 4 sites (Warrendale, Hayden Island, Columbia and Beaver): 14 of 16 samples exceeded Water Quality Standard for Arsenic, Table 20. Values where 1ug/l.	Additio n	
Tenasillahe Island to Willamette River	Bacteria	Water Contact Recreatio n (fecal coliform-96 Std)	Fall-Winter-Spring	WA DOE Data: Greater than 10% of the samples exceeded fecal coliform standard (400) near Sauvie Island (Hallock and Ehinger, 1993); Combined Sewer Overflows are present in Portland; Listed for Fecal Coliform on WA DOE 303(d) list.	No Change	
Tenasillahe Island to Willamette River	Dissolved Oxygen (DO)	Cold-water aquatic life: DO < 8 mg/l or 90% sat.	Summer	Bi-state Data - Task 6: Reconnaissance Report (Tetra Tech, 1993).	No Change	TMDL
Tenasillahe Island to Willamette River	pH		Spring	DEQ Data (Site 402293; RM 102.5): 42% (3 of 7) Spring values exceed pH standard (6.5 - 8.5) with a maximum of 8.6 between 91-95; USGS Data: 2 of 17 values exceeded standard in April/May in 1994 (USGS, 1996).	No Change	

Description	Parameter	Criteria	Season	Supporting Data or Information	Change From 1994/96	TMDL Status
Tenasillahe Island to Willamette River	Temperature		Summer	USGS Data (3 Sites): Temperature standard (68) is exceeded 10%/75%/10% at Bradwood; 25%/75%/10% at Kalama; and 25%/75%/25% at Warrendale for the July/Aug/Sep values with maximums of 72.1, 73.8, 72.0 respectively based on daily mean values between 1969-92.	No Change	Draft TMDL
Tenasillahe Island to Willamette River	Total Dissolved Gas		Year Around	1993 Dissolved Gas Monitoring for the Columbia and Snake Rivers (US Army Corp of Engineers, 1993), Fuhrer et al (USGS, 1995).	No Change	TMDL
Tenasillahe Island to Willamette River	Toxics	Arsenic (Water)	Year Around	USGS date from 4 sites (Warrendale, Hayden Island, Columbia and Beaver): 14 of 16 samples exceeded Water Quality Standard for Arsenic, Table 20. Values where 1ug/l.	Additio n	
Tenasillahe Island to Willamette River	Toxics	Tissue - Pesticides (DDE, DDT)		Levels of DDE/DDT found in some fish (carp, peamouth, sucker) exceed health criteria, OR/WA Health Depts have issued recommendations regarding fish consumption for particular groups (WSDH/OHD, 96); reduced bald eagle reproduction in LCR noted (USFWS, 96).	No Change	
Tenasillahe Island to Willamette River	Toxics	Tissue - PCB		Levels of PCBs found in some fish (carp, peamouth, sucker) exceed health criteria, OR/WA Health Depts have issued recommendations regarding fish consumption for particular groups (WSDH/OHD, 96); reduced bald eagle reproduction in LCR noted (USFWS, 96).	No Change	

Description	Parameter	Criteria	Season	Supporting Data or Information	Change From 1994/96	TMDL Status
Willamette River to Bonneville Dam	pH		Spring	DEQ Data (Site 402293; RM 102.5): 42% (3 of 7) Spring values exceed pH standard (6.5 - 8.5) with a maximum of 8.6 between 91-95; USGS Data: 2 of 17 values exceeded standard in April/May in 1994 (USGS, 1996).	No Change	
Willamette River to Bonneville Dam	Temperature		Summer	USGS Data (3 Sites): Temperature standard (68) is exceeded 10%/75%/10% at Bradwood; 25%/75%/10% at Kalama; and 25%/75%/25% at Warrendale for the July/Aug/Sep values with maximums of 72.1, 73.8, 72.0 respectively based on daily mean values between 1969-92.	No Change	Draft TMDL
Willamette River to Bonneville Dam	Total Dissolved Gas		Year Around	1993 Dissolved Gas Monitoring for the Columbia and Snake Rivers (US Army Corp of Engineers, 1993), Fuhrer et al (USGS, 1995).	No Change	TMDL
Willamette River to Bonneville Dam	Toxics	Tissue - PCB		Levels of PCBs found in some fish (carp, peamouth, sucker) exceed health criteria, OR/WA Health Depts have issued recommendations regarding fish consumption for particular groups (WSDH/OHD, 96); reduced bald eagle reproduction in LCR noted (USFWS, 96).	No Change	
Willamette River to Bonneville Dam	Toxics	Arsenic (Water)	Year Around	USGS date from 4 sites (Warrendale, Hayden Island, Columbia and Beaver): 14 of 16 samples exceeded Water Quality Standard for Arsenic, Table 20. Values where 1ug/l.	Additio n	

Description	Parameter	Criteria	Season	Supporting Data or Information	Change From 1994/96	TMDL Status
Willamette River to Bonneville Dam	Toxics	Tissue - Pesticides (DDE, DDT)		Levels of DDE/DDT found in some fish (carp, peamouth, sucker) exceed health criteria, OR/WA Health Depts have issued recommendations regarding fish consumption for particular groups (WSDH/OHD, 96); reduced bald eagle reproduction in LCR noted (USFWS, 96).	No Change	

4.7 Artificial Production

Artificial production is one of many tools for meeting fish recovery objectives and other strategies as may be periodically identified by resource planners. The need for artificial production programs, and their effectiveness, must be evaluated as objectives evolve. Artificial production should be used in a manner consistent to the evolving Mainstem Lower Columbia River and Columbia River Estuary subbasin plan and must be consistent with an ecologically based scientific foundation for fish recovery so that fish can be raised for harvest while minimizing the impact on, or benefiting, fish that spawn naturally.

Providing direction on how to integration hatchery programs with the Mainstem Lower Columbia River and Columbia River Estuary subbasin strategies is beyond the scope of this plan. Managers and Co-managers of artificial production programs are well on their way towards integrating hatchery genetic management plans (HGMPs), required by the federal BiOp for the benefit of ESA listed species, and the Artificial Production Review & Evaluation (APREs) reports. Such plans will need to first meet *U.S. v Oregon* production goals, and be consistent with Endangered Species Act (ESA) requirements. The APRE reports are, however, useful for benchmarking hatchery programs against subbasin goals, and provides a starting point for the eventual alignment of these programs with the subbasin plans.

Table 4-10 provides a brief overview of hatchery programs impacting the lower Columbia ESU, and outlines areas where these programs may intersect with basin-wide working hypotheses and impact the proposed Mainstem Lower Columbia River and Columbia River Estuary subbasin plan strategies, including those for the Western Oregon tributaries.

It should be noted that the Mainstem Lower Columbia River and Columbia River Estuary is impacted by a cumulative effect of hatchery policies throughout the Columbia Basin, and thus a rigorous analysis of the impacts of artificial production policies on the Mainstem Lower Columbia River and Columbia River Estuary would be a significant undertaking. With respect to the impacts of artificial production programs in the subbasin, the following observations are offered:

- Efforts to re-establish and support a late run coho in the coastal stratum would require significant coordination with local hatcheries

- Interactions between juvenile salmonids in the estuary (working hypothesis E.H10) remains an unknown; understanding capacity of the estuary to support the rearing of naturally spawned and artificially produced salmonids is a priority.

- Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined that projects to mitigate for lack of fishing in the lower Columbia river through Select Area Fishing (SAFE) does not likely jeopardize the continued existence of listed salmonid stocks.
- The impact of hatchery facilities on potentially productive upstream habitat in the Western Oregon tributaries is an area that needs to be explored

Table 4-10. Review of artificial prodcution facilities and thier relation to subbasin planning in the Mainstem Lower Columbia and Columbia River Estruary subbasin, including the Western Oregon tributaries

Hatchery/Program	Type	Purpose	Comments on Relation to Subbasin Planning	Subbasin working hypotheses significant to operation of facility	
Sea Resources Integrated Chum	Integrated	Conservation, recovery, and research as mitigation for hydropower and habitat impacts		E.H4 E.H6 E.H8 E.H11	
Big Creek Hatchery Coho	Segregated	Harvest mitigation for hydropower and habitat impacts	Passage around hatchery and mitigation of disease risk signficant to "barriers" strategies	E.H4 E.H6 E.H8 E.H11	W.H5 W.H2
CEDC Sandy River Hatchery Coho	Segregated	Harvest mitigation for hydropower and habitat impacts; mitigation for lack of fishing in columbia	Contributes to sustainable fisheries strategy; Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.	E.H4 E.H6 E.H8 E.H11	W.H2
SAFE Tanner Creek Hatchery Coho	Segregated	Harvest mitigation for hydropower and habitat impacts; mitigation for lack of fishing in columbia	Contributes to sustainable fisheries strategy; Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks Significant to "barriers" strategy	E.H4 E.H6 E.H8 E.H11	W.H5 W.H2
Steamboat Slough Hatchery Coho	Segregated	Harvest mitigation for hydropower and habitat impacts		E.H4 E.H6 E.H8 E.H11	

Hatchery/Program	Type	Purpose	Comments on Relation to Subbasin Planning	Subbasin working hypotheses significant to operation of facility	
Sea Resources Integrated Early Coho	Integrated	Conservation/recovery mitigation for habitat loss		E.H4 E.H6 E.H8 E.H11	
Rogue CEDC Hatchery Fall Chinook	Segregated	Harvest mitigation for hydropower and habitat impacts; mitigation for lack of fishing in columbia	Contributes to sustainable fisheries strategy; Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.	E.H4 E.H6 E.H8 E.H11	
Sea Resources Integrated Fall Chinook	Segregated	Harvest mitigation for hydropower and habitat impacts		E.H4 E.H6 E.H8 E.H11	
Big Creek Integrated Fall Chinook Tule	Segregated	Harvest mitigation for hydropower and habitat impacts	Passage around hatchery and mitigation of disease risk signficant to "barriers" strategies	E.H4 E.H6 E.H8 E.H11	W.H5
Grays Deep River Coho	Segregated	Harvest mitigation for hydropower and habitat impacts		E.H4 E.H6 E.H8 E.H11	
Grays Deep River Spring Chinook	Segregated	Harvest mitigation for hydropower mpacts		E.H4 E.H6 E.H8 E.H11	
FFA Late Coho	Segregated	Harvest mitigation for impacts other than harvest and hydropower	Contributes to life-history diversity strategy	E.H4 E.H6 E.H8 E.H11	W.H5 W.H2

Hatchery/Program	Type	Purpose	Comments on Relation to Subbasin Planning	Subbasin working hypotheses significant to operation of facility	
CEDC SAFE Willamette Hatchery Spring Chinook	Segregated	Harvest mitigation for hydropower and habitat impacts; mitigation for lack of fishing in columbia	Contributes to sustainable fisheries strategy; Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.	E.H4 E.H6 E.H8 E.H11	
CEDC South Santiam Hatchery Spring Chinook	Segregated	Harvest mitigation for hydropower and habitat impacts; mitigation for lack of fishing in columbia	Contributes to sustainable fisheries strategy; Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.	E.H4 E.H6 E.H8 E.H11	
Big Creek Hatchery Winter Steelhead	Segregated	Harvest mitigation for hydropower and habitat impacts	Passage around hatchery and mitigation of disease risk signficant to "barriers" strategies	E.H4 E.H6 E.H8 E.H11	

Research, Monitoring, and Evaluation

A robust and adaptive monitoring, research, and evaluation (RME) framework will be critical for weighing progress towards desired future conditions and for making appropriate course adjustments along the way. The Planning Group recognizes that in the Mainstem Lower Columbia River and Columbia River Estuary and Western Oregon tributaries, RME efforts from a variety of entities will be responding to an array of court mandated or Northwest Power Planning Act inspired management plans and recovery plans. The RME efforts discussed here with respect to Mainstem Lower Columbia River and Columbia River Estuary subbasin planning are therefore an effort to acknowledge these complimentary efforts which are continually evolving.

Additional RME efforts specifically developed specifically to implement this subbasin plan are included with the LCFRB's Lower Columbia Salmon and Steelhead Recovery and Subbasin Plan, Management Plan, Volume 1, Chapter 8. It is expected that existing RME efforts can be utilized to assist planners in evaluating progress towards achieving the desired future conditions for the subbasin, as articulated in the Mainstem Lower Columbia River and Columbia River Estuary subbasin plan. The remainder of this section then, summarizes existing RME efforts, and identifies potential ties and applicability to this subbasin plan.

The RME objectives in the following sections and a review of research-related strategies from section 4.4 highlight several common research tasks that must be continued or pursued in order to achieve the desired future conditions of the subbasin; these research needs include:

- For the estuary and mainstem development of diagnostics tool that will enable resource planners to effectively prioritize restoration and protection priorities. Such a tool should be able to predict outcomes of management actions for both resident fish species (salmonids that produce in the Mainstem Lower Columbia River and Columbia River Estuary) and for upriver stock that use the estuary for part of their life history
- Map, quantify, and compare the pre-twentieth century and current aquatic habitats of the estuary. The historic condition of the estuary provides an important template for restoration planning. It indicates where habitats used to occur, their natural, size, shape, community composition, and connectedness to other elements of the ecosystem. How much of various habitat types were present, where were they located, how were they organized/arranged, and their geomorphology are all important considerations. Fulfilling this goal will allow us to understand how the estuary aquatic habitats have changed and use data on previous presumably productive habitat conditions to guide the project selection process. This goal is currently included in LCREP's proposed habitat restoration program.
- Establish goals, objectives, and scientific principles for restoration in the estuary. This goal provides a scientific basis for restoration using the best available research data in the context of the mission and specific program objectives Efforts are underway to identify locations where carefully targeted restoration activities should occur. These will be selected based on a high confidence in ecological benefits and success, and where there is a high likelihood that they the restoration will further enhance our understanding about how to restore the estuary. Sequencing and prioritizing actions will depend upon the results of earlier efforts. This goal is currently included in LCREP's proposed habitat restoration program.

- Establish a program infrastructure including a framework for soliciting, developing, selecting, and funding priority restoration projects. This goal is currently included in LCREP's proposed habitat restoration program.
- Establish habitat monitoring program. Monitoring is a critical component of ecosystem recovery planning. Monitoring designs are intended to provide high quality data on the restoration of the Estuary, including how it works, how it responds to changes (our actions), and how well we are able to predict what we think is going to happen. Monitoring activities include specific projects designed to gather project-specific data, efforts to assess restoration progress on a regional scale, and projects to continue the collection of long-term trend information for species, habitats, and hydrologic data. Monitoring is intended to provide information that is integrated into an adaptive management process. This goal is currently included in LCREP's proposed habitat restoration program.

4.7.1 *Estuary workshop*

The Lower Columbia Estuary Partnership (LCREP) hosted a workshop on March 24 and 25, 2003 in Portland Oregon at the World Trade Center to discuss research status and needs for the Columbia River Estuary (CRE) (R2 Consultants, 2003). The objectives of the workshop included:

- Review the basis for USACE involvement in the CRE;
- Review past and ongoing research being conducted in the CRE;
- Identify data gaps and key research needs for future studies; and
- Prioritize as much as possible those research needs.

A large number of themes were discussed at the workshop, including: Developing a conceptual framework for ecosystem restoration in the CRE; Monitoring and selecting meaningful metrics and parameters; Identifying and prioritizing habitat creation and restoration options; Endpoint (target) definition; Mining under-used, older data; Information access and integration; Comparing historic vs. present habitat conditions; Hydrodynamic model data collection; Sediment transport and fate; Hydrograph changes; Linking physical processes with biological systems; Salmonid abundance, habitat use, migration, and timing; Stock identification, hatchery influences and phenotypic expression; Wetlands function; Nutrients, detritus, and primary productivity; Food web dynamics; Tributary conditions and opportunities for off-site mitigation; Toxic contaminants and geochemistry; Invasive species; Risks associated with restoring 10, 000 acres in the CRE; and other miscellaneous topics. The workshop partially informed the development of a federal RME effort, currently in draft form, for the Columbia River Estuary & Plume in response to the 2000 Biological Opinion (BiOp) on operation of the Federal Columbia River Power System (FCRPS)

Additionally, LCREP is developing, as part of its Comprehensive Conservation Management Plan an Aquatic Ecosystem Monitoring Strategy (Monitoring Strategy), details how to build on existing monitoring programs to provide a structure for coordinated monitoring of the lower Columbia River. It represents an important strategy in establishing a cooperative, long-term approach to understanding the complex ecosystem of the Columbia River. The basic components of the Monitoring Strategy include: coordinating and overseeing the program, developing a data management system, monitoring for and assessing the impacts of

conventional pollutants and toxic contaminants, measuring and assessing habitat health, measuring primary productivity, developing an understanding of food web relationships, and evaluating the impacts of exotic species.

4.7.2 *Draft Research, Monitoring, and Evaluation Plan, Federal Columbia River Power System (FCRPS)*

Bonneville Power Administration, the U.S. Army Corps of Engineers, and Pacific Northwest National Laboratories are in the process of preparing, for NOAA Fisheries, a Research, Monitoring and Evaluation Plan for Listed Salmon of the Columbia River Estuary and Plume (Johnson, G. et al, 2004). The plan, currently in draft form, will form the basis of much of the RME work in the Mainstem Lower Columbia River and Columbia River Estuary that will be necessary to follow-up on the strategies identified in the Mainstem Lower Columbia River and Columbia River Estuary subbasin plan.

The research, monitoring, and evaluation (RME) program for the Columbia River estuary and plume (CRE&P) is part of the federal RME effort developed in response to the 2000 Biological Opinion (BiOp) on operation of the Federal Columbia River Power System (FCRPS).

The overall NOAA Fisheries/Action Agency goal for the Columbia River estuary is to protect and restore the Columbia River estuary ecosystem to increase life history diversity, spatial distribution, and survival of juvenile listed salmonids. The goal of estuary/plume RME (EP-RME) is threefold: 1) Status Monitoring -- quantify the status and trends in listed salmon usage and survival in the CRE&P; 2) Action Effectiveness -- quantify the effects of the habitat restoration actions on listed salmon in the CRE&P; and 3) Uncertainties -- resolve uncertainties related to salmon recovery actions in the CRE&P. Action effectiveness research in the CRE&P focuses on habitat restoration, as does the uncertainties research. The EP-RME plan addresses the objectives identified in See Table 4-6. Possible connections to the Mainstem Lower Columbia River and Columbia River estuary subbasin effort have been identified.

Table 4-11: Summary of draft objectives from federal RME effort (Johnson, G.E. et al 2004)

1. Category	2. Designation	3. Description	4. Relates to Working Hypotheses	5. Relates to Strategies
6. Status Monitoring Objectives	7. SM 1.	8. Describe the present status of the CRE&P ecosystem in terms of habitat inventory, connectivity, and fauna relative to pre-European settlement conditions.	9. E.H1, E.H2, E.H3	10. S23
	11. SM 2	12. Determine the role of the CRE&P relative to tributary, hydrosystem, and oceanic habitats in the recovery of listed salmon ESUs by monitoring spatial distribution, life history diversity, and growth of juvenile salmon in the CRE&P.	13. E.H1, EH4, E.H7, E.H8, E.H10, E.H11, E.H12	14. S19, S7
	15. SM 3.	16. Estimate the survival rates of juvenile salmon of listed ESUs during the applicable migrations through the tidal-freshwater reach (RM 46-146), the estuarine reach (RM-0-46), and the plume.	17. E, H9, E.H10, E.H11	18. S23
	19. SM 4.	20. Determine the water quality in CRE&P salmon spawning and rearing habitat relative to state and federal water quality standards.	21. E.H2, W.H7	22. S12
	23. SM 5.	24. Describe trends in the physical condition of CRE&P salmon spawning and rearing habitat in terms of substrate type, accretion rates, re-dox potential, ground water level, large woody debris, water velocity and water surface elevation compared to present conditions.	25. E.H1, E.H2, E.H3, E.H4, E.H7, E.H8, E.H9, E.H12	26. S23, S5, S2
	27. SM 6.	28. Determine the status and trends of abundance, species composition, and distribution of invasive species in the CRE&P, such as purple loosestrife, shad, and zebra mussels.	29. E.H2, E.H5, EH10,	30. S8, S13, S22
	31. SM 7.	32. Provide annual summaries of the status and trends of hydrographic and oceanic conditions affecting salmon survival within the CRE&P and salmon population size for Columbia River ESUs.	33.	34.
35. Action Effectiveness Research Objectives	36. AER1	37. (a) Determine if individual restoration projects in the CRE&P, as implemented, meet the project-specific performance goals. (b) Determine if the projects collectively meet program goals.	38. E.H12	39. S23, S20, S1, S3, S5, S6, S11, S18
	40. AER2	41. Determine whether individual restoration projects in the CRE&P are effectively changing relevant structural or functional parameters relative to reference and/or control sites.	42. E.H12	43. S23, S20, S1, S3, S5, S6, S11, S18

1. Category	2. Designation	3. Description	4. Relates to Working Hypotheses	5. Relates to Strategies
	44. AER3	45. Determine the extent to which habitat restoration projects in the CRE&P, collectively, are affecting targeted ecosystem processes that support listed salmon. Determine the cumulative effect of habitat restoration on juvenile salmon survival in the CRE&P.	46. E.H1, E.H12, EH8, EH11, E.H12, EH7	47. S23, S20, S1, S3, S5, S6, S11, S18
48. Uncertainties Research Objectives	49. UR1	50. Determine the significance of the CRE&P to listed salmon ESUs.	51. E.H1, E.H2, EH4, E.H6, E.H7, E.H8, E.H10, E.H11, E.H12	52. S19, S7, S23
	53. UR2	54. Identify changes that could be made to FCRPS operations that would improve habitat conditions in the CRE&P.	55. E.H2, E.H9	56. S16, S2, S1, S6
	57. UR3	58. Determine the highest priority habitat types for restoration in the CRE.	59. E.H2.E.H4, , EH8, E.H9, E.H12	60. S1, S5, S6, S18, S23
	61. UR4	62. Assess whether the offsite mitigation program involving habitat restoration in the CRE is working.	63.	64.

4.8 References

ISAB (Independent Scientific Advisory Board). 2000. ISAB Artificial production review report 3: recommendations for the design of hatchery monitoring programs and the organization of data systems. Northwest Power and Conservation Council. ISAB 200-4.

ISAB (Independent Scientific Advisory Board). 2003. A review of strategies for recovering tributary habitat. Northwest Power and Conservation Council. ISAB 2003-2.

Johnson et al. 2003 estuary M&E plan

Miller, M., J. North, P. Frazier, T. Jones, A. Dietrichs, and T. Miethe. 2002. Select Area Fishery Evaluation Project. 1997-2000 Annual Completion Report for Project #199206000 prepared for the Bonneville Power Administration, Portland, Oregon. 94 pp.

NMFS Biological opinion

NMFS (National Marine Fisheries Service). 1998. Endangered Species Act – Section 7 consultation biological opinion. Impacts of select area fisheries enhancement project (SAFE) on salmon and steelhead species in the Columbia River Basin listed under the Endangered Species Act. NMFS, Northwest Region, Seattle, WA. 15pp.

NMFS (National Marine Fisheries Service). 2003a. Endangered Species Act (ESA) Section 7 consultation – Supplemental Biological Opinion.

2001 U.S. v. Oregon "Interim management agreement for upriver spring Chinook, summer Chinook, and sockeye on salmon and steelhead listed under the Endangered Species Act", covering winter, spring, summer season treaty and ono-indian Columbia River Basin fisheries for 2003-2005. Consultation Number F/NWR/2003/00357. Issued July 11, 2003. NMFS, Northwest Region, Seattle, WA. 21 pp.

NMFS (National Marine Fisheries Service). 2003b. Biological Opinion on impacts of treaty indian and non-indian fall season fisheries in the Columbia River Basin in year 2003, on salmon and steelhead listed under the Endangered Species Act. Consultation Number F/NWR/2003/00865. Issued July 30, 2003. NMFS, Northwest Region, Seattle, WA. 70 pp.

NOAA (National Oceanic and Atmospheric Administration). 2003. Draft research, monitoring, and evaluation plan for NOAA-Fisheries 2000 Federal Columbia River Power System Biological Opinion. Jordan, C., J. Geiselman, M. Newsom, and J. Athearn, editors. Seattle.

Northwest Planning and Conservation Council (NPCC), 2001 . Technical Guide for Subbasin Planners. Council Document 2001-20

PNAMP (Pacific Northwest Aquatic Monitoring Partnership). 2004. Consideration for monitoring in subbasin plans. Prepared for Northwest Power and Conservation Council.

R2 Resource Consultants, Inc. (R2). 2003. 2003 Lower Columbia River and estuary research needs identification workshop proceedings. Prepared for U.S. Army Corps of Engineers, Portland District, Oregon.

SRFB (Salmon Recovery Funding Board). 2002. Comprehensive Monitoring Strategy and Action Plan for Watershed Health and Salmon Recovery. Washington.

UCRTT (Upper Columbia Regional Technical Team). 2004. Monitoring strategy for the upper Columbia Basin. Report by BioAnalysts to Upper Columbia Salmon Recovery Board.

Willamette/Lower Columbia Technical Recovery Team (TRT). 2003. Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids. http://research.nwfsc.noaa.gov/trt/viability_report.htm

Willamette/Lower Columbia Technical Recovery Team (TRT). 2004. Memorandum to NOAA Fisheries, Oregon Department of Fish & Wildlife, and Willamette Restoration Initiative: Population Evaluation for Oregon State Tributary Population of Lower Columbia River and Upper Willamette River Chinook Salmon, Chum Salmon, Coho Salmon, and Steelhead

Johnson, G.E., H.L. Diefenderfer, T. Berquam, B.D. Ebberts and J.D. Wilcox. 2004. Research, Monitoring, and Evaluation Plan for Listed Salmon of the Columbia River Estuary and Plume. Draft report prepared by Bonneville Power Administration, U.S. Army Corps of Engineers, and Pacific Northwest National Laboratory for NOAA Fisheries, March 18, 2004.

5. MANAGEMENT PLAN SUPPLEMENTARY MATERIAL

5.1 Overview

Because the Mainstem Lower Columbia River and Columbia River Estuary are considered "out-of-basin" effect for most upstream users, the Planning Group directed that the plan should recognize the needs of stocks that use the estuary for only part of their life history. In setting out the goals of the Mainstem Lower Columbia River and Columbia River Estuary subbasin plan, the Planning Group identified a large number of aquatic and terrestrial species that were to should be addressed in this plan. Consequently, a large amount of material was generated for all salmonid stocks using the estuary; it was recognized that building a management plan around all of this information would require a significant amount of condensing and summarizing. In an effort to keep the policy considerations as focused as possible, the "species specific" information was organized into this "Management Plan Supplement." This supplement has species-specific limiting factors, working hypotheses, threats identification, physical objectives, strategies and measures. In otherwords, this chapter contains the more precise logical progression from assessment through the identification of physical objectives and, ultimately, strategies that are presented in Chapter 4.

Focal species selection followed the NPCC's *Technical Guide for Subbasin Planners* (NPCC 2001). The *Technical Guide* indicates that the assessment of focal species serves two functions:

- It provides insight on the status of species that warrant legal consideration because of Endangered Species Act (ESA) or treaty right considerations; and
- It serves a diagnostic function, with certain species used as an indicator of broad ecological health.

Further, focal species are used to evaluate the effectiveness of management actions and the health of the ecosystem. The *Technical Guide* offers four criteria for selecting focal species (in order of importance):

- Designation as Federal endangered or threatened species;
- Ecological significance;
- Cultural significance; and
- Local significance.

Within the Lower Columbia and Estuary subbasins, identification and selection of species has been a thoughtful and deliberative facet of the subbasin planning process. Early in 2001, the Lower Columbia Fish Recovery Board (LCFRB), together with the Washington Department of Fish and Wildlife, considered an initial set of 21 species for the 11 subbasins on the Washington State side of the Lower Columbia Region, including the mainstem and estuary. In 2003, the Lower Columbia River Estuary Program (LCREP; now called the Lower Columbia River Estuary Partnership) entered into an agreement with Oregon to participate with the LCFRB in the co-development of a subbasin plan for the Columbia Estuary and Lower Columbia Subbasins. The Planning Group was formed to guide this effort. The Planning Group added three additional species not contemplated by the LCFRB (river otter, osprey, and bald eagle) Table 5-1

depicts the selection of species for the estuary/mainstem subbasin assessment and their relationship to selection criteria.

Table 5-1. Species Selection and Planning Context.

Species	ESA	Ecological[1]	Cultural	Economic[2]	Recreation[3]
Species of Primary Interest (Focal Species)					
Fall Chinook	X	X	X	X	X
Chum	X	X	X	X	X
Spring Chinook	X	X	X	X	X
Winter Steelhead	X	X	X	X	X
Summer Steelhead	X	X	X	X	X
Coho	X	X	X	X	X
Pacific Lamprey	X	X	X		
Bald Eagle	X	X	X		
CWT Deer	X	X[4]	X		
Green Sturgeon		X	X		
White Sturgeon		X	X	X	X
Species of Ecological Significance					
N. Pikeminnow		X		X[8]	X
Shad		X[7]		X	X
River Otter		X[9]			
Eulachon		X	X	X	X
Caspian Tern		X[6]		X	
Osprey		X			
Yellow Warbler		X[10]			
Red-eyed Vireo		X[10]			
Species of Management Interest					
Dusky Canada Goose				X[5]	
Sandhill Crane	X			X[5]	
Species of Recreational Significance					
Walleye		X[7]			X
Smallmouth Bass		X[7]			X
Channel Catfish		X[7]			X

1 May be positive or negative ecological impact; this column only indicates relative significance.

2 May be positive or negative economic impact; this column only indicates relative significance.

3Active recreation potential (e.g., harvest).

4 Likely historically ecologically important.

5 Seasonal crop damage.

6 Historically not present in estuary.

7 Non-native species.

8 Some economic importance for control program.

9 Indicator of ecosystem health.

10 Indicator of habitat type.

In the species selection process, it became evident that individual species were important to the subbasin planning process for different purposes and significance at the subbasin- and Columbia River Basin-scale. Some species, like summer steelhead, have basin-wide significance in terms of their legal, ecological, cultural, economic, and recreational significance. Other

species are of interest because of their value as an indicator of ecosystem health. Still others, like yellow warblers, are indicators of a specific habitat type.

The Planning Group decided to organize the list of species into broad categories that help convey the purpose and significance that individual species play in the planning process. All species will be addressed in the management plan and will have biological objectives and strategies developed for them, although the structure of the biological objectives and strategies may take different form due to inherent differences in their significance, ecological interactions, information available, and management structures in place.

Species of Primary Interest (Focal Species): This category of species will receive the highest level of attention and are considered the focal species for purposes of developing a subbasin plan that adheres to the standards of the Council. The ocean-type and stream-type salmonids play a major role in structure and content of the subbasin assessment because of their importance to all of the selection criteria, the absence of management plans in the estuary/mainstem, and the far-reaching implications of their life cycle requirements to various landscape-level processes and habitat conditions within and outside of the subbasins. Well developed recovery or management plans exist for bald eagle, CWT deer, pacific lamprey, and the green/white sturgeon. The plans augment this assessment and provide the basis for developing biological objectives and strategies for these species. The subbasin management plan will address the integration of the various species-specific management plans into a balanced approach for all focal species.

Species of Ecological Interest: This category of species is intended to inform subbasin planners of the general health of the estuary/mainstem in terms of quality of the environment, habitat diversity, or management issues. Each of these species will be addressed in the management plan. Native species include: Northern Pikeminnow, River Otter, eulachon, Caspian terns, Osprey, yellow warbler, and red-eyed vireo; non-native species include shad.

Species of Management Interest: This category of species is important from a management perspective and is indicative of a habitat type that is not represented elsewhere in the planning process (e.g. agricultural lands). Species include the Dusky Canada Goose and the Sandhill Crane (federally listed).

Species of Recreational Interest: This category of non-native species has recreational interest in the estuary/mainstem, as well as poorly understood ecological interactions with salmonids. They include walleye, smallmouth bass, and channel catfish.

Detailed descriptions of the biology and life history of each species are found elsewhere in the Technical Foundation (Appendix A). The following sections are intended to briefly describe the life history of each focal species as it relates to potential use of lower Columbia River mainstem and estuary habitats.

5.1.1 *A Brief Review of Organization*

5.1.1.1 Limiting factors

In an attempt to rank limiting factors, a subjective evaluation was conducted based on what is known or suspected regarding the present status of each species in relation to historical conditions. Throughout this document, the qualitative terms of "High," "Medium" and "Low" have been used to provide a relative level of importance for the limiting factors identified for each species. It is important to note that, because of the subjective nature of this evaluation, no two scientists will likely qualify each limiting factor in precisely the same manner. The purpose of the evaluation is to identify the most important limiting factors for each species. Thus, actions intended to improve those limiting factors are expected to have the greatest benefit for the species population. In the context of species-specific limiting factors, the qualitative terms are defined as:

- High – The factor currently limits population viability because of effects on mortality rates or productivity. The limiting factor is of primary importance in maintaining current levels of population abundance/productivity *or* the limiting factor must be addressed to promote recovery of the species.
- Medium – The factor currently effects population viability, but at present impact levels, may not be significantly reducing population abundance or productivity. The limiting factor does effect current levels of population abundance/productivity or recovery of the species, however, addressing this factor will have less impact on overall population viability than the high impact factors.
- Low – The factor exists, but unlikely effects population viability at present impact levels. The limiting factor should be recognized but will unlikely produce measurable effects on population viability until the high and medium limiting factors have improved.

The level of impact of each limiting factor is further qualified based on the current level of certainty in the impact designation. Thus, the qualitative terms of "High," "Medium" and "Low" are again used and, in the context of certainty, are defined as:

- High – Considerable research has been performed on the subject and has repeatedly produced similar results.
- Medium – Considerable research has been performed on the subject and results have been inconclusive or contradictory *or* some research has been performed on the subject and preliminary results suggest a relationship exists.
- Low – Some research has been performed on the subject and preliminary results are inconclusive or contradictory *or* little to no research has been performed on the subject and any relationships are assumed based on other related scientific data or relationships.

5.1.1.2 Biological and Physical Objectives

In an attempt to rank physical objectives, a subjective evaluation was conducted based on what is known or suspected regarding the present status of each species and the level to which the physical objective would address an important limiting factor. Throughout this document, the qualitative terms of "High," "Medium" and "Low" have been used to provide a relative benefit

of each identified physical objective. As with the limiting factors, these are qualitative judgements. The purpose of the evaluation is to identify those physical objectives that address the most important limiting factors for each species; thus, achieving these physical objectives are expected to have the greatest benefit for the species population. In the context of species-specific physical objectives, these terms are defined as:

- High – The physical objective addresses a limiting factor that currently limits population viability because of effects on mortality rates or productivity. Achieving the physical objective is of primary importance in maintaining current levels of population abundance/productivity or in promoting recovery of the species.
- Medium – The physical objective addresses a limiting factor that currently effects population viability, but at present impact levels, may not be significantly reducing population abundance or productivity. Achieving this physical objective will have less impact on overall population viability than the high benefit objectives.
- Low – The physical objective addresses a limiting factor that exists, but unlikely effects population viability at present impact levels. Achieving the physical objective will unlikely produce measurable effects on population viability until the high and medium benefit physical objectives are implemented.

The physical objectives benefit level is further qualified based on the current level of certainty that the objective will address limiting factors. The qualitative terms of “High,” “Medium” and “Low” are defined similarly to the certainty terms applied to the limiting factors.

5.2 Focals

5.2.1 *Aquatic Focal*

5.2.1.1.1 Chum Salmon

.5.2.1.1.1.1 Background

Chum salmon (Oncorhynchus keta) return during fall (generally October/November) to spawn in the lowermost reaches of the Columbia River tributaries often just above tidewater. Chum fry migrate downstream almost immediately after emergence and spend most of their life in the estuary or ocean. Runs of one to two million chum are believed to have once returned to the Columbia River. The total minimum chum return to the Columbia River in 2002 was estimated to be 19,914 fish, based on Washington tributary and lower Columbia mainstem spawning surveys (19,403), commercial fishery incidental catch (14), hatchery escapement (309), and the Bonneville Dam count (188). All naturally produced chum populations in the Columbia River and its tributaries in Oregon and Washington were listed as threatened in August 1999

.5.2.1.1.1.2 Status

Chum salmon once migrated in the Columbia River as far upstream as the Walla Walla River. Today, production is generally limited to areas downstream of Bonneville Dam, including Grays River, Hardy Creek, Hamilton Creek, and in the mainstem Columbia River near Ives Island. The latter three populations are located near Bonneville Dam. Chum salmon populations exist in other river systems of the lower Columbia, but have not been consistently monitored and abundances are assumed to be extremely low. The Willamette/Lower Columbia Technical Recovery Team has identified 16 historical populations of chum salmon in the Columbia River ESU. Of these, eight occur only in Washington, six occur only in Oregon, and two are shared between the states. The 16 populations include the Grays/Chinook, Elochoman/Skamokawa, Youngs Bay, Mill/Germany/Abernathy, Big Creek, Clatskanie, Scappoose, Lower Cowlitz, Kalama, Lewis, Salmon Creek, Washougal, Sandy, Clackamas, lower Gorge, and upper Gorge. Chum populations have been largely extirpated for 14 of 16 historic populations, although 2002 spawner survey data indicate that small remnant populations may exist throughout the lower Columbia. Significant populations remain in Grays River and the lower Gorge.

Table 5-2. Chum salmon abundance estimates by life stage.

Life Stage	Historical Abundance	Current Abundance
Juvenile Rearing (in-basin & out-of-basin tributary populations)	Historical productivity of chum salmon was likely very high. Assuming a productivity of 900 smolts per spawner (based on Grays River EDT template estimate), an undocumented estimate of juveniles using the lower mainstem, Western Oregon tributaries, estuary, and plume is 1.26 billion	Current productivity of chum salmon is assumed to be 165 smolts per spawner (lower Gorge EDT patient estimate). Based on this level of productivity, juveniles using the lower mainstem, Western Oregon tributaries, estuary, and plume is estimated to be 3.3 million
Adult Migration (in-basin & out-of-basin tributary populations)	Historical run size up to 1.4 million with distribution to the Walla Walla River	Total run size estimates approximately 20,000 in 2002
Adult Spawning (in-basin only)	A large percentage of the estimated 1.4 million adults in the Columbia River Basin likely spawned in the lower mainstem, estuary or lower Columbia River tributaries. Estimate 80% of 1.4 million or 1.12 million adults	2002 mainstem spawning estimates range from 4,671 to 7,929
		Ives Island estimate: 3,179-4,232 (Jolly-Seber estimate using seining or carcass tagging) or 3,209 (area under the curve method using spawner surveys)
		Multnomah Falls estimate: 228-1,282 (Jolly-Seber estimate using seining or carcass tagging) or 1,150 (area under the curve method using spawner surveys)
		I-205 estimate: 211-3,468 (Jolly-Seber estimate using seining or carcass tagging) or 628 (area under the curve method using spawner surveys)
		Anectodal evidence of chum spawning in the Western Oregon tributaries, including the Youngs bay and the Clatskanie river

.5.2.1.1.1.3 Value statement

Lower Columbia River chum are currently listed as threatened under the Endangered Species Act; additionally, chum salmon are culturally, economically, and ecologically important. Juvenile rearing in the estuary and adult spawning in the mainstem are vital life history trajectories for chum salmon. Because chum salmon pass hydroelectric facilities with poor efficiency, it is likely that restoration efforts of chum will achieve the highest success in the lower Columbia mainstem, the estuary, and the various tributaries below Bonneville Dam. Therefore, strategies and measures to return selected historic chum populations in these areas to viability are among the highest levels of importance. The restoration goal for lower Columbia

chum salmon is to increase the population to a self-sustaining, viable population that can provide for tribal, sport, and commercial fishery harvest.

.5.2.1.1.1.4 Limiting factors

Chum salmon in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume have threats to all three life histories expressed in the combined subbasins and adjacent tributaries. Historically, chum populations existed as far upstream as the Walla Walla River. The development of upstream hydroelectric facilities was detrimental to these upstream populations primarily because of the chum's inability to migrate through fish ladders and inundated habitats. Downstream of Bonneville dam, chum salmon have been impacted by low flows, disconnected or lost habitats, and predation losses. The period of estuarine residence appears to be a critical phase in the life history of chum salmon and may play a major role in determining the size of the subsequent adult run back to fresh water.

Table 5-3. Chum salmon limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Juvenile Rearing (within and out-of-subbasin populations)	Ch.LF.1 Availability of preferred habitat (i.e. shallow water, low velocity, peripheral habitats). Chum salmon are closely associated with peripheral habitats. There has been extensive loss of peripheral wetland and side channel habitat throughout the mainstem and estuary, and in the Western Oregon tributaries (WOTs) as a result of water regulation, dike construction, and urban and agricultural development.	High/High
	Ch.LF.2 Microdetritus-based food web. The current microdetritus-based food web is expected to be less productive than the historical macrodetritus-based food web. Loss of wetland and side channel habitat identified above has reduced the local macrodetritus inputs from terrestrial and riparian habitats that supported the historical food web. Present detrital inputs to the food web are dominated by microdetritus from upriver sources and are controlled primarily by reservoir production and flow rates from Bonneville Dam. Further, the microdetritus-based food web is thought to be less available to chum salmon because it is pelagic in nature and may be focused on the spatially-confined estuary turbidity maximum region.	High/Medium
	Ch.LF.3 Loss of habitat connectivity. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids. As juveniles grow, they move across a spectrum of salinities, depths, and water velocities. For species like chum salmon that rear in the estuary and in tidally influenced areas of the Western Oregon tributaries for extended time periods, a broad range of habitat types in the proper proximities to one another may be necessary to satisfy feeding and refuge requirements within each salinity zone.	High/High

Life Stage	Limiting Factors	Impact/Certainty
	Ch.LF.4 Predation mortality. Current levels of predation on chum salmon are unknown but are expected to be lower than other salmonids, potentially as a result of lower abundance, smaller size, or spatial segregation from predators. For example, Caspian tern predation is higher for larger emigrating salmonids, such as steelhead. Also, because chum salmon spawn downstream of Bonneville Dam, emigrating chum do not encounter the known concentration of northern pikeminnow just below Bonneville Dam.	Low/Medium
	Ch.LF.5 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on salmonids. Juvenile chum salmon are closely associated with peripheral, side channel habitats where contaminants commonly accumulate.	Medium/Medium
	Ch.LF.6 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on chum salmon are unknown but are expected to be negative.	High/Low
	Ch.LF.7 Density dependence. Density dependent mechanisms in the lower mainstem, Western Oregon tributaries, estuary, and plume may limit juvenile salmonid survival and productivity, however, the significance is unclear. NOAA Fisheries is currently conducting research intended to clarify this issue.	Medium/Low
	Ch.LF-W1 Development, as well as agricultural and timber practices have caused a loss of habitat diversity and channel stability due to the loss of recruitment of large woody debris (LWD) into the systems throughout the subbasin.	High/High
Adult Migration (within and out-of-subbasin populations)	Ch.LF.8 Dam passage. Chum salmon are often unable or unwilling to migrate through fish ladders or inundated habitats. Thus, Bonneville Dam has blocked most upstream migration of chum salmon to historical spawning areas.	Medium/High
	Ch.LF.9 Migration barriers/ lack of resting habitats. Elevated water temperature or high water flow may act as a temporary adult migration barrier. Additionally, high water flow likely reduces available resting habitat for migrating adults.	Low/High
	Ch.LF.10 Predation losses. Marine mammals (pinnepeds) prey on adult salmon, but the significance is unclear.	Low/Medium
Adult Spawning (within subbasin)	Ch.LF.11 Availability of spawning habitat (i.e. accessibility/ quantity). Chum salmon have been observed spawning in multiple lower mainstem locations between the I-205 Bridge and Bonneville Dam., and in the lower reaches of the Western Oregon tributaries. These spawning aggregations represent an important component of current chum natural production. Water regulation at Bonneville Dam substantially effects water level in these mainstem spawning locations. Low flow may limit access to spawning areas while high flow may decrease the quality of these spawning locations (i.e. depth or velocity too high).	High/High
	Ch.LF.12 Decreased flows during spawning and incubation. Water regulation at Bonneville Dam substantially effects water flow in these mainstem spawning locations and may also negatively impact flow in the lower reaches of the Western Oregon tributaries. Low flow may decrease the delivery of nutrients and dissolved oxygen to incubating eggs, thereby decreasing survival.	High/Medium

Life Stage	Limiting Factors	Impact/Certainty
	Ch.LF.13 Dewatering of redds. Water regulation at Bonneville Dam substantially effects water level in these mainstem spawning locations. Flow reductions to the point of dewatering redds will result in substantial mortality of incubating eggs or pre-emergent alevins.	High/Medium

.5.2.1.1.1.5 Biological objectives & working hypotheses

Biological objectives for chum salmon, including both biological performance and the corresponding environmental conditions, are formulated to support the value statement identified above. It is understood that estimates of historical and current chum population numbers are uncertain, given the assumptions in data collection and the variability that governs population dynamics. As a result, the numeric biological objective goals for the lower mainstem and estuary should be viewed as "order of magnitude" estimates and interim in nature until more certainty can be achieved in abundance estimates and more specific goals can be quantified.

Table 5-4. Chum salmon biological performance levels.

Metric[a]	Performance Level	
Mortality[b]	Current mortality estimates range from 0.28 to 0.59 and average 0.46. Mortality estimates at population recovery goals range from 0.23 to 0.58 and average 0.42.	
Productivity	>1 recruit per spawner	
Abundance[c] (estuary/mainstem adult spawning only)	I-205	1,250
	Ives Island	6,400
	Multnomah Falls	2,300
	Western Oregon tributaries	TBD

[a] Mortality metric applies to within and out of subbasin chum populations. Productivity and abundance metrics apply only to the subbasin spawning population.

[b] Mortality is based on preliminary analysis by the LCFRB based on comparison of EDT estimates of mainstem and estuary habitat effects on lower Columbia River chum salmon populations, current population abundance estimates, and population abundance recovery goals.

[c] Abundance performance levels represent twice the 2002 spawning escapement estimates.

Table 5-5. Chum salmon desired environmental conditions (within and out-of-basin populations).

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
Juvenile Rearing (all juveniles in the Columbia River Basin)	Ch.PO.1 Protect existing rearing habitat to ensure no further net degradation. *Hypothesis Statement:* If current rearing habitat is protected, then juvenile rearing capacity and productivity in the lower mainstem, Western Oregon tributaries, estuary, and plume can be maintained. *Justification:* Protection and maintenance of existing rearing habitat will provide a base level of juvenile chum production and diversity. Further, protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High
	Ch.PO.2 Increase shallow water peripheral and side channel habitats toward historic levels. *Hypothesis Statement:* If shallow water habitat is increased, then juvenile rearing capacity in the estuary and mainstem will increase. *Justification:* Rearing juvenile chum salmon are closely associated with shallow water habitats in the estuary and lower mainstem.	High	High/High
	Ch.PO.3 Restore connectivity between tributary deltas and the estuary, the river and the floodplain, as well as in-river habitats. *Hypothesis Statement:* If connectivity with the floodplain is restored, then juvenile chum productivity in the estuary and mainstem will increase. *Justification:* Connectivity with the floodplain will restore macrodetrital inputs and alter the current food web. A macrodetritus-based food web will increase productivity and support greater life history diversity.	High	High/High
	Ch.PO.4 Reduce predation mortality on emigrating juveniles. *Hypothesis Statement:* If predation on juveniles is reduced, then juvenile chum survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Predation on juvenile salmonids in the lower Columbia River and estuary has increased as a result of increased predator populations, such as northern pikeminnow or Caspian terns. Although predation on chum salmon may be lower than other salmonids, predation mortality may be significant and needs to be quantified.	High	Low/Medium

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	Ch.PO.5 Reduce contaminant exposure of emigrating juveniles. *Hypothesis Statement:* If contaminant exposure is reduced, then juvenile chum survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Contaminants have been shown to have detrimental effects on juvenile salmonids, such as decreased immune function, disrupted physiological processes, and generally reduced fitness. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. Chum salmon may be particularly susceptible to contaminant exposure because they are closely associated with peripheral, shallow water habitats where contaminants are known to accumulate.	High	Medium/Medium
	Ch.PO.6 Document the interaction between emigrating juvenile chum salmon and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then juvenile chum survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	High/Low
	Ch.PO.7 Develop an understanding of emigrating juvenile chum salmon life history diversity and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of salmonid integration with the ecosystem increases, then management and recovery actions will proceed with greater certainty. *Justification:* Our current understanding of life history diversity and salmonid interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; ongoing research continues to increase our knowledge and reduce uncertainty.	High	High/Medium
Adult Migration (all adults in the Columbia River Basin)	Ch.PO.8 Maintain favorable water flow and temperature throughout migration period (October-November). *Hypothesis Statement:* If extreme water flows or temperatures exist during migration, then spawning may be delayed or averted. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier that generally results in one of three outcomes: delayed arrival to spawning grounds, spawning activity in less than desirable locations, or no spawning. Each of these scenarios often results in decreased juvenile fitness or productivity.	Medium	Medium/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	Ch.PO.9 Reduce predation mortality on migrating adults. *Hypothesis Statement:* If predation on adults is reduced, then chum survival in the estuary and mainstem will increase. *Justification:* Marine mammal predation on adult salmonids in the lower Columbia River and estuary has been observed. Predation mortality may be significant and needs to be quantified.	High	Low/High
Adult Spawning (adult spawners in estuary, lower mainstem, and Western Oregon tributaries)	Ch.PO.10 Protect existing spawning habitat to ensure no further net degradation. *Hypothesis Statement:* If current spawning habitat is protected, then adult spawning capacity and productivity in the estuary and mainstem can be maintained. *Justification:* Protection and maintenance of existing spawning habitat will provide a base level of chum salmon production. Further, protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High
	Ch.PO.11 Maintain favorable water flow and temperature throughout mainstem spawning period (approx. November). *Hypothesis Statement:* If extreme water flows or temperatures exist during spawning, then chum salmon may not have access to current spawning areas. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier and prevent access to current spawning areas. Further, extreme flow and temperature may decrease the quality of existing spawning habitat.	Medium	High/High
	Ch.PO.12 Maintain favorable water flow and temperature throughout mainstem incubation period (approx. November-March). *Hypothesis Statement:* If extreme water flows or temperatures exist during incubation, then egg mortality will be unacceptably high. *Justification:* Extreme (i.e. both high and low) water flow and temperature can decrease egg to fry survival. High flow can cause bed scour and subsequent egg loss. Low flow reduces nutrient and oxygen transport to developing eggs; extreme low flow can result in redd dewatering. High temperature can increase egg mortality. Low temperature delays emergence and subsequent emigration. Each of these scenarios often results in decreased juvenile fitness.	Medium	High/High
	Ch.PO-W.13 Restore habitat diversity and geomorphology of tidally influenced reaches in the WOTs subbarea	Medium	High/High

.5.2.1.1.1.6 Strategies

Habitat potential includes both quantity and quality. The properly functioning benchmark is less than the pristine historical condition. Properly functioning conditions (PFC) represent

favorable habitat for salmon as defined by NOAA Fisheries. PFC generally represent a reasonable upper bound on the potential for habitat improvement although in some cases presume large-scale changes that would be difficult to implement (e.g. levee removal). As a general rule, populations may typically be considered viable when properly functioning conditions exist throughout the historical distribution. However, populations may also be viable where not all available habitat is properly functioning. Populations may sometimes fall short of viability despite properly functioning habitat conditions, if the historical range has been substantially reduced or other mortality factors are severe.

Healthy, harvestable salmon populations depend on favorable habitats for spawning and rearing. Salmon populations typically go extinct when periodic poor ocean conditions drive populations in poor habitat to low numbers from which they cannot rebound. High quality habitat increases fish population productivity which helps maintain adequate numbers even during poor ocean conditions and allows them to rebound quickly. Populations can typically withstand some combination of stream habitat degradation, mainstem and estuary habitat degradation, and other impacts such as fishing or hatchery domestication. Historical populations appeared to sustain very high fishing and hatchery impacts prior to the cumulative effects of widespread habitat declines. Conversely, no level of fishery or hatchery reductions will be sufficient to offset severe habitat declines.

Current habitat conditions in most areas are much less favorable than historical conditions and substantially less favorable than necessary to support viable wild salmon and steelhead populations. Assessments detailed in the Technical Foundation identified tributary habitat degradation as the largest single impact among the various limiting factors (i.e. the 4-Hs). Land and water use practices have contributed large decreases in habitat quality and quantity in all subbasins.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving salmon habitat conditions in some areas and will further improve salmon habitat over time, but additional changes are needed in many areas to support the recovery of wild populations. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on salmon and increased commitment to protect this resource. More fish-friendly practices have been implemented for many activities both before and after listing of salmon. Some changes have already produced effects; others will be expected to pay future dividends. Still others will be needed to offset the cumulative effects of years of habitat degradation.

A significant level of increased habitat protection and restoration will be required to just to arrest declining trends and ensure that population status does not decline further. Additional efforts will be required to make substantial gains. Recovery depends on arresting and reversing declining trends in salmon numbers. The size of the required change will depend on the steepness of the decline and the level of improvement needed to meet region-wide recovery goals. Projected human population growth in lower Columbia river subbasins will compound the demands for increased habitat protection and restoration just to stabilize fish populations at current levels.

Salmon depend on suitable habitat conditions which in turn are regulated by conditions in adjacent and upstream watersheds. Local habitat activities can provide short term benefits but long-term improvements in habitat conditions will depend on restoration of functional watershed

processes. Where watershed processes are not intact, habitat conditions rapidly revert to equilibrium with their surroundings.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue. For instance, riparian protection measures might require 50-150 years to provide full benefits based on the time it takes for trees to mature and restore shade and channel stability, then die and provide woody debris and channel diversity. Because of the required scale and delayed effects, watershed improvements typically provide limited prospects for immediate relief of acute extinction risks for salmon caused by current low numbers.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance. However, protection measures alone will not suffice to recover some species to viability, especially in light of future growth trends. The geographical distribution of some species overlaps significantly with areas that have been subjected to significant human disturbance, including urban development and agriculture. For example, chum salmon occupy lower reaches of watersheds that have historically been highly urbanized and developed, or that will be in the next 50 years. Active restoration in previously disturbed areas may be necessary for this species in particular.

Although effects may often be temporary, site-specific improvements in habitat conditions and access, in concert with non-habitat measures can help ameliorate immediate extinction risks in the interim, until underlying causes of stream habitat declines are addressed. Even where recent changes to land and water use patterns can be expected to provide suitable conditions for population viability in the long term, more immediate actions may be required to make sure that the fish are around to reap those long term benefits.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by salmon and steelhead populations to any given suite of actions. These uncertainties limit our ability to stipulate precise levels of improvement needed to achieve recovery. The recovery plan needs to recognize these uncertainties with adequate safety factors, contingences, and in-course corrections.

Habitat

Ch.S1. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Physical Objectives Addressed: Ch.PO.1, Ch.PO.2, Ch.PO.3, Ch.PO.8, Ch.PO.10, Ch.PO.11, and Ch.PO.12, Ch.PO-W.13

Explanation: Important habitats in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

Ch.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Physical Objectives Addressed: Ch.PO.1, Ch.PO.2, Ch.PO.3, Ch.PO.8, Ch.PO.10, Ch.PO.11, Ch.PO.12, Ch.PO-W.13

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

Ch.S3. Avoid large-scale habitat changes where risks to salmon and steelhead are uncertain.

Physical Objectives Addressed: Ch.PO.1 and Ch.PO.10

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that things don't continue to get worse.

Ch.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: Ch.PO.1 and Ch.PO.10, Ch.PO-W.13

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

Ch.S5. Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Physical Objectives Addressed: Ch.PO.1, Ch.PO.2, Ch.PO.3, and Ch.PO.10, Ch.PO-W.13

Explanation: Salmonid recovery is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will require some restoration of areas that are substantially degraded but also provides significant flexibility in where habitat restoration efforts are distributed among and within subbasins.

Ch.S6. Utilize a combination of active and passive habitat restoration measures to

provide near term and long term benefits.

Physical Objectives Addressed: Ch.PO.1, Ch.PO.2, Ch.PO.3, Ch.PO.8, Ch.PO.10, Ch.PO.11 and Ch.PO-W.13

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but effects are rarely lasting unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures in the riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions).

Ch.S7. Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Physical Objectives Addressed: Ch.PO.7

Explanation: Salmon are an integral component of both the freshwater and marine ecosystem of which they are a part. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the status of salmon. Many significant salmon predators including bull trout, eagles, and grizzly bears have declined concurrent with salmon declines, albeit for a variety of reasons. Large numbers of salmon returning to spawn streams also introduce significant amounts of marine-derived nutrients into freshwater systems. These nutrients may stimulate primary and secondary productivity when other appropriate habitat conditions exist; this increased productivity increases food for juvenile salmon as well as other species. Finally, salmon actually affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

Introduced Species

Ch.S8. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introducing species.

Physical Objectives Addressed: Ch.PO.6

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Predators

Ch.S9. As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Physical Objectives Addressed: Ch.PO.4 and Ch.PO.9

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Research

Ch.S10. Our understanding of the relationships between chum salmon and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: Ch.PO.1 through Ch.PO.12

Explanation: Emerging research and understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume are promising tools in the near future. Also needed are additional understanding about how chum populations use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume. Additionally, future research should also focus on establishing clear relationships between chum salmon and the various predators or introduced species in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Ch.S11. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: Ch.PO.1 through Ch.PO.12

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection, habitat restoration, and recovery measures are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

Ch.S12. Assess the Mainstem Lower Columbia River and Columbia River Estuary by discreet geographic reaches for restoration and protection priorities.

Physical Objectives Addressed: Ch.PO.1,Ch.PO.2, Ch.PO.3,Ch.PO.4, Ch.PO.5, Ch.PO.6, Ch.PO.7, Ch.PO.9, Ch.PO.10, Ch.PO.11, and Ch.PO.12

Explanation: A chronic problem exists in the information systems of resource planners who are unable, today, to accurately inventory where protection and restoration work has been completed or is ongoing, and where additional work is needed. Throughout the subbasin planning process, an urgent need was identified to develop a "desktop" triage tool to identify where measures should be applied, or where mitigation steps might be needed in response to some natural or anthropogenic system disturbance. A systematic way of identifying the protection and restoration potential of specific areas within the subbasin needs to be developed. Such a system could then provide a means for prioritizing actions.Measures to achieve strategies

.5.2.1.1.1.7 Measures to Achieve Strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary.

Habitat

Ch.M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Loss of tidal swamp and marsh habitat has respectively resulted in an estimated 77% and 43% loss of these habitat types from 1870 to 1983. The substantial acreage loss of the tidal swamp and tidal marsh habitat types has important implications on juvenile salmonid survival in the estuary because evidence suggests salmonids, particularly ocean-type salmonids, depend on these habitats for food and cover requirements.

Variables	**Context**
Strategies addressed	Ch.S1, Ch.S2, Ch.S3, Ch.S4, Ch.S5, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of tidal and marsh habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of tidal marsh and swamp habitats would have a high benefit because of the close association of juvenile chum salmon with these habitats.
Barriers to success	*Explanation:* Tidal marsh and swamp habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

Ch.M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified lower mainstem, Western Oregon tributaries, estuary, and plume habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that emulate a more natural regime will help improve habitat conditions for salmonids and other resident fish and wildlife species.

Variables	Context
Strategies addressed	Ch.S1, Ch.S2, Ch.S3, Ch.S4, Ch.S5, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit.
Barriers to success	*Explanation:* An annual allocation of water for salmonids will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

Ch.M3. Maintain adequate water flows throughout spawning, incubation, and migration periods.

Explanation: Prevents dewatering and decreased flows in redds during spawning and incubation, as well as increasing the potential spawning sites available for adults. Prevents migration barriers, high temperatures in late summer, lack of resting habitats, and predation losses. Facilitates juvenile movement through the mainstem to the estuary.

Variables	Context
Strategies addressed	Ch.S1, Ch.S2, Ch.S3, Ch.S4, Ch.S5, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for maintaining water flows during spawning, incubation, and migration. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Maintenance of water flows during spawning, incubation, and migration would have a high benefit because of the significance of chum salmon mainstem spawners to the population.
Barriers to success	*Explanation:* Maintenance of water flows during spawning, incubation, and migration will be possible through the modification of current water uses, which at present seems possible if current water budget is only modified for brief periods. Additionally, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

Ch.M4. Restore connectedness between river and floodplain.

Explanation: Restoring the access to the floodplain increases juvenile salmonid access to shallow water, low velocity, peripheral habitats. Further, connection of the river and floodplain begins to restore the historical macrodetritus-based food web.

Variables	Context
Strategies addressed	Ch.S1, Ch.S2, Ch.S3, Ch.S4, Ch.S5, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands , as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

Ch.M5. Protect and restore riparian and wetland habitat condition and function.

Explanation: Riparian zones are critical habitats for many species. This measure incorporates a variety of tools including, local land use regulatory actions, acquisition, and restoration activities.

Variables	Context
Strategies addressed	Ch.S1, Ch.S2, Ch.S3, Ch.S4, Ch.S5, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective for protecting wetland and riparian habitats. The current programs cannot be expected to attain the physical objective for restoring wetland and riparian habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability..
Potential to contribute to biological objectives	High. *Explanation*: Restoration of riparian habitats would have a high benefit because of the close association of juvenile chum with these habitats.
Barriers to success	*Explanation:* Riparian and wetland habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

Ch.M6. Restore impaired sediment transport processes affecting the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Sediment dynamics are a critical component of lower mainstem, Western Oregon tributaries, estuary, and plume habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation, and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	Ch.S1, Ch.S2, Ch.S3, Ch.S4, Ch.S5, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

Ch.M7. Mitigate channel dredging activities in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that alter habitat forming processes, reduce salmon population resilience, and inhibit recovery.

Explanation: Channel dredge activities affect the quality of the various lower mainstem, Western Oregon tributaries, estuary, and plume salmonid habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Indirectly, wakes from large ships increase erosion and can cause stranding of juvenile salmonids located along the shoreline. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context
Strategies addressed	Ch.S1, Ch.S2, Ch.S3, Ch.S4, Ch.S5, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for mitigating dredging activity effects. The primary reason is that the sole purpose of the Channel Deepening BiOp is to protect ESA-listed salmonids and their habitat while allowing dredging activity to proceed.
Potential to contribute to biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects throughout the channel deepening process and beyond. However, there remains uncertainty as to the short- and long-term effects of channel modification on flow dynamics, sediment transport, and habitat forming processes.

Ch.M8. Limit the effects of toxic contaminants on salmonid fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on salmonids, resident fish, or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	Context
Strategies addressed	Ch.S4, Ch.S7, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and estuary, as well as uncertainty in exposure risks to salmonids.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

Introduced Species

Ch.M9. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

ariables	Context
Strategies addressed	Ch.S3, Ch.S4, Ch.S7, Ch.S8, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

Ch.M10. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intention species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	Ch.S7, Ch.S8, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years

Variables	Context
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Ch.M11. Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon bycatch. The impacts of shad on salmon are unclear but the large shad population biomass has the potential for significant impacts. Elimination or control of shad is not a silver bullet for salmon recovery but the significance of interactions and opportunities for management warrant closer consideration.

Variables	Context
Strategies addressed	Ch.S7, Ch.S8, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing shad management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of shad.

Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Ch.M12. Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.

Explanation: Established populations may be managed to shape fishery benefits as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. Walleye fisheries can be managed with size regulations for instance to shape fishery benefits with no effect on salmonids.

Variables	Context
Strategies addressed	Ch.S7, Ch.S8, Ch.S9, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing gamefish management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of gamefish.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

predators

Ch.M13. Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikemnnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

Variables	Context
Strategies addressed	Ch.S7, Ch.S9, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing pikeminnow predation on juvenile salmonids. Currently, there are no plans to discontinue the pikeminnow management program.
Potential to contribute to biological objectives	Low. *Explanation*: Pikeminnow predation on juvenile chum salmon is thought to be low, thus, pikeminnow management will have minor effects on chum salmon.
Barriers to success	*Explanation:* The current pikeminnow management program has been successful at removing the large, predaceous pikeminnow from the population, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

Ch.M14. Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where salmon predation might pose added risks.

Variables	Context
Strategies addressed	Ch.S3, Ch.S4, Ch.S7, Ch.S9, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years

Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing Caspian tern predation on juvenile salmonids. Currently, there are no plans to discontinue the Caspian tern relocation program.
Potential to contribute to biological objectives	Low. *Explanation*: Caspian tern predation on juvenile chum salmon is thought to be low, thus, tern management will have minor effects on chum salmon.
Barriers to success	*Explanation:* The current Caspian tern relocation program has been successful at relocating the tern colony from Rice to East Sand Island, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

Ch.M15. Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.

Explanation: Only after adoption of the U.S. Marine Mammal Protection Act have seals and sea lions begun to recover from historical low levels. Populations have expanded greatly and significant numbers now occur in the lower Columbia River.

Variables	Context
Strategies addressed	Ch.S7, Ch.S9, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs in place that are intended to quantify the amount and significance of pinniped predation on adults salmonids.
Potential to contribute to biological objectives	Low. *Explanation*: The significance of pinniped predation on adult salmonids is unclear but expected to be somewhat low.
Barriers to success	*Explanation:* Establishing regulatory control of pinnipeds to limit predation on adult salmonids is challenged by pinniped protection under the Marine Mammal Protection Act, however, some level of management is possible if warranted for salmon recovery.

Research

Ch.M16. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of causal relationships between salmonids, resident fish, and wildlife species is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	Ch.S2, Ch.S3, Ch.S5, Ch.S7, Ch.S8, Ch.S9, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for Our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. The primary reason is that these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

Ch.M17. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by ocean- and stream-type salmonids is poorly understood. The use of tagging and other marking studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	Ch.S7, Ch.S10, and Ch.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years

Variables	Context
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for understanding salmonid behavior and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. The primary reason is that these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding salmonid life history diversity and mainstem/estuary habitat use will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

Ch.M18. Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Mainstem Lower Columbia River and Columbia River Estuary

Explanation: Identifying priority habitat for protection and restoration within the Mainstem Lower Columbia River and Columbia River Estuary should be a priority. The approach should be the development of both a tool and a process that could be used iteratively to provide an adaptive management framework for resource planners. In the Columbia basin tributaries, Ecosystem Diagnostic and Treatment (EDT) has provided planners with a quantitative method for determining prioritiesand for modeling likely outcomes. Such a tool has been difficult to apply to the estuary because many species with use the estuary for critical life stages do not produce in the estuary. The challenge will be to develop a tool that reflects the importance of the estuary that use it for important but non-productive portions of their life history.

Variables	Context
Strategies addressed	Ch.S1,Ch.S2, Ch.S3, Ch.S4, Ch.S5, Ch.S6, Ch.S9, Ch.S10, Ch.S11, and Ch.S12
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary

Variables	Context
	are insufficient for determining where to target protection and restoration activities, although our understanding of the habitat forming processes and relationships between species and habitat attributes is growing significantly.
Potential to contribute to biological objectives	High. *Explanation*: While measures and strategies intended to effect positive change in the Mainstem Lower Columbia River and Columbia River Estuary are becoming clear, knowing where to apply these measures is uncertain. Tools that help target resources will increase all other measures chances of being successful.
Barriers to success	*Explanation:* A key goal of any desktop management goal should be to provide a means of predicting outcomes of restoration and protection activities, but standard measures of performance, for example, production and abundance are likely to occur out-of-basin, making expected outcomes a difficult measure to quantify. Chum will be key to this measure because it is one of the few salmonids that produce in the proposed study area

Sustainable Fisheries

Ch.M20: Continue the Select Area Fisheries Project

Explanation: The project primarily utilizes existing hatchery facilities to spawn, hatch, and conduct initial rearing of juvenile salmonids for subsequent out planting to net pen facilities at each of the select area sites. Hatcheries providing production are South Fork Klaskanine (CEDC); Big Creek, Bonneville, Cascade, Gnat Creek, North Fork Klaskanine, Oxbow, Sandy, South Santiam, and Willamette (all ODFW); Cowlitz, Elochoman, and Gray's River (all WDFW), and Eagle Creek (USFWS). The Clatsop Count Economic Development Council (CEDC) Fisheries Project operates estuarine net-pen sites in Youngs Bay, Tongue Point, and Blind Slough. The Washington Department of Fish and Wildlife has net-pen sites at Deep River and Steamboat Slough. Fish are grown and released from these pens under varying management and grow-out regimes including two-week acclimation, over-winter, and full term net pen rearing. Annual releases for 2000-2003 have averaged 3.8 million coho, 1.0 million spring chinook, and 1.0 million select area bright fall chinook (includes ODFW's Restoration and Enhancement production). Ex-vessel values of 2000-2003 SAFE commercial fisheries were $408,000-$787,000, with state-level personal income impacts of $1.4 - $3.1 million dollars for al l regional fisheries combined.

Variables	Context
Strategies addressed	SXX-15
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Program Table (CEDC Fisheries)
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are sufficient for directing harvest of commercial and recreational fishers to targeted stocks of hatchery stocks of summer Chinook, fall Chinook, and Coho
Potential to contribute to biological objectives	High. *Explanation*: The Terminal Fisheries project has been demonstrated to be effectives for addressing the following objectives: Supports a healthy Columbia basin, Maintains biological diversity, Maintains genetic integrity, Increases run sizes or populations As these objectives are addressed by the measure, the wants, needs, and desires of the fishers can be met.
Barriers to success	*Explanation:* Barriers to success are very low, as most of the logistical and technical problems have been addressed. The project has addressed concerns about juvenile interactions, predation, and straying. The major barrier is that the program is not self-

	sustaining

.5.2.1.1.1.8 *Programs to implement strategies and measures*

Table 5-6. Existing programs and their connection to recovery measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	1, 4, 5
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; collaboration with these efforts is vital.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	5
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	5
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	5
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	5
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	6
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	6
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	5
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	2, 3, 6
Washington State Conservation Commission/ Conservation	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify	1, 4

Program Name and Affiliation	Program Description	Measures Addressed
Districts	improvements needed, and publish and disseminate the information.	
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 4, 5, 6, 7, 8
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	1, 4, 5
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 5, 7
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	2, 3, 8
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 5, 8
Habitat Program – WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	1, 4, 5, 6, 10, 11, 12, 13, 16, 17

Program Name and Affiliation	Program Description	Measures Addressed
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	1, 4, 5
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 4, 5, 6, 8
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	The goal of the SRFB is to protect and restore salmon habitat. The board provides grant funds to protect or restore salmon habitat and assist related activities; it works closely with local watershed groups. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SRFB guides spending of funds targeted for salmon recovery activities and projects.	1, 4, 5, 6
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	8
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	1, 5
Partners for Fish and Wildlife	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
Program – USFWS	based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	16
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	16, 17
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	6, 7
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	6, 7
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	9, 10
Pikeminnow Management	The goal of the program is to manage annual pikeminnow predation on juvenile salmonids. The program pays rewards to anglers for harvesting pikeminnow	13

Program Name and Affiliation	Program Description	Measures Addressed
Program	over a prescribed size, thus providing an incentive to remove the large, predaceous pikeminnow from the population.	
Caspian Tern Relocation Project	The goal of the project was to relocate terns to another location in the estuary where tern predation on juvenile salmonids would be reduced but the viability of the tern population would be maintained.	14

5.2.1.1.2 Fall Chinook

.5.2.1.1.2.1 Background

Chinook salmon (Oncorhynchus tshawytscha) are the largest and most diverse of the Pacific salmon. Two runs of fall chinook return to Washington lower Columbia River tributaries: “tule” fall chinook and “bright” late fall chinook. Tule fall chinook return from August through November to spawn almost immediately, typically in large tributary mainstems. Tule fall chinook have ocean-type life histories where juveniles gradually migrate downstream as subyearlings during their first spring and summer. Most tule fall chinook adults return after 2 to 3 years in the ocean where they range along the coasts of Washington, Oregon, and British Columbia. Bright late fall chinook return from August through October and spawn November through January. Life history is otherwise similar to tule fall chinook except the lower river bright fall run migrates farther north, and may spend up to 4 years in the ocean before returning.

.5.2.1.1.2.2 Status

Lower Columbia River chinook populations were listed as threatened in 1999. Chinook salmon were historically present in all Washington lower Columbia tributaries. Tule fall chinook were widely distributed while bright fall chinook were limited to the Lewis River, and perhaps the mainstem Columbia near the present Bonneville Dam site. The Willamette/Lower Columbia Technical Recovery Team has identified 31 historical populations of chinook salmon in the Columbia River ESU. Washington accounts for 13 of 20 tule fall and 1 of 2 late fall chinook populations in this ESU; the other chinook populations originate in Oregon waters. All Washington lower Columbia chinook populations are below proposed recovery targets with the possible exceptions of Lewis late fall, Coweeman fall, and East Fork Lewis fall population. Current runs of tule fall chinook are dominated by hatchery-produced fish.

Table 5-7. Fall chinook salmon abundance estimates by life stage.

Life Stage	Historical Abundance	Current Abundance
Juvenile Rearing (in-basin & out-of-basin tributary populations)	Historical productivity of fall chinook was likely very high. Assuming a productivity of 900 smolts per spawner (based on EF Lewis River EDT template estimate), an estimated 360 million juveniles used the lower mainstem, Western Oregon tributaries, estuary, and plume (based on assumed lower and upper run escapement of 400,000)	Current productivity of fall chinook is assumed to be 385 smolts per spawner (EF Lewis EDT patient estimate). Based on this level of productivity, juveniles using the lower mainstem, Western Oregon tributaries, estuary, and plume is estimated to be 115.5 million (assuming a lower and upper run escapement of 300,000)
Adult Migration (in-basin & out-of-basin tributary populations)	Historical combined lower and upper river run size ranged from about 250,000 to 1.1 million	The 2000 combined lower and upper river run size was about 325,000 (dominated by hatchery fish)
Adult Spawning (in-basin only)	Evidence suggests fall chinook did not historically spawn within the estuary or lower mainstem	An estimated 6,000 fall chinook spawned in the lower mainstem near Ives and Pierce Islands during 2002 (fish are expected to be stray bright late fall chinook from local hatchery programs)

.5.2.1.1.2.3 Value statement

Lower Columbia River chinook and Snake River fall chinook are currently listed as threatened under the Endangered Species Act; additionally, fall chinook are culturally, economically, and ecologically important. Juvenile rearing in the estuary and adult spawning in the mainstem are vital life history trajectories for fall chinook. The restoration goal for lower Columbia fall chinook is to increase the population to a self-sustaining, viable population that can provide for tribal, sport, and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage, it is likely that restoration efforts of fall chinook will achieve the highest success in the lower Columbia mainstem, the estuary, and the various tributaries below Bonneville Dam. However, recovery efforts of upriver fall chinook have shown some success and should continue to be pursued. Strategies and measures to return fall chinook populations to viability throughout the historical distribution are among the highest level of importance.

.5.2.1.1.2.4 Limiting factor (Threats)

Fall chinook salmon in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume have threats to all three life stages expressed in the combined subbasins and adjacent tributaries. Historically, fall chinook salmon populations were distributed throughout the Columbia River basin. Within the Lower Columbia River ESU, the Cowlitz and Lewis River

subbasins were likely supported the largest fall chinook populations, although historical escapement data are limited. Each of these subbasins has undergone development of hydroelectric facilities that have blocked access to a considerable amount of historical chinook spawning habitat. Downstream of Bonneville dam, fall chinook have been impacted by low flows, disconnected or lost habitats, and predation losses. The period of estuarine residence appears to be a critical phase in the life history of fall chinook and may play a major role in determining the size of the subsequent adult run back to fresh water.

Table 5-8. Fall chinook salmon limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Juvenile Rearing (within and out-of-subbasin populations)	Fch.LF.1 Availability of preferred habitat (i.e. shallow water, low velocity, peripheral habitats). Fall chinook are closely associated with peripheral habitats. There has been extensive loss of peripheral wetland and side channel habitat throughout the mainstem and estuary as a result of water regulation, dike construction, and urban and agricultural development.	High/High
	Fch.LF.2 Microdetritus-based food web. The current microdetritus-based food web is expected to be less productive than the historical macrodetritus-based food web. Loss of wetland and side channel habitat identified above has reduced the local macrodetritus inputs from terrestrial and riparian habitats that supported the historical food web. Present detrital inputs to the food web are dominated by microdetritus from upriver sources and are controlled primarily by reservoir production and flow rates from Bonneville Dam. Further, the microdetritus-based food web is thought to be less available to fall chinook because it is pelagic in nature and may be focused on the spatially-confined estuary turbidity maximum region.	High/Medium
	Fch.LF.3 Loss of habitat connectivity. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids. As juveniles grow, they move across a spectrum of salinities, depths, and water velocities. For species like fall chinook that rear in the estuary for extended time periods, a broad range of habitat types in the proper proximities to one another may be necessary to satisfy feeding and refuge requirements within each salinity zone.	High/High
	Fch.LF.4 Predation mortality. Current levels of predation on fall chinook are unknown but are expected to be higher than chum salmon but lower than stream-type salmonids, potentially as a result of smaller size or spatial segregation from predators. For example, Caspian tern predation is higher for larger emigrating salmonids, such as steelhead.	Medium/Medium
	Fch.LF.5 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on salmonids. Juvenile fall chinook are closely associated with peripheral, side channel habitats where contaminants commonly accumulate.	Medium/Medium
	Fch.LF.6 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on fall chinook are unknown but are expected to be negative.	High/Low

Life Stage	Limiting Factors	Impact/Certainty
	Fch.LF.7 Density dependence. Density dependent mechanisms in the lower mainstem, Western Oregon tributaries, estuary, and plume may limit juvenile salmonid survival and productivity, however, the significance is unclear. NOAA Fisheries is currently conducting research intended to clarify this issue.	Medium/Low
	Fch.LF.8 Fitness and timing of juvenile salmonids entering the subbasin. Juveniles entering the subbasin from upriver via barge releases or dam passage experience lower survival than historical mainstem emigration prior to hydrosystem development.	High/High
	Fch.LF-W.15 Urbanization, as well as agricultural and timber practices have caused a loss of habitat diversity and channel stability throughout the Western Oregon tributaries (WOTs).	High/High
Adult Migration (within and out-of-subbasin populations)	Fch.LF.9 Dam passage. Fall chinook access to historical spawning areas has been blocked in 2 major fall chinook-producing subbasins, the Cowlitz and Lewis, and in key areas of the Western Oregon tributaries.	Medium/High
	Fch.LF.10 Migration barriers/ lack of resting habitats. Elevated water temperature or high water flow may act as a temporary adult migration barrier. Additionally, high water flow likely reduces available resting habitat for migrating adults. Hatchery weirs, culverts and other passage barriers exist in the Western Oregon tributaries that block access to potentially productive habitat.	Low/High
	Fch.LF.11 Predation losses. Marine mammals (pinnepeds) prey on adult salmon, but the significance is unclear.	Low/Medium
Adult Spawning (within subbasin); impacts to spawning adults were classified as "unknown" because of the hatchery origin of mainstem spawners	Fch.LF.12 Availability of spawning habitat (i.e. accessibility/ quantity). Fall chinook have been observed spawning in multiple lower mainstem locations, particularly in the Ives and Pierce Island area. These spawning aggregations are believed to be derived from local hatchery strays, so their importance to ESU recovery is unclear. Water regulation at Bonneville Dam substantially effects water level in these mainstem spawning locations. Low flow may limit access to spawning areas while high flow may decrease the quality of these spawning locations (i.e. depth or velocity too high).	Medium/Low
	Fch.LF.13 Decreased flows during spawning and incubation. Water regulation at Bonneville Dam substantially effects water flow in these mainstem spawning locations. Low flow may decrease the delivery of nutrients and dissolved oxygen to incubating eggs, thereby decreasing survival.	High/Medium
	Fch.LF.14 Dewatering of redds. Water regulation at Bonneville Dam substantially effects water level in these mainstem spawning locations. Flow reductions to the point of dewatering redds will result in substantial mortality of incubating eggs or pre-emergent alevins.	High/Medium
	Fch.LF-W.15. Decreased flows in tributaries during spawning and incubation. Agricultural and urban use of in-stream flows substantially effects water flow in Western Oregon tributaries spawning locations. Low flow may decrease the delivery of nutrients and dissolved oxygen to incubating eggs, thereby decreasing survival.	Unknown
	Fch.LF-W.15. Availability of spawning habitat (i.e. accessibility/ quantity) Several historic spawning areas in the Demographically Independent Populations (DIPs) in the Coast Range Stratum have been limited due to barriers such as culverts and hatchery weirs. Lack of access to productive habitat limits recovery potential in these DIPs.	Unknown

.5.2.1.1.2.5 *Biological objectives & working hypotheses*

Biological objectives for fall chinook, including both biological performance and the corresponding environmental conditions, are formulated to support the value statement identified above. It is understood that estimates of historical and current fall chinook population numbers are uncertain, given the assumptions in data collection and the variability that governs population dynamics. As a result, the numeric biological objective goals for the lower mainstem and estuary should be viewed as "order of magnitude" estimates and interim in nature until more certainty can be achieved in abundance estimates and more specific goals can be quantified.

Table 5-9. Fall chinook biological performance levels.

Metric[a]	Performance Level	
Mortality[b]	Current mortality estimates range from 0.29 to 0.38 and average 0.33. Mortality estimates at population recovery goals range from 0.16 to 0.36 and average 0.27. Current mortality estimate for the Lewis River late fall population was 0.39; mortality estimate at population recovery was 0.26.	
Productivity	>1 recruit per spawner	
Abundance[c] (estuary/mainstem adult spawning only)	Ives and Pierce Islands	12,000

[a] Mortality metric applies to within and out of subbasin fall chinook populations. Productivity and abundance metrics apply only to the subbasin spawning population.

[b] Mortality is based on preliminary analysis by the LCFRB based on comparison of EDT estimates of mainstem and estuary habitat effects on lower Columbia River fall chinook salmon populations, current population abundance estimates, and population abundance recovery goals.

[c] Abundance performance levels represent twice the 2002 spawning escapement estimates.

Table 5-10. Fall chinook desired environmental conditions (within and out-of-basin populations).

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
Juvenile Rearing (all juveniles in the Columbia River Basin)	**Fch.PO-W.15 Protect and restore juvenile rearing habitat in the Western Oregon tributaries** *Hypothesis Statement:* If Juvenile rearing habitat in priority reaches of stream reaches in the Coastal stratum are restored juvenile rearing capacity and productivity in the subbasin can be enhanced *Justification:* Restoration of historically utilized rearing habitat in the Western Oregon tributaries will improve the diversity and spatial structure of the coast range DIPs		
	Fch.PO.1 Protect existing rearing habitat to ensure no further net degradation. *Hypothesis Statement:* If current rearing habitat is protected, then juvenile rearing capacity and productivity in the Western Oregon tributaries, estuary, and mainstem can be maintained. *Justification:* Protection and maintenance of existing rearing habitat will provide a base level of juvenile fall chinook production and diversity. Further, protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High
	Fch.PO.2 Increase shallow water peripheral and side channel habitats toward historic levels. *Hypothesis Statement:* If shallow water habitat is increased, then juvenile rearing capacity in tidally influenced areas of the Western Oregon tributaries, the estuary and mainstem will increase. *Justification:* Rearing juvenile fall chinook are closely associated with shallow water habitats in the Western Oregon tributaries, the estuary and lower mainstem.	High	High/High
	Fch.PO.3 Restore connectivity between tributary deltas and the estuary; the river and thefloodplain; as well as in-river habitats. *Hypothesis Statement:* If connectivity between the river, tributary deltas, and the floodplain is restored, then juvenile fall chinook productivity in the tributaries, estuary and mainstem will increase. *Justification:* Connectivity with the floodplain will restore macrodetrital inputs and alter the current food web. A macrodetritus-based food web will increase productivity and support greater life history diversity.	High	High/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	Fch.PO.4 Reduce predation mortality on emigrating juveniles. *Hypothesis Statement:* If predation on juveniles is reduced, then juvenile fall chinook survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Predation on juvenile salmonids in the lower Columbia River and estuary has increased as a result of increased predator populations, such as northern pikeminnow or Caspian terns. Although predation on fall chinook may be lower than other salmonids, predation mortality may be significant and needs to be quantified.	Medium	Medium/Medium
	Fch.PO.5 Reduce contaminant exposure of emigrating juveniles. *Hypothesis Statement:* If contaminant exposure is reduced, then juvenile fall chinook survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Contaminants have been shown to have detrimental effects on juvenile salmonids, such as decreased immune function, disrupted physiological processes, and generally reduced fitness. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. Fall chinook may be particularly susceptible to contaminant exposure because they are closely associated with peripheral, shallow water habitats where contaminants are known to accumulate.	High	Medium/Medium
	Fch.PO.6 Document the interaction between emigrating juvenile fall chinook and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then juvenile fall chinook survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	High/Low

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	Fch.PO.7 Develop an understanding of emigrating juvenile fall chinook life history diversity and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of salmonid integration with the ecosystem increases, then management and recovery actions will proceed with greater certainty. *Justification:* Our current understanding of life history diversity and salmonid interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; ongoing research continues to increase our knowledge and reduce uncertainty.	High	High/Medium
	Fch.PO.8 Evaluate/improve survival of upriver juvenile fall chinook emigrating via barge or dam passage. *Hypothesis Statement:* If survival and fitness of emigrating upriver fall chinook improves, then these fish will be better prepared for emigration through the lower mainstem, Western Oregon tributaries, estuary, and plume. *Justification:* Current survival/fitness of upriver fish is lower than historical conditions. This lower fitness may predispose fish to predation as they enter the subbasin, delay attainment of threshold size needed for smoltification, or disrupt physiological processes that control smoltification.	High	High/High
Adult Migration (all adults in the Columbia River Basin)	Fch.PO.9 Maintain favorable water flow and temperature throughout mainstem migration period (approx. August-November). *Hypothesis Statement:* If extreme water flows or temperatures exist during migration, then spawning may be delayed or averted. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier that generally results in one of three outcomes: delayed arrival to spawning grounds, spawning activity in less than desirable locations, or no spawning. Each of these scenarios often results in decreased juvenile fitness or productivity.	Medium	Medium/High
	Fch.PO.10 Reduce predation mortality on migrating adults. *Hypothesis Statement:* If predation on adults is reduced, then fall chinook survival in the estuary and mainstem will increase. *Justification:* Marine mammal predation on adult salmonids in the lower Columbia River and estuary has been observed. Predation mortality may be significant and needs to be quantified.	High	Low/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	FCh.PO-W.16 Eliminate or mitigate artificial access barriers for migrating adults *Hypothesis Statement:* If access is improved to high quality habitat abundance will be improved *Justification:* Restoration of access to productive habitat will improve population diversity and spatial structure of DIPs within the coastal stratum		
	Fch.PO.15 Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery derived stocks *Hypothesis Statement:* Continuation of Select Area (terminal) fishing opportunities in the lower Columbia River will support productive sport and commercial fisheries on harvestable stocks without negatively affecting rebuilding efforts directed at weak stocks. *Justification:* Commercial and recreational harvest in the lower Columbia River has the potential to negatively impact salmonid stocks, if not managed and directed. Harvesters are generally agreeable to targeting specific hatchery stocks, and the technology exists to manage fisheries with selectivity in the estuary without negatively impacting biological diversity and genetic integrity of wild stocks.		
Adult Spawning (adult spawners in the estuary lower mainstem, and Western Oregon tributaries)	Fch.PO.11 Protect existing spawning habitat to ensure no further net degradation. *Hypothesis Statement:* If current spawning habitat is protected, then adult spawning capacity and productivity in the Western Oregon tributaries, the estuary, and mainstem can be maintained. *Justification:* Protection and maintenance of existing spawning habitat will provide a base level of fall chinook production. Further, protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High
	Fch.PO.12 Maintain favorable water flow and temperature throughout mainstem spawning period (approx. November to December). *Hypothesis Statement:* If extreme water flows or temperatures exist during spawning, then fall chinook may not have access to current spawning areas. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier and prevent access to current spawning areas. Further, extreme flow and temperature may decrease the quality of existing spawning habitat.	Medium	High/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	Fch.PO.13 Maintain favorable water flow and temperature throughout mainstem and western Oregon tributary incubation period (approx. November-March). *Hypothesis Statement:* If extreme water flows or temperatures exist during incubation, then egg mortality will be unacceptably high. *Justification:* Extreme (i.e. both high and low) water flow and temperature can decrease egg to fry survival. High flow can cause bed scour and subsequent egg loss. Low flow reduces nutrient and oxygen transport to developing eggs; extreme low flow can result in redd dewatering. High temperature can increase egg mortality. Low temperature delays emergence and subsequent emigration. Each of these scenarios often results in decreased juvenile fitness.	Medium	High/High

.5.2.1.1.2.6 Strategies

Habitat potential includes both quantity and quality. The properly functioning benchmark is less than the pristine historical condition. Properly functioning conditions (PFC) represent favorable habitat for salmon as defined by NOAA Fisheries. PFC generally represent a reasonable upper bound on the potential for habitat improvement although in some cases presume large-scale changes that would be difficult to implement (e.g. levee removal). As a general rule, populations may typically be considered viable when properly functioning conditions exist throughout the historical distribution. However, populations may also be viable where not all available habitat is properly functioning. Populations may sometimes fall short of viability despite properly functioning habitat conditions, if the historical range has been substantially reduced or other mortality factors are severe.

Healthy, harvestable salmon populations depend on favorable habitats for spawning and rearing. Salmon populations typically go extinct when periodic poor ocean conditions drive populations in poor habitat to low numbers from which they cannot rebound. High quality habitat increases fish population productivity which helps maintain adequate numbers even during poor ocean conditions and allows them to rebound quickly. Populations can typically withstand some combination of stream habitat degradation, mainstem and estuary habitat degradation, and other impacts such as fishing or hatchery domestication. Historical populations appeared to sustain very high fishing and hatchery impacts prior to the cumulative effects of widespread habitat declines. Conversely, no level of fishery or hatchery reductions will be sufficient to offset severe habitat declines.

Current habitat conditions in most areas are much less favorable than historical conditions and substantially less favorable than necessary to support viable wild salmon and steelhead populations. Assessments detailed in the Technical Foundation identified tributary habitat degradation as the largest single impact among the various limiting factors (i.e. the 4-Hs). Land and water use practices have contributed large decreases in habitat quality and quantity in all subbasins.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving salmon habitat conditions in some areas and will further improve salmon habitat over time, but additional changes are needed in many areas to support the recovery of wild populations. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on salmon and increased commitment to protect this resource. More fish-friendly practices have been implemented for many activities both before and after listing of salmon. Some changes have already produced effects; others will be expected to pay future dividends. Still others will be needed to offset the cumulative effects of years of habitat degradation.

A significant level of increased habitat protection and restoration will be required to just to arrest declining trends and ensure that population status does not decline further. Additional efforts will be required to make substantial gains. Recovery depends on arresting and reversing declining trends in salmon numbers. The size of the required change will depend on the steepness of the decline and the level of improvement needed to meet region-wide recovery goals. Projected human population growth in lower Columbia river subbasins will compound the

demands for increased habitat protection and restoration just to stabilize fish populations at current levels.

Salmon depend on suitable habitat conditions which in turn are regulated by conditions in adjacent and upstream watersheds. Local habitat activities can provide short term benefits but long-term improvements in habitat conditions will depend on restoration of functional watershed processes. Where watershed processes are not intact, habitat conditions rapidly revert to equilibrium with their surroundings.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue. For instance, riparian protection measures might require 50-150 years to provide full benefits based on the time it takes for trees to mature and restore shade and channel stability, then die and provide woody debris and channel diversity. Because of the required scale and delayed effects, watershed improvements typically provide limited prospects for immediate relief of acute extinction risks for salmon caused by current low numbers.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance. However, protection measures alone will not suffice to recover some species to viability, especially in light of future growth trends. The geographical distribution of some species overlaps significantly with areas that have been subjected to significant human disturbance, including urban development and agriculture. For example, chum salmon occupy lower reaches of watersheds that have historically been highly urbanized and developed, or that will be in the next 50 years. Active restoration in previously disturbed areas may be necessary for this species in particular.

Although effects may often be temporary, site-specific improvements in habitat conditions and access, in concert with non-habitat measures can help ameliorate immediate extinction risks in the interim, until underlying causes of stream habitat declines are addressed. Even where recent changes to land and water use patterns can be expected to provide suitable conditions for population viability in the long term, more immediate actions may be required to make sure that the fish are around to reap those long term benefits.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by salmon and steelhead populations to any given suite of actions. These uncertainties limit our ability to stipulate precise levels of improvement needed to achieve recovery. The recovery plan needs to recognize these uncertainties with adequate safety factors, contingences, and in-course corrections.

Habitat

F.ch.S1. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Physical Objectives Addressed: F.ch.PO.1, F.ch.PO.2, F.ch.PO.3, F.ch.PO.9, F.ch.PO.11, F.ch.PO.12, F.ch.PO.13,and F.ch.PO-W.15

Explanation: Important habitats in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

F.ch.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Physical Objectives Addressed: F.ch.PO.1, F.ch.PO.2, F.ch.PO.3, F.ch.PO.9, F.ch.PO.11, F.ch.PO.12, F.ch.PO.13, and F.ch.PO-W.15

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

F.ch.S3. Avoid large-scale habitat changes where risks to salmon and steelhead are uncertain.

Physical Objectives Addressed: F.ch.PO.1 and F.ch.PO.11

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that things don't continue to get worse.

F.ch.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: F.ch.PO.1, F.ch.PO.11,and F.ch.PO-W.15

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

F.ch.S5. Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Physical Objectives Addressed: F.ch.PO.1, F.ch.PO.2, F.ch.PO.3, and F.ch.F.ch.PO.11

Explanation: Salmonid recovery is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will require some restoration of areas that are substantially degraded but also provides significant flexibility in where habitat restoration efforts are distributed among and within subbasins.

F.ch.S6. Utilize a combination of active and passive habitat restoration measures to provide near term and long term benefits.

Physical Objectives Addressed: F.ch.F.ch.PO.1, F.ch.F.ch.PO.2, F.ch.F.ch.PO.3, F.ch.PO.9, F.ch.PO.11, and F.ch.PO.12

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but effects are rarely lasting unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures in the riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions).

F.ch.S7. Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Physical Objectives Addressed: F.ch.PO.7

Explanation: Salmon are an integral component of both the freshwater and marine ecosystem of which they are a part. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the status of salmon. Many significant salmon predators including bull trout, eagles, and grizzly bears have declined concurrent with salmon declines, albeit for a variety of reasons. Large numbers of salmon returning to spawn streams also introduce significant amounts of marine-derived nutrients into freshwater systems. These nutrients may stimulate primary and secondary productivity when other appropriate habitat conditions exist; this increased productivity increases food for juvenile salmon as well as other species. Finally, salmon actually affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

F.ch.S-W7. Open access to productive habitat by removing or mitigating passage barriers

Physical Objectives Addressed: F.ch.PO-W.16

Explanation: Tide gates, culverts, hatchery weirs, and other barriers have impeded or severed access to habitat that was historically productive, and which could yet provide additional spawning and rearing habitat for salmonids that are currently limited by the amount of available productive habitat. In some cases around hatcheries, barriers have been been erected to prevent potentially disease infected fish from spawning upstream of the water intake for the hatchery and transferring disease to fish being raised at the hatchery. One of the recovery plan strategies for some salmonids populations is to to provide adult passage at several of these locations, consistent with the likelihood of gains in natural production and not unduly compromising the hatchery rearing environment in terms of disease.

Introduced Species

F.ch.S8. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introducing species.

Physical Objectives Addressed: F.ch.PO.6

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Sustainable Fisheries

F.ch.S15 Optimize continued harvest of healthy hatchery stocks while reducing harvest rates on weak, endangered stocks in mixed stock, mainstem fisheries.

Explanation: As native salmon runs on the Lower Columbia River diminished, the fishing community looked for a way to bolster the commercial industry, a backbone of the region's economy for generations of families. The goal was to were to create and expand known stock fisheries for high-quality salmon in the Columbia River Basin while providing greater protection for endangered stocks. In its 1993 Strategy For Salmon, the Northwest Power Planning Council recommended that select area (formerly terminal area) fishing sites be identified and developed to harvest abundant fish stocks while minimizing the incidental harvest of weak stocks. The Council, through its Fish and Wildlife Program, called on the BPA to: “Fund a study to evaluate potential terminal fishery sties and opportunities. Beginning in 1993, BPA initiated the Columbia River Terminal Fisheries Project (now the Columbia River Select Area Fishery Evaluation Project), a 10-year comprehensive program to investigate the feasibility of select area fisheries in Youngs Bay and other sites in Oregon and Washington (BPA 1996, Miller et al. 2002). Select area fisheries are being explored as a means to increase the sport and commercial harvest of hatchery fish while providing greater protection of weak wild salmon stocks. Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.

Predators

F.ch.S9. As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Physical Objectives Addressed: F.ch.PO.4 and F.ch.PO.10

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to

temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Research

F.ch.S10. Our understanding of the relationships between fall chinook and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: F.ch.PO.1 through F.ch.PO.13

Explanation: Emerging research and understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume are promising tools in the near future. Also needed are additional understanding about how fall chinook populations use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume. Additionally, future research should also focus on establishing clear relationships between fall chinook and the various predators or introduced species in the lower mainstem, Western Oregon tributaries, estuary, and plume.

F.ch.S11. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: F.ch.PO.1 through F.ch.PO.13

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection, habitat restoration, and recovery measures are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

F.ch.S12. Assess the Mainstem Lower Columbia River and Columbia River Estuary by discreet geographic reaches for restoration and protection priorities.

Physical Objectives Addressed: F.ch.PO.1, F.ch.PO.2, F.ch.PO.3, F.ch.PO.4, F.ch.PO.6, F.ch. PO.7, F.ch. PO.8, F.ch. PO.9, F.ch. PO.10, F.ch. PO.11, F.ch. PO.12, and F.ch. PO.13,

Explanation: A chronic problem exists in the information systems of resource planners who are unable, today, to accurately inventory where protection and restoration work has been completed or is ongoing, and where additional work is needed. Throughout the subbasin planning process, an urgent need was identified to develop a "desktop" triage tool to identify where measures should be applied, or where mitigation steps might be needed in response to some natural or anthropogenic system disturbance. A systematic way of identifying the protection and restoration potential of specific areas within the subbasin needs to be developed. Such a system could then provide a means for prioritizing actions.(talk to blaine ebberts re Corps)

.5.2.1.1.2.7 Measures to achieve strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary.

Habitat

F.ch.M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Loss of tidal swamp and marsh habitat has respectively resulted in an estimated 77% and 43% loss of these habitat types from 1870 to 1983. The substantial acreage loss of the tidal swamp and tidal marsh habitat types has important implications on juvenile salmonid survival in the estuary because evidence suggests salmonids, particularly ocean-type salmonids, depend on these habitats for food and cover requirements.

Variables	Context
Strategies addressed	F.ch.S1, F.ch.S2, F.ch.S3, F.ch.S4, F.ch.S5, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of tidal and marsh habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of tidal marsh and swamp habitats would have a high benefit because of the close association of juvenile chinook salmon with these habitats.
Barriers to success	*Explanation:* Tidal marsh and swamp habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

F.ch.M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified lower mainstem, Western Oregon tributaries, estuary, and plume habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that emulate a more natural regime will help improve habitat conditions for salmonids and other resident fish and wildlife species.

Variables	Context
Strategies addressed	F.ch.S1, F.ch.S2, F.ch.S3, F.ch.S4, F.ch.S5, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit.
Barriers to success	*Explanation:* An annual allocation of water for salmonids will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

F.ch.M3. Maintain adequate water flows throughout spawning, incubation, and migration periods.

Explanation: Prevents dewatering and decreased flows in redds during spawning and incubation, as well as increasing the potential spawning sites available for adults. Prevents migration barriers, high temperatures in late summer, lack of resting habitats, and predation losses. Facilitates juvenile movement through the mainstem to the estuary.

Variables	Context
Strategies addressed	F.ch.S1, F.ch.S2, F.ch.S3, F.ch.S4, F.ch.S5, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for maintaining water flows during spawning, incubation, and migration. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Maintenance of water flows during spawning, incubation, and migration would have a high benefit because of the significance of fall chinook mainstem spawners and juvenile rearing in the subbbasins.
Barriers to success	*Explanation:* Maintenance of water flows during spawning, incubation, and migration will be possible through the modification of current water uses, which at present seems possible if current water budget is only modified for brief periods. Additionally, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

F.ch.M4. Restore connectedness between river and floodplain.

Explanation: Restoring the access to the floodplain increases juvenile salmonid access to shallow water, low velocity, peripheral habitats. Further, connection of the river and floodplain begins to restore the historical macrodetritus-based food web.

Variables	Context
Strategies addressed	F.ch.S1, F.ch.S2, F.ch.S3, F.ch.S4, F.ch.S5, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

F.ch.M5. Protect and restore riparian and wetland habitat condition and function.

Explanation: Riparian zones are critical habitats for many species. This measure incorporates a variety of tools including, local land use regulatory actions, acquisition, and restoration activities.

Variables	Context
Strategies addressed	F.ch.S1, F.ch.S2, F.ch.S3, F.ch.S4, F.ch.S5, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective for protecting wetland and riparian habitats. The current programs cannot be expected to attain the physical objective for restoring wetland and riparian habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	• High. *Explanation*: Restoration of riparian habitats would have a high benefit because of the close association of juvenile fall chinook with these habitats.
Barriers to success	*Explanation:* Riparian and wetland habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

F.ch.M6. Restore impaired sediment transport processes affecting the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Sediment dynamics are a critical component of lower mainstem, Western Oregon tributaries, estuary, and plume habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation, and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	F.ch.S1, F.ch.S2, F.ch.S3, F.ch.S4, F.ch.S5, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

F.ch.M7. Mitigate channel dredging activities in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that alter habitat forming processes, reduce salmon population resilience, and inhibit recovery.

Explanation: Channel dredge activities affect the quality of the various lower mainstem, Western Oregon tributaries, estuary, and plume salmonid habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Indirectly, wakes from large ships increase erosion and can cause stranding of juvenile salmonids located along the shoreline. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context

Strategies addressed	F.ch.S1, F.ch.S2, F.ch.S3, F.ch.S4, F.ch.S5, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for mitigating dredging activity effects. The primary reason is that the sole purpose of the Channel Deepening BiOp is to protect ESA-listed salmonids and their habitat while allowing dredging activity to proceed.
Potential to contribute to biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects throughout the channel deepening process and beyond. However, there remains uncertainty as to the short- and long-term effects of channel modification on flow dynamics, sediment transport, and habitat forming processes.

F.ch.M8. Limit the effects of toxic contaminants on salmonid fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on salmonids, resident fish, or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	Context
Strategies addressed	F.ch.S4, F.ch.S7, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and estuary, as well as uncertainty in exposure risks to salmonids.
Potential to contribute to	Medium.

Variables	Context
biological objectives	*Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

F.ch.M-W8. Implement mitigation and enhancement measures to provide access to productive spawning and rearing habitat

Explanation: Watershed Assessments in the Western Oregon tributaries include in many cases fish passage surveys. Culverts and other passage barriers have been inventoried and prioritized.

Variables	Context
Strategies addressed	F.ch.S-W7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* While many passage barriers can be addressed through systematic review of passage barrier inventories, the current programs and/or projects cannot be expected to attain the physical objective for providing additional habitat. The primary reason is uncertainty on the best means for protecting against spreading disease past hatchery wiers.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of providing additional access to potentially productive habitat are significant, however uncertainty remains on the best means of protecting against desease.
Barriers to success	*Explanation:* Hatchery policies that manage the risk of spreading disease; financial means to address barriers in a systematic way

Introduced Species

F.ch.M9. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	F.ch.S3, F.ch.S4, F.ch.S7, F.ch.S8, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

F.ch.M10. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intention species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	F.ch.S7, F.ch.S8, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

F.ch.M11. Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon bycatF.ch. The impacts of shad on salmon are unclear but the large shad population biomass has the potential for significant impacts. Elimination or control of shad is not a silver bullet for salmon recovery but the significance of interactions and opportunities for management warrant closer consideration.

Variables	Context
Strategies addressed	F.ch.S7, F.ch.S8, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing shad management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of shad.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

F.ch.M12. Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.

Explanation: Established populations may be managed to shape fishery benefits as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. Walleye fisheries can be managed with size regulations for instance to shape fishery benefits with no effect on salmonids.

Variables	Context
Strategies addressed	F.ch.S7, F.ch.S8, F.ch.S9, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing gamefish management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of gamefish.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Predators

F.ch.M13. Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikemnnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

Variables	Context
Strategies addressed	F.ch.S7, F.ch.S9, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing pikeminnow predation on juvenile salmonids. Currently, there are no plans to discontinue the pikeminnow management program.
Potential to contribute to biological objectives	Medium. *Explanation*: Pikeminnow predation on juvenile fall chinook is thought to be moderate, thus, pikeminnow management will continue to have positive effects on fall chinook.
Barriers to success	*Explanation:* The current pikeminnow management program has been successful at removing the large, predaceous pikeminnow from the population, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

F.ch.M14. Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where salmon predation might pose added risks.

Variables	Context
Strategies addressed	F.ch.S3, F.ch.S4, F.ch.S7, F.ch.S9, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing Caspian tern predation on juvenile salmonids. Currently, there are no plans to discontinue the Caspian tern relocation program.
Potential to contribute to biological objectives	Medium. *Explanation*: Caspian tern predation on juvenile fall chinook is thought to be moderate, thus, tern management will continue to have positive effects on fall chinook.
Barriers to success	*Explanation:* The current Caspian tern relocation program has been successful at relocating the tern colony from Rice to East Sand Island, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

F.ch.M15. Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.

Explanation: Only after adoption of the U.S. Marine Mammal Protection Act have seals and sea lions begun to recover from historical low levels. Populations have expanded greatly and significant numbers now occur in the lower Columbia River.

Variables	Context
Strategies addressed	F.ch.S7, F.ch.S9, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs in place that are intended to quantify the amount and significance of pinniped predation on adults salmonids.
Potential to contribute to biological objectives	Low. *Explanation*: The significance of pinniped predation on adult salmonids is unclear but expected to be somewhat low.
Barriers to success	*Explanation:* Establishing regulatory control of pinnipeds to limit predation on adult salmonids is challenged by pinniped protection under the Marine Mammal Protection Act, however, some level of management is possible if warranted for salmon recovery.

Research

F.ch.M16. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of causal relationships between salmonids, resident fish, and wildlife species is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	F.ch.S2, F.ch.S3, F.ch.S5, F.ch.S7, F.ch.S8, F.ch.S9, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for Our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. The primary reason is that these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

F.ch.M17. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by ocean- and stream-type salmonids is poorly understood. The use of tagging and other marking studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	F.ch.S7, F.ch.S10, and F.ch.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for understanding salmonid behavior and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. The primary reason is that these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding salmonid life history diversity and mainstem/estuary habitat use will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

Co.M18 Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Mainstem Lower Columbia River and Columbia River Estuary

Explanation: Identifying priority habitat for protection and restoration within the Mainstem Lower Columbia River and Columbia River Estuary should be a priority. The approach should be the development of both a tool and a process that could be used iteratively to provide an adaptive management framework for resource planners. In the Columbia basin tributaries, Ecosystem Diagnostic and Treatment (EDT) has provided planners with a quantitative method for determining prioritiesand for modeling likely outcomes. Such a tool has been difficult to apply to the estuary because many species with use the estuary for critical life stages do not produce in the estuary. The challenge will be to develop a tool that reflects the importance of the estuary that use it for important but non-productive portions of their life history.

Variables	Context
Strategies addressed	F.ch.S1, F.ch.S2, F.ch.S3, F.ch.S4, F.ch.S5, F.ch.S6, F.ch.S-W7, F.ch.S9, F.ch.S10, F.ch.S11, and F.ch.S12
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are insufficient for determining where to target protection and restoration activities, although our understanding of the habitat forming processes and relationships between species and habitat attributes is growing significantly.
Potential to contribute to biological objectives	High. *Explanation*: While measures and strategies intended to effect positive change in the Mainstem Lower Columbia River and Columbia River Estuary are becoming clear, knowing where to apply these measures is uncertain. Tools that help target resources will increase all other measures chances of being successful.
Barriers to success	*Explanation:* A key goal of any desktop management goal should be to provide a means of predicting outcomes of restoration and protection activities, but standard measures of performance, for example, production and abundance are likely to occur out-of-basin, making expected outcomes a difficult measure to quantify.

Sustainable Fisheries

Fch.M20: Continue the Select Area Fisheries Project

Explanation: The project primarily utilizes existing hatchery facilities to spawn, hatch, and conduct initial rearing of juvenile salmonids for subsequent out planting to net pen facilities at each of the select area sites. Hatcheries providing production are South Fork Klaskanine (CEDC); Big Creek, Bonneville, Cascade, Gnat Creek, North Fork Klaskanine, Oxbow, Sandy, South Santiam, and Willamette (all ODFW); Cowlitz, Elochoman, and Gray's River (all WDFW), and Eagle Creek (USFWS). The Clatsop Count Economic Development Council (CEDC) Fisheries Project operates estuarine net-pen sites in Youngs Bay, Tongue Point, and Blind Slough. The Washington Department of Fish and Wildlife has net-pen sites at Deep River and Steamboat Slough. Fish are grown and released from these pens under varying management and grow-out regimes including two-week acclimation, over-winter, and full term net pen rearing. Annual releases for 2000-2003 have averaged 3.8 million coho, 1.0 million spring chinook, and 1.0 million select area bright fall chinook (includes ODFW's Restoration and Enhancement production). Ex-vessel values of 2000-2003 SAFE commercial fisheries were $408,000-$787,000, with state-level personal income impacts of $1.4 - $3.1 million dollars for al l regional fisheries combined.

Variables	Context
Strategies addressed	F.ch..S15
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Program Table (CEDC Fisheries)
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are sufficient for directing harvest of commercial and recreational fishers to targeted stocks of hatchery stocks of summer Chinook, fall Chinook, and Coho
Potential to contribute to biological objectives	High. *Explanation*: The Terminal Fisheries project has been demonstrated to be effectives for addressing the following objectives: Supports a healthy Columbia basin, Maintains biological diversity, Maintains genetic integrity, Increases run sizes or populations As these objectives are addressed by the measure, the wants, needs, and desires of the fishers can be met.
Barriers to success	*Explanation:* Barriers to success are very low, as most of the logistical and technical problems have been addressed. The project has addressed concerns about juvenile interactions, predation, and straying. The major barrier is that the program is not self-sustaining

.5.2.1.1.2.8 Programs to implement strategies and measures

Table 5-11. Existing programs and their connection to recovery measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	1, 4, 5
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; collaboration with these efforts is vital.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	5
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	5
CEDC Fisheres	Manages Select Area Fishing project to direct harvest away from listed stocks, and mitigate for lack of harvest in the lower Columbia River	20
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	5
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	5
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	6
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	6
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	5
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	2, 3, 6
Washington State Conservation Commission/	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable	1, 4

Program Name and Affiliation	Program Description	Measures Addressed
Conservation Districts	natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 4, 5, 6, 7, 8
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	1, 4, 5
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 5, 7
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	2, 3, 8
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 5, 8
Habitat Program – WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary	1, 4, 5, 6, 10, 11, 12, 13, 16, 17

Program Name and Affiliation	Program Description	Measures Addressed
	habitat conditions and distribution of salmonid stocks in Washington.	
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	1, 4, 5
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 4, 5, 6, 8
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	The goal of the SRFB is to protect and restore salmon habitat. The board provides grant funds to protect or restore salmon habitat and assist related activities; it works closely with local watershed groups. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SRFB guides spending of funds targeted for salmon recovery activities and projects.	1, 4, 5, 6
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	8
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	1, 5
Partners for Fish and	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
Wildlife Program – USFWS	Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	16
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	16, 17
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	6, 7
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	6, 7
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	9, 10
Pikeminnow	The goal of the program is to manage annual pikeminnow predation on juvenile	13

Program Name and Affiliation	Program Description	Measures Addressed
Management Program	salmonids. The program pays rewards to anglers for harvesting pikeminnow over a prescribed size, thus providing an incentive to remove the large, predaceous pikeminnow from the population.	
Caspian Tern Relocation Project	The goal of the project was to relocate terns to another location in the estuary where tern predation on juvenile salmonids would be reduced but the viability of the tern population would be maintained.	14

5.2.1.1.3 Coho Salmon

.5.2.1.1.3.1 Background

Coho (Oncorhynchus kisutch) salmon spawn during fall in small streams with the onset of spawning typically tied to fall freshets in September and October. Coho adults are almost entirely 3-year olds although a few jacks return at age 2. Juvenile coho rear in freshwater for one year prior to migration during spring. Lower Columbia River coho runs include early and late returning stocks. Most early-run fish migrate south to mature in coastal Oregon waters. Most late-run coho migrate north into Washington coastal waters, although many of the Oregon tributaries are populated with an s-type coho that migrate south.

.5.2.1.1.3.2 Status

Coho are currently a candidate for listing under the ESA. Coho salmon historically returned to spawn in all accessible tributary reaches in the lower Columbia River basin. Today, coho populations in Washington tributaries of the lower Columbia River have been heavily influenced by extensive hatchery releases. Past fishery impacts were excessive for coho, however, current fishing impacts are relatively low as a result of implementation of selective fisheries. Tributary hydropower development has blocked significant coho habitat in the Cowlitz and Lewis basins. Current stream habitat conditions severely limit coho production.

Recent numbers of natural coho spawners are generally unknown although most wild populations are thought to have been extirpated or consist of no more than a few hundred fish. Although 6 historical populations were identified in the recovery plan, at the time of its writing in 2001 the ODFW Lower Columbia River Coho plan (ODFW,2004) assumed that several of these populations had likely gone extinct. However, with the advent of improved ocean survival conditions and more rigorous spawning survey methodology it now appears that this judgment was premature; naturally produced coho were observed in all six key Oregon lower Columbia river populations in 2003. While it is too early to determine if these populations are self-sustaining, the signs are encouraging. Approximately 13 Washington lower Columbia River subbasins were historically used by coho salmon according to the NOAA Fisheries status review and Washington's salmon stock inventory. Recovery targets have not yet been proposed for coho because of incomplete habitat and status information on which they could be based.

Table 5-12. Coho salmon abundance estimates by life stage.

Life Stage	Historical Abundance	Current Abundance
Juvenile Rearing (out-of-subbasin	Historical productivity of coho	Current productivity of coho is

populations, Western Oregon tributaries)	was assumed to be 360 smolts per spawner (based on lower Cowlitz River EDT template estimate), an estimated 144 million juveniles used the lower mainstem, Western Oregon tributaries, estuary, and plume (based on assumed total Columbia River run of 400,000 [primarily hatchery fish]).	assumed to be 90 smolts per spawner (lower Cowlitz River EDT patient estimate). Based on this level of productivity, juveniles using the lower mainstem, Western Oregon tributaries, estuary, and plume is estimated to be 36 million (assuming a total Columbia River run of 400,000 [primarily hatchery fish]). The 2002 passage index of coho at Bonneville Power House #2 was 2.3 million fish.
Adult Migration (out-of-subbasin populations, Western Oregon tributries)	Historical total Columbia River run size ranged from about 50,000 to 1.6 million (primarily hatchery fish)	The 2000 total Columbia River run size was about 600,000 (primarily hatchery fish). The 2002 coho passage count at Bonneville Dam totaled 95,003. in 2003, 1080 natural spawners (thought to be primarily from hatchery strays) were observed in three downstream watersheds of the Western Oregon tributaries

.5.2.1.1.3.3 Value statement

Lower Columbia River coho salmon are currently a candidate species for listing under the Endangered Species Act; additionally, coho are culturally, economically, and ecologically important. Juvenile rearing in the lower mainstem, Western Oregon tributaries, estuary, and plume are a vital life history trajectory for coho. The restoration goal for lower Columbia coho is to increase the population to a self-sustaining, viable population that can provide for tribal, sport, and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage, it is likely that restoration efforts of coho will achieve the highest success in the lower Columbia mainstem, the estuary, and the various tributaries below Bonneville Dam. However, recovery efforts of upriver coho should continue to be pursued. Strategies and measures to return coho populations to viability throughout the historical distribution are among the highest level of importance.

.5.2.1.1.3.4 Limiting factor (Threats)

Coho salmon in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume have threats to both life stages expressed in the combined subbasins and adjacent tributaries. Historically, coho salmon populations were distributed throughout the Columbia River basin. Within the Lower Columbia River ESU, the Cowlitz and Lewis River subbasins likely supported the largest coho populations, although historical escapement data are limited. Each of these subbasins has undergone development of hydroelectric facilities that have blocked access to a considerable amount of historical coho spawning habitat. Downstream of Bonneville Dam, juvenile coho have been impacted by low flows, disconnected or lost habitats,

and predation losses. The period of estuarine residence may be a critical phase in the life history of coho and thus plays a major role in determining the size of the subsequent adult run back to fresh water.

Table 5-13. Coho salmon limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Juvenile Rearing (out-of-subbasin populations, Western Oregon tributaries)	Co.LF.1 Microdetritus-based food web. The current microdetritus-based food web is expected to be less productive than the historical macrodetritus-based food web. Loss of wetland and side channel habitat has reduced the local macrodetritus inputs from terrestrial and riparian habitats that supported the historical food web. Present detrital inputs to the food web are dominated by microdetritus from upriver sources and are controlled primarily by reservoir production and flow rates from Bonneville Dam. Further, the microdetritus-based food web is thought to be limited to the spatially-confined estuary turbidity maximum region.	High/Medium
	Co.LF.2 Loss of habitat connectivity. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids. As juveniles grow, they move across a spectrum of salinities, depths, and water velocities. Specifically, research suggests that proximity of feeding and refuge areas for stream-type salmonids may be important for survival and olfactory cues needed for a successful return migration.	High/High
	Co.LF.3 Predation mortality. Current primary sources of predation on coho are substantial, however, how current predation levels compare to those experienced historically is unknown. Primary predation sources on coho include Caspian terns and pikeminnow.	High/High
	Co.LF.4 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on salmonids. Exposure risks to coho are not clear; contaminant uptake may be through contaminated diet items.	Medium/Medium
	Co.LF.5 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on coho are unknown but are expected to be negative.	High/Low
	Co.LF.6 Density dependence. Density dependent mechanisms in the lower mainstem, Western Oregon tributaries, estuary, and plume may limit juvenile salmonid survival and productivity, however, the significance is unclear. NOAA Fisheries is currently conducting research intended to clarify this issue.	Low/Low
	Co.LF.7 Fitness and timing of juvenile salmonids entering the subbasin. Juveniles entering the subbasin from upriver via barge releases or dam passage experience lower survival than historical mainstem emigration prior to hydrosystem development.	High/High
	Co.LF-W.12. Urbanization, as well as agricultural and timber practices have caused a loss of habitat diversity and channel stability throughout the Western Oregon tributaries (WOTs). Habitat complexity is important for creating rearing opportunities for young-of-the-year coho	High/High
Adult Migration (out-of-	Co.LF.9 Dam passage. Coho likely experience some mortality and delay associated with mainstem dam passage, however, an average per dam survival rate estimate for coho was not available.	Medium/Medium

Life Stage	Limiting Factors	Impact/Certainty
subbasin populations, Western Oregon tributaries)	Co.LF.10 Migration barriers/ lack of resting habitats. Elevated water temperature or high water flow may act as a temporary adult migration barrier. Additionally, high water flow likely reduces available resting habitat for migrating adults. Hatchery weirs, culverts and other passage barriers exist in the Western Oregon tributaries that block access to potentially productive habitat.	Low/High
	Co.LF.11 Predation losses. Marine mammals (pinnepeds) prey on adult salmon, but the significance is unclear.	Low/Medium
Adult Spawning (western Oregon tributaries);	Co.LF-W.13 Hatchery impacts on diversity. Early hatchery practices resulted in the proliferation of s-type coho populations, which are not ideally matched with the environmental characteristics of the coast range ecological zone.	Medium
	Co.LF-W.14 Urbanization, as well as agricultural and timber practices have caused a loss of habitat diversity and channel stability throughout the Western Oregon tributaries (WOTs), resulting in the loss of spawning habitat	High

.5.2.1.1.3.5 Biological objectives & working hypotheses

Biological objectives for coho, based on desired environmental conditions, are formulated to support the value statement identified above. At present, we lack the ability to develop meaningful biological performance metrics to describe focal species response to subbasin habitat conditions in terms of productivity, capacity, abundance, or life history diversity. Coho utilize the lower mainstem, Western Oregon tributaries, estuary, and plume subbasins primarily for migration, although evidence suggests that juvenile coho feed as they migrate and that the brief mainstem and estuarine residence time is extremely important in the physiological transformation to smolts and in gathering olfactory cues needed for a successful return migration. Thus, actions within the lower mainstem and estuary subbasins (e.g. restored floodplain connectivity or predator management) can affect coho survival within the subbasins, however, biological performance levels are likely determined by out-of-subbasin effects (e.g. spawning tributary conditions or mainstem/ tributary dam passage success).

Table 5-14. Coho desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
Juvenile Rearing (all juveniles in the Columbia River Basin)	Co.PO.1 Protect existing rearing habitat to ensure no further net degradation. *Hypothesis Statement:* If current rearing habitat is protected, then juvenile rearing capacity and productivity in the lower mainstem, Western Oregon tributaries, estuary, and plume can be maintained. *Justification:* Protection and maintenance of existing rearing habitat will provide a base level of juvenile coho production and diversity. Further, protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High
	Co.PO.2 Restore connectivity between tributary deltas and the estuary, the river and the floodplain, as well as in-river habitats. *Hypothesis Statement:* If connectivity with the floodplain is restored, then juvenile coho productivity in the Western Oregon tributaries, estuary and mainstem will increase. *Justification:* Connectivity with the floodplain and tidally influenced areas of adjacent tributaries will restore macrodetrital inputs and alter the current food web. A macrodetritus-based food web will increase productivity and support greater life history diversity. Connectivity among in-river habitats can provide both resting and feeding habitats.	High	High/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	Co.PO.3 Reduce predation mortality on emigrating juveniles. *Hypothesis Statement:* If predation on juveniles is reduced, then juvenile coho survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Predation on juvenile salmonids in the lower Columbia River and estuary has increased as a result of increased predator populations, such as northern pikeminnow or Caspian terns. Predator control and relocation programs have been successful at reducing predation, however, it is unclear how current levels of predation compare to historical levels.	Medium	High/High
	Co.PO-W.10 Protect and restore juvenile rearing habitat in the Western Oregon tributaries *Hypothesis Statement:* If Juvenile rearing habitat in priority reaches of stream reaches in the Coastal stratum are restored juvenile rearing capacity and productivity in the subbasin can be enhanced *Justification:* Restoration of historically utilized rearing habitat in the Western Oregon tributaries will improve the diversity and spatial structure of the coast range DIPs		High/High
	Co.PO.4 Reduce contaminant exposure of emigrating juveniles. *Hypothesis Statement:* If contaminant exposure is reduced, then juvenile coho survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Contaminants have been shown to have detrimental effects on juvenile salmonids, such as decreased immune function, disrupted physiological processes, and generally reduced fitness. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. Exposure routes are not certain and may be from contact with contaminated substrates or uptake through prey.	High	Medium/Medium
	Co.PO.5 Document the interaction between emigrating juvenile coho and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then juvenile coho survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	High/Low

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	Co.PO.6 Develop an understanding of emigrating juvenile coho life history diversity and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of salmonid integration with the ecosystem increases, then management and recovery actions will proceed with greater certainty. *Justification:* Our current understanding of life history diversity and salmonid interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; ongoing research continues to increase our knowledge and reduce uncertainty.	High	High/Medium
	Co.PO.7 Evaluate/improve survival of upriver juvenile coho emigrating via barge or dam passage. *Hypothesis Statement:* If survival and fitness of emigrating upriver coho improves, then these fish will be better prepared for emigration through the lower mainstem, Western Oregon tributaries, estuary, and plume. *Justification:* Current survival/fitness of upriver fish is lower than historical conditions. This lower fitness may predispose fish to predation as they enter the subbasin, delay attainment of threshold size needed for smoltification, or disrupt physiological processes that control smoltification.	High	High/High
Adult Migration (all adults in the Columbia River Basin)	Co.PO.8 Maintain favorable water flow and temperature throughout mainstem migration period (~ August-November). *Hypothesis Statement:* If extreme water flows or temperatures exist during migration, then spawning may be delayed or averted. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier that generally results in one of three outcomes: delayed arrival to spawning grounds, spawning activity in less than desirable locations, or no spawning. Each of these scenarios often results in decreased juvenile fitness or productivity.	Medium	Medium/High
	Co.PO.9 Reduce predation mortality on migrating adults. *Hypothesis Statement:* If predation on adults is reduced, then coho survival in the estuary and mainstem will increase. *Justification:* Marine mammal predation on adult salmonids in the lower Columbia River and estuary has been observed. Predation mortality may be significant and needs to be quantified.	High	Low/Medium

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	Co.PO-W.11 Eliminate or mitigate artificials access barriers for migrating adults, creating additional spawning & rearing habitat- *Hypothesis Statement:* If access to high quality habitat within the historic range of coho is restored, abundance will be improved *Justification:* Restoration of access to productive habitat will improve population diversity and spatial structure of DIPs within the coastal stratum		
	Co.PO-W.15 Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery derived stocks. *Hypothesis*: Continuation of Select Area (terminal) fishing opportunities in the lower Columbia River will support productive sport and commercial fisheries on harvestable stocks without negatively affecting rebuilding efforts directed at weak stocks. *Justification*: Commercial and recreational harvest in the lower Columbia River has the potential to negatively impact salmonid stocks, if not managed and directed. Harvesters are generally agreeable to targeting specific hatchery stocks, and the technology exists to manage fisheries with selectivity in the estuary without negatively impacting biological diversity and genetic integrity of wild stocks.		
Adult Spawning (Western Oregon tributaries);	Co.PO-W.12 Restore N-type coho to coastal stratum *Hypothesis Statement:* If late-run type of coho were returned to the Western Oregon tributaries, viability of the population would be improved. *Justification:* The physical and environmental characteristics of watersheds in the coastal range ecological zone are suited to support a late-run (n-type) coho population. Restoration of this population would add needed diversity to these DIPs		
	Co.PO-W.13 Protect and restore adult spawning spawning habitat in the Western Oregon tributaries *Hypothesis Statement:* If Juvenile spawning habitat in priority reaches of stream reaches in the Coastal stratum are restored juvenile rearing capacity and productivity in the subbasin can be enhanced *Justification:* Restoration of historically utilized spawning habitat in the Western Oregon tributaries will improve the diversity and spatial structure of the coast range DIPs		

5.2.1.1.4 Strategies

Habitat potential includes both quantity and quality. The properly functioning benchmark is less than the pristine historical condition. Properly functioning conditions (PFC) represent favorable habitat for salmon as defined by NOAA Fisheries. PFC generally represent a reasonable upper bound on the potential for habitat improvement although in some cases presume large-scale changes that would be difficult to implement (e.g. levee removal). As a general rule, populations may typically be considered viable when properly functioning conditions exist throughout the historical distribution. However, populations may also be viable where not all available habitat is properly functioning. Populations may sometimes fall short of viability despite properly functioning habitat conditions, if the historical range has been substantially reduced or other mortality factors are severe.

Healthy, harvestable salmon populations depend on favorable habitats for spawning and rearing. Salmon populations typically go extinct when periodic poor ocean conditions drive populations in poor habitat to low numbers from which they cannot rebound. High quality habitat increases fish population productivity which helps maintain adequate numbers even during poor ocean conditions and allows them to rebound quickly. Populations can typically withstand some combination of stream habitat degradation, mainstem and estuary habitat degradation, and other impacts such as fishing or hatchery domestication. Historical populations appeared to sustain very high fishing and hatchery impacts prior to the cumulative effects of widespread habitat declines. Conversely, no level of fishery or hatchery reductions will be sufficient to offset severe habitat declines.

Current habitat conditions in most areas are much less favorable than historical conditions and substantially less favorable than necessary to support viable wild salmon and steelhead populations. Assessments detailed in the Technical Foundation identified tributary habitat degradation as the largest single impact among the various limiting factors (i.e. the 4-Hs). Land and water use practices have contributed large decreases in habitat quality and quantity in all subbasins.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving salmon habitat conditions in some areas and will further improve salmon habitat over time, but additional changes are needed in many areas to support the recovery of wild populations. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on salmon and increased commitment to protect this resource. More fish-friendly practices have been implemented for many activities both before and after listing of salmon. Some changes have already produced effects; others will be expected to pay future dividends. Still others will be needed to offset the cumulative effects of years of habitat degradation.

A significant level of increased habitat protection and restoration will be required to just to arrest declining trends and ensure that population status does not decline further. Additional efforts will be required to make substantial gains. Recovery depends on arresting and reversing declining trends in salmon numbers. The size of the required change will depend on the steepness of the decline and the level of improvement needed to meet region-wide recovery goals. Projected human population growth in lower Columbia river subbasins will compound the demands for increased habitat protection and restoration just to stabilize fish populations at current levels.

Salmon depend on suitable habitat conditions which in turn are regulated by conditions in adjacent and upstream watersheds. Local habitat activities can provide short term benefits but long-term improvements in habitat conditions will depend on restoration of functional watershed processes. Where watershed processes are not intact, habitat conditions rapidly revert to equilibrium with their surroundings.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue. For instance, riparian protection measures might require 50-150 years to provide full benefits based on the time it takes for trees to mature and restore shade and channel stability, then die and provide woody debris and channel diversity. Because of the required scale and delayed effects, watershed improvements typically provide limited prospects for immediate relief of acute extinction risks for salmon caused by current low numbers.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance. However, protection measures alone will not suffice to recover some species to viability, especially in light of future growth trends. The geographical distribution of some species overlaps significantly with areas that have been subjected to significant human disturbance, including urban development and agriculture. Active restoration in previously disturbed areas may be necessary for recovery.

Although effects may often be temporary, site-specific improvements in habitat conditions and access, in concert with non-habitat measures can help ameliorate immediate extinction risks in the interim, until underlying causes of stream habitat declines are addressed. Even where recent changes to land and water use patterns can be expected to provide suitable conditions for population viability in the long term, more immediate actions may be required to make sure that the fish are around to reap those long term benefits.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by salmon and steelhead populations to any given suite of actions. These uncertainties limit our ability to stipulate precise levels of improvement needed to achieve recovery. The recovery plan needs to recognize these uncertainties with adequate safety factors, contingences, and in-course corrections.

Habitat

Co.S1. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Physical Objectives Addressed: Co.PO.1, Co.PO.2, Co.PO.8, Co.PO-W.13, and Co.PO-W.10,

Explanation: Important habitats in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

Co.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Physical Objectives Addressed: Co.PO.1, Co.PO.2, Co.PO.8,Co.PO-W.13, and Co.PO-W.10

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

Co.S3. Avoid large-scale habitat changes where risks to salmon and steelhead are uncertain.

Physical Objectives Addressed: Co.PO.1

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that things don't continue to get worse.

Co.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: Co.PO.1, Co.PO-W.10, Co.PO-W.13

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

Co.S5. Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Physical Objectives Addressed: Co.PO.1, Co.PO.2, Co.PO-W.10, and Co.PO-W.13

Explanation: Salmonid recovery is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will require some restoration of areas that are substantially degraded but also provides significant flexibility in where habitat restoration efforts are distributed among and within subbasins.

Co.S6. Utilize a combination of active and passive habitat restoration measures to provide near term and long term benefits.

Physical Objectives Addressed: Co.PO.1, Co.PO.2, Co.PO.8, Co.PO-W.10, and Co.PO-W.13

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but effects are rarely lasting unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures in the riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions).

Co.S7. Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Physical Objectives Addressed: Co.PO.6

Explanation: Salmon are an integral component of both the freshwater and marine ecosystem of which they are a part. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the status of salmon. Many significant salmon predators including bull trout, eagles, and grizzly bears have declined concurrent with salmon declines, albeit for a variety of reasons. Large numbers of salmon returning to spawn streams also introduce significant amounts of marine-derived nutrients into freshwater systems. These nutrients may stimulate primary and secondary productivity when other appropriate habitat conditions exist; this increased productivity increases food for juvenile salmon as well as other species. Finally, salmon actually affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

Co.S-W7. Open access to productive habitat by removing or mitigating passage barriers

Physical Objectives Addressed: CoPO-W.11

Explanation: Tide gates, culverts, hatchery weirs, and other barriers have impeded or severed access to habitat that was historically productive, and which could yet provide additional spawning and rearing habitat for salmonids that are currently limited by the amount of available productive habitat. In some cases around hatcheries, barriers have been been erected to prevent potentially disease infected fish from spawning upstream of the water intake for the hatchery and transferring disease to fish being raised at the hatchery. One of the recovery plan strategies for some salmonid populations is to to provide adult passage at several of these locations, consistent with the likelihood of gains in natural production and not unduly compromising the hatchery rearing environment in terms of disease.

Co.S-W8. Promote management actions that support sufficient life-history diversity to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes.

Physical Objectives Addressed: Co.PO-W.13

Explanation: Viable salmonid population parameters suggest that sufficient life-history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. Metrics and benchmarks for evaluating the diversity of a population should be evaluated over multiple generations and should include a substantial proportion of the diversity of a life-history trait(s) that existed historically, gene flow

and genetic diversity similar to historical (natural) levels and origins, successful utilization of habitats throughout the range, and resilience and adaptation to environmental fluctuations.

Introduced Species

Co.S8. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introducing species.

Physical Objectives Addressed: Co.PO.5

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Predators

Co.S9. As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Physical Objectives Addressed: Co.PO.3 and Co.PO.9

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Research

Co.S10. Our understanding of the relationships between coho and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: Co.PO.1 through Co.PO.9

Explanation: Emerging research and understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume are promising tools in the near future. Also needed are additional understanding about how coho populations use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume. Additionally, future research should also focus on establishing

clear relationships between coho and the various predators or introduced species in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Co.S11. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: Co.PO.1 through Co.PO.9

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection, habitat restoration, and recovery measures are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

Co.S12. Assess the Mainstem Lower Columbia River and Columbia River Estuary by discreet geographic reaches for restoration and protection priorities.

Physical Objectives Addressed: Co.PO.1, Co.PO.2, Co.PO.3, Co.PO.4, Co.PO.6, Co.PO.8, and Co.PO.9

Explanation: A chronic problem exists in the information systems of resource planners who are unable, today, to accurately inventory where protection and restoration work has been completed or is ongoing, and where additional work is needed. Throughout the subbasin planning process, an urgent need was identified to develop a "desktop" triage tool to identify where measures should be applied, or where mitigation steps might be needed in response to some natural or anthropogenic system disturbance. A systematic way of identifying the protection and restoration potential of specific areas within the subbasin needs to be developed. Such a system could then provide a means for prioritizing actions.

Sustainable Fisheries

Co.S15 Optimize continued harvest of healthy hatchery stocks while reducing harvest rates on weak, endangered stocks in mixed stock, mainstem fisheries.

Explanation: As native salmon runs on the Lower Columbia River diminished, the fishing community looked for a way to bolster the commercial industry, a backbone of the region's economy for generations of families. The goal was to were to create and expand known stock fisheries for high-quality salmon in the Columbia River Basin while providing greater protection for endangered stocks. In its 1993 Strategy For Salmon, the Northwest Power Planning Council recommended that select area (formerly terminal area) fishing sites be identified and developed to harvest abundant fish stocks while minimizing the incidental harvest of weak stocks. The Council, through its Fish and Wildlife Program, called on the BPA to: “Fund a study to evaluate potential terminal fishery sties and opportunities. Beginning in 1993, BPA initiated the Columbia River Terminal Fisheries Project (now the Columbia River Select Area Fishery Evaluation Project), a 10-year comprehensive program to investigate the feasibility of select area fisheries in Youngs Bay and other sites in Oregon and Washington (BPA 1996, Miller et al. 2002). Select area fisheries are being explored as a means to increase the sport and commercial harvest of hatchery fish while providing greater protection of weak wild salmon stocks. Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.

.5.2.1.1.4.1 Measures to achieve strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary.

Habitat

Co.M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Loss of tidal swamp and marsh habitat has respectively resulted in an estimated 77% and 43% loss of these habitat types from 1870 to 1983. The substantial acreage loss of the tidal swamp and tidal marsh habitat types has reduced local inputs of macrodetritus, thereby converting the estuarine foodweb to a microdetritus base dominated by upriver reservoir inputs. Additionally, although ocean-type salmonids are typically associated with these shallow water, peripheral habitats, evidence suggests that stream-type salmonids also use these habitats.

Variables	Context
Strategies addressed	Co.S1, Co.S2, Co.S3, Co.S4, Co.S5, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of tidal and marsh habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of tidal marsh and swamp habitats would have a high benefit because they may increase food web productivity and provide resting habitat for stream-type salmonids.
Barriers to success	*Explanation:* Tidal marsh and swamp habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

Co.M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified lower mainstem, Western Oregon tributaries, estuary, and plume habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that emulate a more natural regime will help improve habitat conditions for salmonids and other resident fish and wildlife species.

Variables	Context
Strategies addressed	Co.S1, Co.S2, Co.S3, Co.S4, Co.S5, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit.
Barriers to success	*Explanation:* An annual allocation of water for salmonids will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

Co.M3. Maintain adequate water flows throughout migration periods.

Explanation: Prevents migration barriers, high temperatures in late summer, lack of resting habitats, and predation losses. Facilitates juvenile movement through the mainstem to the estuary.

Variables	Context
Strategies addressed	Co.S1, Co.S2, Co.S3, Co.S4, Co.S5, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for maintaining water flows during migration. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	Medium. *Explanation*: Maintenance of water flows during migration would have a medium benefit because of the significance of the subbasins as a migratory pathway and for juvenile rearing/smoltification.
Barriers to success	*Explanation:* Maintenance of water flows during migration will be possible through the modification of current water uses, which at present seems possible if current water budget is only modified for brief periods. Additionally, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

Co.M4. Restore connectedness between river and floodplain.

Explanation: Restoring the access to the floodplain increases juvenile salmonid access to shallow water, low velocity, peripheral habitats. Further, connection of the river and floodplain begins to restore the historical macrodetritus-based food web.

Variables	Context
Strategies addressed	Co.S1, Co.S2, Co.S3, Co.S4, Co.S5, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

Co.M5. Protect and restore riparian and wetland habitat condition and function.

Explanation: Riparian zones are critical habitats for many species. This measure incorporates a variety of tools including, local land use regulatory actions, acquisition, and restoration activities. This measure is inherently linked with measures 1 and 4.

Variables	Context
Strategies addressed	Co.S1, Co.S2, Co.S3, Co.S4, Co.S5, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective for *protecting* wetland and riparian habitats. The current programs cannot be expected to attain the physical objective for *restoring* wetland and riparian habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of riparian habitats would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Riparian and wetland habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

Co.M6. Restore impaired sediment transport processes affecting the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Sediment dynamics are a critical component of lower mainstem, Western Oregon tributaries, estuary, and plume habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation, and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	Co.S1, Co.S2, Co.S3, Co.S4, Co.S5, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

Co.M7. Mitigate channel dredging activities in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that alter habitat forming processes, reduce salmon population resilience, and inhibit recovery.

Explanation: Channel dredge activities affect the quality of the various lower mainstem, Western Oregon tributaries, estuary, and plume salmonid habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Indirectly, wakes from large ships increase erosion and can cause stranding of juvenile salmonids located along the shoreline. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context
Strategies addressed	Co.S1, Co.S2, Co.S3, Co.S4, Co.S5, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for mitigating dredging activity effects. The primary reason is that the sole purpose of the Channel Deepening BiOp is to protect ESA-listed salmonids and their habitat while allowing dredging activity to proceed.
Potential to contribute to biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects throughout the channel deepening process and beyond. However, there remains uncertainty as to the short- and long-term effects of channel modification on flow dynamics, sediment transport, and habitat forming processes.

Co.M8. Limit the effects of toxic contaminants on salmonid fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on salmonids, resident fish, or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	Context
Strategies addressed	Co.S4, Co.S7, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and

Variables	Context
	estuary, as well as uncertainty in exposure risks to salmonids.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

Co.M-W8. Implement mitigation and enhancement measures to provide access to productive spawning and rearing habitat

Explanation: Watershed Assessments in the Western Oregon tributaries include in many cases fish passage surveys. Culverts and other passage barriers have been inventoried and prioritized.

Variables	Context
Strategies addressed	Co.S-W7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6 (make sure to add ODFW endangered species plan)
Program Gap Analysis	*Analysis:* While many passage barriers can be address through systematic review of passage barrier inventories, the current programs and/or projects cannot be expected to attain the physical objective for providing additional habitat. The primary reason is uncertainty on the best means for protecting against spreading disease past hatchery wiers.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of providing additional access to potentially productive habitat are significant, however uncertainty remains on the best means of protecting against desease.
Barriers to success	*Explanation:* Hatchery policies that manage the risk of spreading disease; financial means to address barriers in a systematic way

Co.M-W12. Seek methods for restoring historic run timing to coastal stratum, including the Western Oregon tributaries.

Explanation: Hatchery practices promulgated an early-run (s-type) variety of coho; combined with harvest regimes, these practices have contributed to the virtual extirpation of late-run coho from the Western Oregon tributaries and other coastal demographically independent populations. The habitat characteristics of these WOTs watersheds are suited to sustain an n-type of coho stock, and could be very successful.

Variables	Context
Strategies addressed	Co.S-W8
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for ??
Potential to contribute to biological objectives	High. *Explanation*:
Barriers to success	*Explanation:*

Introduced Species

Co.M9. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	Co.S3, Co.S4, Co.S7, Co.S8, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to	High.

Variables	Context
biological objectives	*Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

Co.M10. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	Co.S7, Co.S8, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Co.M11. Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon bycatch. The impacts of shad on salmon are unclear but the large shad population biomass has the potential for significant impacts. Elimination or control of shad is not a silver bullet for salmon recovery but the significance of interactions and opportunities for management warrant closer consideration.

Variables	Context
Strategies addressed	Co.S7, Co.S8, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing shad management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of shad.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Co.M12. Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.

Explanation: Established populations may be managed to shape fishery benefits as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. Walleye fisheries can be managed with size regulations for instance to shape fishery benefits with no effect on salmonids.

Variables	Context
Strategies addressed	Co.S7, Co.S8, Co.S9, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing gamefish management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of gamefish.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Predators

Co.M13. Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikeminnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

Variables	Context
Strategies addressed	Co.S7, Co.S9, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing pikeminnow predation on juvenile salmonids. Currently, there are no plans to discontinue the pikeminnow management program.
Potential to contribute to biological objectives	High. *Explanation*: Continued management of pikeminnow predation will minimize predation effects on juvenile salmon.
Barriers to success	*Explanation:* The current pikeminnow management program has been successful at removing the large, predaceous pikeminnow from the population, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

Co.M14. Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where salmon predation might pose added risks.

Variables	Context
Strategies addressed	Co.S3, Co.S4, Co.S7, Co.S9, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing Caspian tern predation on juvenile salmonids. Currently, there are no plans to discontinue the Caspian tern relocation program.
Potential to contribute to biological objectives	High. *Explanation*: Caspian tern predation in the past has been substantial, thus, continued tern management will minimize predation effects on juvenile salmon.
Barriers to success	*Explanation:* The current Caspian tern relocation program has been successful at relocating the tern colony from Rice to East Sand Island, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

Co.M15. Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.

Explanation: Only after adoption of the U.S. Marine Mammal Protection Act have seals and sea lions begun to recover from historical low levels. Populations have expanded greatly and significant numbers now occur in the lower Columbia River.

Variables	Context
Strategies addressed	Co.S7, Co.S9, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs in place that are intended to quantify the amount and significance of pinniped predation on adults salmonids.
Potential to contribute to biological objectives	Low. *Explanation*: The significance of pinniped predation on adult salmonids is unclear but expected to be somewhat low.
Barriers to success	*Explanation:* Establishing regulatory control of pinnipeds to limit predation on adult salmonids is challenged by pinniped protection under the Marine Mammal Protection Act, however, some level of management is possible if warranted for salmon recovery.

Research

Co.M16. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of causal relationships between salmonids, resident fish, and wildlife species is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	Co.S2, Co.S3, Co.S5, Co.S7, Co.S8, Co.S9, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

Co.M17. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by ocean- and stream-type salmonids is poorly understood. The use of tagging and other marking studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	Co.S7, Co.S10, and Co.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of salmonid behavior and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding salmonid life history diversity and mainstem/estuary/ plume habitat use will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

Co.M19. Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Mainstem Lower Columbia River and Columbia River Estuary

Explanation: Identifying priority habitat for protection and restoration within the Mainstem Lower Columbia River and Columbia River Estuary should be a priority. The approach should be the development of both a tool and a process that could be used iteratively to provide an adaptive management framework for resource planners. In the Columbia basin tributaries, Ecosystem Diagnostic and Treatment (EDT) has provided planners with a quantitative method for determining prioritiesand for modeling likely outcomes. Such a tool has been difficult to apply to the estuary because many species with use the estuary for critical life stages do not produce in the estuary. The challenge will be to develop a tool that reflects the importance of the estuary that use it for important but non-productive portions of their life history.

Variables	Context
Strategies addressed	Co.S1, Co.S2, Co.S5, Co.S6, Co.S12, and Co.S-W7
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are insufficient for determining where to target protection and restoration activities, although our understanding of the habitat forming processes and relationships between species and habitat attributes is growing significantly.
Potential to contribute to biological objectives	High. *Explanation*: While measures and strategies intended to effect positive change in the Mainstem Lower Columbia River and Columbia River Estuary are becoming clear, knowing where to apply these measures is uncertain. Tools that help target resources will increase all other measures chances of being successful.
Barriers to success	*Explanation:* A key goal of any desktop management goal should be to provide a means of predicting outcomes of restoration and protection activities, but standard measures of performance, for example, production and abundance are likely to occur out-of-basin, making expected outcomes a difficult measure to quantify.

Sustainable Fisheries

Co.M20. Continue the Select Area Fisheries Project

Explanation: The project primarily utilizes existing hatchery facilities to spawn, hatch, and conduct initial rearing of juvenile salmonids for subsequent out planting to net pen facilities at each of the select area sites. Hatcheries providing production are South Fork Klaskanine (CEDC); Big Creek, Bonneville, Cascade, Gnat Creek, North Fork Klaskanine, Oxbow, Sandy, South Santiam, and Willamette (all ODFW); Cowlitz, Elochoman, and Gray's River (all WDFW), and Eagle Creek (USFWS). The Clatsop Count Economic Development Council (CEDC) Fisheries Project operates estuarine net-pen sites in Youngs Bay, Tongue Point, and Blind Slough. The Washington Department of Fish and Wildlife has net-pen sites at Deep River and Steamboat Slough. Fish are grown and released from these pens under varying management and grow-out regimes including two-week acclimation, over-winter, and full term net pen rearing. Annual releases for 2000-2003 have averaged 3.8 million coho, 1.0 million spring chinook, and 1.0 million select area bright fall chinook (includes ODFW's Restoration and Enhancement production). Ex-vessel values of 2000-2003 SAFE commercial fisheries were $408,000-$787,000, with state-level personal income impacts of $1.4 - $3.1 million dollars for al l regional fisheries combined.

Variables	Context
Strategies addressed	Co.S15
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Program Table (CEDC Fisheries)
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are sufficient for directing harvest of commercial and recreational fishers to targeted stocks of hatchery stocks of summer Chinook, fall Chinook, and Coho
Potential to contribute to biological objectives	High. *Explanation*: The Terminal Fisheries project has been demonstrated to be effectives for addressing the following objectives: Supports a healthy Columbia basin, Maintains biological diversity, Maintains genetic integrity, Increases run sizes or populations As these objectives are addressed by the measure, the wants, needs, and desires of the fishers can be met.
Barriers to success	*Explanation:* Barriers to success are very low, as most of the logistical and technical problems have been addressed. The project has addressed concerns about juvenile interactions, predation, and straying. The major barrier is that the program is not self-

	sustaining

.5.2.1.1.4.2 *Programs to implement strategies and measures*

Table 5-15. Existing programs and their connection to recovery measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	1, 4, 5
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; collaboration with these efforts is vital.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	5
CEDC Fisheres	Manages Select Area Fishing project to direct harvest away from listed stocks, and mitigate for lack of harvest in the lower Columbia River	20
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	5
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	5
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	5
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	6
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	6
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	5
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	2, 3, 6
Washington State Conservation	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct	1, 4

Program Name and Affiliation	Program Description	Measures Addressed
Commission/ Conservation Districts	surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 4, 5, 6, 7, 8
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	1, 4, 5
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 5, 7
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	2, 3, 8
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 5, 8
Habitat Program – WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a	1, 4, 5, 6, 10, 11, 12, 13, 16, 17

Program Name and Affiliation	Program Description	Measures Addressed
	partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	1, 4, 5
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 4, 5, 6, 8
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	The goal of the SRFB is to protect and restore salmon habitat. The board provides grant funds to protect or restore salmon habitat and assist related activities; it works closely with local watershed groups. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SRFB guides spending of funds targeted for salmon recovery activities and projects.	1, 4, 5, 6
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	8
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	1, 5
Partners for	The program is the USFWS's primary mechanism for delivering voluntary on-	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
Fish and Wildlife Program – USFWS	the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	16
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	16, 17
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	6, 7
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	6, 7
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	9, 10

Program Name and Affiliation	Program Description	Measures Addressed
Pikeminnow Management Program	The goal of the program is to manage annual pikeminnow predation on juvenile salmonids. The program pays rewards to anglers for harvesting pikeminnow over a prescribed size, thus providing an incentive to remove the large, predaceous pikeminnow from the population.	13
Caspian Tern Relocation Project	The goal of the project was to relocate terns to another location in the estuary where tern predation on juvenile salmonids would be reduced but the viability of the tern population would be maintained.	14

5.2.1.1.5 Winter Steelhead

.5.2.1.1.5.1 Background

Steelhead (Oncorhynchus mykiss) are rainbow trout that migrate to and from the ocean. Resident and anadromous life histories are often found in the same population. Steelhead exhibit tremendous variability in life history with juveniles rearing for 1 to 4 years in freshwater before migrating seaward and as adults spending 1 to 3 years in the ocean. Steelhead generally migrate northward along the coast of Canada and Alaska before dispersing far out into the North Pacific. Winter steelhead return to fresh water between December and May and generally spawn in late April and early May. In the lower Columbia River, winter steelhead returned to the Cowlitz, Kalama, NF and EF Lewis, Washougal, and Wind. Where winter and summer runs occur in the same stream, winter steelhead tend to spawn lower in the watershed than summer steelhead.

.5.2.1.1.5.2 Status

Lower Columbia River steelhead are listed as threatened under the ESA. The Willamette/Lower Columbia Technical Recovery Team has identified 23 historical populations of steelhead in the Lower Columbia River ESU. Washington accounts for 14 of 17 winter run steelhead and 5 of 6 summer run steelhead populations in this ESU. Three additional winter run populations of the unlisted Washington Coast ESU occur in lower Columbia subbasins included in this planning process. Small but significant steelhead populations remain in most Washington subbasins where they were historically present. All Washington lower Columbia winter steelhead populations are below proposed recovery planning targets with the possible exception of the Kalama winter steelhead population.

Table 5-16. Winter steelhead abundance estimates by life stage.

Life Stage	Historical Abundance	Current Abundance
Juvenile Rearing (out-of-subbasin populations, Western Oregon tributaries)	Historical productivity of winter steelhead was assumed to be 265 smolts per spawner (based on Kalama River EDT template estimate), an estimated 26.5 million juveniles used the lower mainstem, Western Oregon tributaries, estuary, and plume (based on assumed Columbia	Current productivity of winter steelhead is assumed to be 70 smolts per spawner (Kalama River EDT patient estimate). Based on this level of productivity, juveniles using the lower mainstem, Western Oregon tributaries, estuary, and plume is estimated to be 1.75 million (assuming a

Life Stage	Historical Abundance	Current Abundance
	River abundance index of 100,000).	Columbia River abundance index of 25,000). The 2002 passage index of steelhead (combined) at Bonneville Power House #2 was 1.5 million fish.
Adult Migration (out-of-subbasin populations, Western Oregon tributaries)	Historical Columbia River winter steelhead abundance index has ranged from about 50,000 to 175,000. Historical winter steelhead abundance in the Western Oregon tributaries subbarea is unknown	The 2000 Columbia River winter steelhead abundance index was about 20,000. The 2002 steelhead (combined) passage count at Bonneville Dam totaled 481,036; the 'wild' component was 143,032.. Current winter steelhead abundance in the Western Oregon tributaries subbarea is unknown

.5.2.1.1.5.3 Value statement

Lower Columbia River steelhead are currently listed as threatened under the Endangered Species Act; additionally, winter steelhead are culturally, economically, and ecologically important. Juvenile rearing in the lower mainstem, Western Oregon tributaries, estuary, and plume are a vital life history trajectory for winter steelhead. The restoration goal for lower Columbia winter steelhead is to increase the population to a self-sustaining, viable population that can provide for tribal, sport, and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage and winter steelhead were historically destined primarily for tributaries below Bonneville Dam, it is likely that restoration efforts of winter steelhead will achieve the highest success in the lower Columbia mainstem, the estuary, and the various tributaries below Bonneville Dam. However, recovery efforts of the few winter steelhead populations above Bonneville Dam should still be pursued. Strategies and measures to return winter steelhead populations to viability throughout the historical distribution are among the highest level of importance.

.5.2.1.1.5.4 Limiting factor (Threats)

Winter steelhead in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume have threats to both life stages expressed in the combined subbasins and adjacent tributaries. Historically, winter steelhead populations were distributed throughout the lower Columbia River basin, up to about the Klikitat River on the Washington side and Hood River on the Oregon side. Within the Lower Columbia River ESU, the Cowlitz and Lewis River subbasins likely supported the largest winter steelhead populations, although historical escapement data are limited. Each of these subbasins has undergone development of hydroelectric facilities that have blocked access to a considerable amount of historical winter steelhead spawning habitat. Downstream of Bonneville Dam, juvenile winter steelhead have been impacted by low flows, disconnected or lost habitats, and predation losses. The period of

estuarine residence may be a critical phase in the life history of winter steelhead and thus plays a major role in determining the size of the subsequent adult run back to fresh water.

Table 5-17. Winter steelhead limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Juvenile Rearing (out-of-subbasin populations and Western Oregon tributaries)	WS.LF.1 Microdetritus-based food web. The current microdetritus-based food web is expected to be less productive than the historical macrodetritus-based food web. Loss of wetland and side channel habitat has reduced the local macrodetritus inputs from terrestrial and riparian habitats that supported the historical food web. Present detrital inputs to the food web are dominated by microdetritus from upriver sources and are controlled primarily by reservoir production and flow rates from Bonneville Dam. Further, the microdetritus-based food web is thought to be limited to the spatially-confined estuary turbidity maximum region.	High/Medium
	WS.LF.2 Loss of habitat connectivity. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids. As juveniles grow, they move across a spectrum of salinities, depths, and water velocities. Specifically, research suggests that proximity of feeding and refuge areas for stream-type salmonids may be important for survival and olfactory cues needed for a successful return migration.	High/High
	WS.LF.3 Predation mortality. Current primary sources of predation on winter steelhead are substantial, however, how current predation levels compare to those experienced historically is unknown. Primary predation sources on winter steelhead include Caspian terns and pikeminnow.	High/High
	WS.LF.4 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on salmonids. Exposure risks to winter steelhead are not clear; contaminant uptake may be through contaminated diet items.	Medium/Medium
	WS.LF.5 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on winter steelhead are unknown but are expected to be negative.	High/Low
	WS.LF.6 Density dependence. Density dependent mechanisms in the lower mainstem, Western Oregon tributaries, estuary, and plume may limit juvenile salmonid survival and productivity, however, the significance is unclear. NOAA Fisheries is currently conducting research intended to clarify this issue.	Low/Low
	WS.LF.7 Fitness and timing of juvenile salmonids entering the subbasin. Juveniles entering the subbasin from upriver via barge releases or dam passage experience lower survival than historical mainstem emigration prior to hydrosystem development.	High/High
	WS.LF-W.13 Urbanization, as well as agricultural and timber practices have caused a loss of habitat diversity and channel stability throughout the Western Oregon tributaries (WOTs). Habitat complexity is important for creating rearing opportunities for young-of-the-year	

Life Stage	Limiting Factors	Impact/Certainty
Adult Migration (out-of-subbasin populations)	WS.LF.9 Dam passage. Winter steelhead experience some mortality and delay associated with mainstem dam passage. For Lower Columbia River mainstem dams, average per dam survival rate estimate for steelhead was 95%; this estimate includes fallback and re-entry.	Medium/High
	WS.LF.10 Migration barriers/ lack of resting habitats. Elevated water temperature or high water flow may act as a temporary adult migration barrier. Additionally, high water flow likely reduces available resting habitat for migrating adults. Hatchery weirs, culverts and other passage barriers exist in the Western Oregon tributaries that block access to potentially productive habitat.	Low/High
	WS.LF.11 Predation losses. Marine mammals (pinnepeds) prey on adult salmon, but the significance is unclear.	Low/Medium
Adult Spawning (Western Oregon tributaries)	WS.LF-W.12. Decreased flows in tributaries during spawning and incubation. Agricultural and urban use of in-stream flows substantially effects water flow in Western Oregon tributaries spawning locations. Low flow may decrease the delivery of nutrients and dissolved oxygen to incubating eggs, thereby decreasing survival.	

.5.2.1.1.5.5 Biological objectives & working hypotheses

Biological objectives for winter steelhead, based on desired environmental conditions, are formulated to support the value statement identified above. At present, we lack the ability to develop meaningful biological performance metrics to describe focal species response to subbasin habitat conditions in terms of productivity, capacity, abundance, or life history diversity. Winter steelhead utilize the lower mainstem, Western Oregon tributaries, estuary, and plume subbasins primarily for migration, although evidence suggests that juvenile winter steelhead feed as they migrate and that the brief mainstem and estuarine residence time is extremely important in the physiological transformation to smolts and in gathering olfactory cues needed for a successful return migration. Thus, actions within the lower mainstem and estuary subbasins (e.g. restored floodplain connectivity or predator management) can affect winter steelhead survival within the subbasins, however, biological performance levels are likely determined by out-of-subbasin effects (e.g. spawning tributary conditions or mainstem/ tributary dam passage success).

Table 5-18. Winter steelhead biological performance levels.

Metric[a]	Performance Level
Mortality[b]	Current mortality estimates range from 0.10 to 0.18 and average 0.14. Mortality estimates at population recovery goals range from 0.10 to 0.18 and average 0.10.

[a] Mortality metric applies to out of subbasin winter steelhead populations.

[b] Mortality is based on preliminary analysis by the LCFRB based on comparison of EDT estimates of mainstem and estuary habitat effects on lower Columbia River winter steelhead populations, current population abundance estimates, and population abundance recovery goals.

Table 5-19. Winter steelhead desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
Juvenile Rearing (all juveniles in the Columbia River Basin)	WS.PO.1 Protect existing rearing habitat to ensure no further net degradation. *Hypothesis Statement:* If current rearing habitat is protected, then juvenile rearing capacity and productivity in the lower mainstem, Western Oregon tributaries, estuary, and plume can be maintained. *Justification:* Protection and maintenance of existing rearing habitat will provide a base level of juvenile winter steelhead production and diversity. Further, protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High
	WS.PO.2 Restore connectivity between river and floodplain, as well as in-river habitats. *Hypothesis Statement:* If connectivity with the floodplain is restored, then juvenile winter steelhead productivity in the Western Oregon tributaries, estuary and mainstem will increase. *Justification:* Connectivity with the floodplain and tidally influenced areas of adjacent tributaries will restore macrodetrital inputs and alter the current food web. A macrodetritus-based food web will increase productivity and support greater life history diversity. Connectivity among in-river habitats can provide both resting and feeding habitats.	High	High/High
	WS.PO.3 Reduce predation mortality on emigrating juveniles. *Hypothesis Statement:* If predation on juveniles is reduced, then juvenile winter steelhead survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Predation on juvenile salmonids in the lower Columbia River and estuary has increased as a result of increased predator populations, such as northern pikeminnow or Caspian terns. Predator control and relocation programs have been successful at reducing predation, however, it is unclear how current levels of predation compare to historical levels.	Medium	High/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	WS.PO.4 Reduce contaminant exposure of emigrating juveniles. *Hypothesis Statement:* If contaminant exposure is reduced, then juvenile winter steelhead survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Contaminants have been shown to have detrimental effects on juvenile salmonids, such as decreased immune function, disrupted physiological processes, and generally reduced fitness. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. Exposure routes are not certain and may be from contact with contaminated substrates or uptake through prey.	High	Medium/Medium
	WS.PO.5 Document the interaction between emigrating juvenile winter steelhead and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then juvenile winter steelhead survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	High/Low
	WS.PO.6 Develop an understanding of emigrating juvenile winter steelhead life history diversity and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of salmonid integration with the ecosystem increases, then management and recovery actions will proceed with greater certainty. *Justification:* Our current understanding of life history diversity and salmonid interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; ongoing research continues to increase our knowledge and reduce uncertainty.	High	High/Medium

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	WS.PO.7 Evaluate/improve survival of upriver juvenile winter steelhead emigrating via barge or dam passage. *Hypothesis Statement:* If survival and fitness of emigrating upriver winter steelhead improves, then these fish will be better prepared for emigration through the lower mainstem, Western Oregon tributaries, estuary, and plume. *Justification:* Current survival/fitness of upriver fish is lower than historical conditions. This lower fitness may predispose fish to predation as they enter the subbasin, delay attainment of threshold size needed for smoltification, or disrupt physiological processes that control smoltification.	High	High/High
Adult Migration (all adults in the Columbia River Basin)	WS.PO.8 Maintain favorable water flow and temperature throughout mainstem migration period (~ December-April). *Hypothesis Statement:* If extreme water flows or temperatures exist during migration, then spawning may be delayed or averted. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier that generally results in one of three outcomes: delayed arrival to spawning grounds, spawning activity in less than desirable locations, or no spawning. Each of these scenarios often results in decreased juvenile fitness or productivity.	Medium	Medium/High
	WS.PO-W.8 Maintain favorable water flow and temperature throughout mainstem migration period (~ December-April). *Hypothesis Statement:* If extreme water flows or temperatures exist during migration, then spawning may be delayed or averted. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier that generally results in one of three outcomes: delayed arrival to spawning grounds, spawning activity in less than desirable locations, or no spawning. Each of these scenarios often results in decreased juvenile fitness or productivity.		
	WS.PO.9 Reduce predation mortality on migrating adults. *Hypothesis Statement:* If predation on adults is reduced, then winter steelhead survival in the estuary and mainstem will increase. *Justification:* Marine mammal predation on adult salmonids in the lower Columbia River and estuary has been observed. Predation mortality may be significant and needs to be quantified.	High	Low/Medium

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	WS.PO-W.15 Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery derived stocks *Hypothesis Statement:* Continuation of Select Area (terminal) fishing opportunities in the lower Columbia River will support productive sport and commercial fisheries on harvestable stocks without negatively affecting rebuilding efforts directed at weak stocks. *Justification:* Commercial and recreational harvest in the lower Columbia River has the potential to negatively impact salmonid stocks, if not managed and directed. Harvesters are generally agreeable to targeting specific hatchery stocks, and the technology exists to manage fisheries with selectivity in the estuary without negatively impacting biological diversity and genetic integrity of wild stocks.		
	WS.PO-W.10 Eliminate or mitigate artificial access barriers for migrating adults, creating additional spawning & rearing habitat- *Hypothesis Statement:* If access to high quality habitat within the historic range of coho is restored, abundance will be improved *Justification:* Restoration of access to productive habitat will improve population diversity and spatial structure of DIPs within the coastal stratum		

.5.2.1.1.5.6 Strategies

Habitat potential includes both quantity and quality. The properly functioning benchmark is less than the pristine historical condition. Properly functioning conditions (PFC) represent favorable habitat for salmon as defined by NOAA Fisheries. PFC generally represent a reasonable upper bound on the potential for habitat improvement although in some cases presume large-scale changes that would be difficult to implement (e.g. levee removal). As a general rule, populations may typically be considered viable when properly functioning conditions exist throughout the historical distribution. However, populations may also be viable where not all available habitat is properly functioning. Populations may sometimes fall short of viability despite properly functioning habitat conditions, if the historical range has been substantially reduced or other mortality factors are severe.

Healthy, harvestable salmon populations depend on favorable habitats for spawning and rearing. Salmon populations typically go extinct when periodic poor ocean conditions drive populations in poor habitat to low numbers from which they cannot rebound. High quality habitat increases fish population productivity which helps maintain adequate numbers even during poor ocean conditions and allows them to rebound quickly. Populations can typically withstand some combination of stream habitat degradation, mainstem and estuary habitat degradation, and other impacts such as fishing or hatchery domestication. Historical populations appeared to sustain very high fishing and hatchery impacts prior to the cumulative effects of widespread habitat declines. Conversely, no level of fishery or hatchery reductions will be sufficient to offset severe habitat declines.

Current habitat conditions in most areas are much less favorable than historical conditions and substantially less favorable than necessary to support viable wild salmon and steelhead populations. Assessments detailed in the Technical Foundation identified tributary habitat degradation as the largest single impact among the various limiting factors (i.e. the 4-Hs). Land and water use practices have contributed large decreases in habitat quality and quantity in all subbasins.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving salmon habitat conditions in some areas and will further improve salmon habitat over time, but additional changes are needed in many areas to support the recovery of wild populations. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on salmon and increased commitment to protect this resource. More fish-friendly practices have been implemented for many activities both before and after listing of salmon. Some changes have already produced effects; others will be expected to pay future dividends. Still others will be needed to offset the cumulative effects of years of habitat degradation.

A significant level of increased habitat protection and restoration will be required to just to arrest declining trends and ensure that population status does not decline further. Additional efforts will be required to make substantial gains. Recovery depends on arresting and reversing declining trends in salmon numbers. The size of the required change will depend on the steepness of the decline and the level of improvement needed to meet region-wide recovery

goals. Projected human population growth in lower Columbia river subbasins will compound the demands for increased habitat protection and restoration just to stabilize fish populations at current levels.

Salmon depend on suitable habitat conditions which in turn are regulated by conditions in adjacent and upstream watersheds. Local habitat activities can provide short term benefits but long-term improvements in habitat conditions will depend on restoration of functional watershed processes. Where watershed processes are not intact, habitat conditions rapidly revert to equilibrium with their surroundings.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue. For instance, riparian protection measures might require 50-150 years to provide full benefits based on the time it takes for trees to mature and restore shade and channel stability, then die and provide woody debris and channel diversity. Because of the required scale and delayed effects, watershed improvements typically provide limited prospects for immediate relief of acute extinction risks for salmon caused by current low numbers.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance. However, protection measures alone will not suffice to recover some species to viability, especially in light of future growth trends. The geographical distribution of some species overlaps significantly with areas that have been subjected to significant human disturbance, including urban development and agriculture. Active restoration in previously disturbed areas may be necessary for recovery.

Although effects may often be temporary, site-specific improvements in habitat conditions and access, in concert with non-habitat measures can help ameliorate immediate extinction risks in the interim, until underlying causes of stream habitat declines are addressed. Even where recent changes to land and water use patterns can be expected to provide suitable conditions for population viability in the long term, more immediate actions may be required to make sure that the fish are around to reap those long term benefits.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by salmon and steelhead populations to any given suite of actions. These uncertainties limit our ability to stipulate precise levels of improvement needed to achieve recovery. The recovery plan needs to recognize these uncertainties with adequate safety factors, contingences, and in-course corrections.

Habitat

WS.S1. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Physical Objectives Addressed: WS.PO.1, WS.PO.2, and WS.PO.8

Explanation: Important habitats in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

WS.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Physical Objectives Addressed: WS.PO.1, WS.PO.2, and WS.PO.8

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

WS.S3. Avoid large-scale habitat changes where risks to salmon and steelhead are uncertain.

Physical Objectives Addressed: WS.PO.1

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that things don't continue to get worse.

WS.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: WS.PO.1

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

WS.S5. Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Physical Objectives Addressed: WS.PO.1 and WS.PO.2

Explanation: Salmonid recovery is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will require some restoration of areas that are substantially degraded but also provides significant flexibility in where habitat restoration efforts are distributed among and within subbasins.

WS.S6. Utilize a combination of active and passive habitat restoration measures to provide near term and long term benefits.

Physical Objectives Addressed: WS.PO.1, WS.PO.2, and WS.PO.8

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but effects are rarely lasting unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures in the riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions).

WS.S7. Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Physical Objectives Addressed: WS.PO.6

Explanation: Salmon are an integral component of both the freshwater and marine ecosystem of which they are a part. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the status of salmon. Many significant salmon predators including bull trout, eagles, and grizzly bears have declined concurrent with salmon declines, albeit for a variety of reasons. Large numbers of salmon returning to spawn streams also introduce significant amounts of marine-derived nutrients into freshwater systems. These nutrients may stimulate primary and secondary productivity when other appropriate habitat conditions exist; this increased productivity increases food for juvenile salmon as well as other species. Finally, salmon actually affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

WS.S-W7 Open access to productive habitat by removing or mitigating passage barriers

Physical Objectives Addressed: WS.PO-W.16

Explanation: Tide gates, culverts, hatchery weirs, and other barriers have impeded or severed access to habitat that was historically productive, and which could yet provide additional spawning and rearing habitat for salmonids that are currently limited by the amount of available productive habitat. In some cases around hatcheries, barriers have been been erected to prevent potentially disease infected fish from spawning upstream of the water intake for the hatchery and transferring disease to fish being raised at the hatchery. One of the recovery plan strategies for some salmonids populations is to to provide adult passage at several of these locations, consistent with the likelihood of gains in natural production and not unduly compromising the hatchery rearing environment in terms of disease.

Introduced Species

WS.S8. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introducing species.

Physical Objectives Addressed: WS.PO.5

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic

and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Predators

WS.S9. As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Physical Objectives Addressed: WS.PO.3 and WS.PO.9

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Research

WS.S10. Our understanding of the relationships between winter steelhead and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: WS.PO.1 through WS.PO.9

Explanation: Emerging research and understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume are promising tools in the near future. Also needed are additional understanding about how winter steelhead populations use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume. Additionally, future research should also focus on establishing clear relationships between winter steelhead and the various predators or introduced species in the lower mainstem, Western Oregon tributaries, estuary, and plume.

WS.S11. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: WS.PO.1 through WS.PO.9

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection, habitat restoration, and recovery measures are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

WS.S12. Assess the Mainstem Lower Columbia River and Columbia River Estuary by discreet geographic reaches for restoration and protection priorities.

Physical Objectives Addressed: WS.PO.1, WS.PO.2, WS.PO.3, WS.PO.5, WS.PO.6, WS.PO-W10

Explanation: A chronic problem exists in the information systems of resource planners who are unable, today, to accurately inventory where protection and restoration work has been completed or is ongoing, and where additional work is needed. Throughout the subbasin planning process, an urgent need was identified to develop a "desktop" triage tool to identify where measures should be applied, or where mitigation steps might be needed in response to some natural or anthropogenic system disturbance. A systematic way of identifying the protection and restoration potential of specific areas within the subbasin needs to be developed. Such a system could then provide a means for prioritizing actions.

Sustainable Fisheries

WS.S15 Optimize continued harvest of healthy hatchery stocks while reducing harvest rates on weak, endangered stocks in mixed stock, mainstem fisheries.

Explanation: As native salmon runs on the Lower Columbia River diminished, the fishing community looked for a way to bolster the commercial industry, a backbone of the region's economy for generations of families. The goal was to were to create and expand known stock fisheries for high-quality salmon in the Columbia River Basin while providing greater protection for endangered stocks. In its 1993 Strategy For Salmon, the Northwest Power Planning Council recommended that select area (formerly terminal area) fishing sites be identified and developed to harvest abundant fish stocks while minimizing the incidental harvest of weak stocks. The Council, through its Fish and Wildlife Program, called on the BPA to: “Fund a study to evaluate potential terminal fishery sties and opportunities. Beginning in 1993, BPA initiated the Columbia River Terminal Fisheries Project (now the Columbia River Select Area Fishery Evaluation Project), a 10-year comprehensive program to investigate the feasibility of select area fisheries in Youngs Bay and other sites in Oregon and Washington (BPA 1996, Miller et al. 2002). Select area fisheries are being explored as a means to increase the sport and commercial harvest of hatchery fish while providing greater protection of weak wild salmon stocks. Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.

.5.2.1.1.5.7 Measures to achieve strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary.

Habitat

WS.M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Loss of tidal swamp and marsh habitat has respectively resulted in an estimated 77% and 43% loss of these habitat types from 1870 to 1983. The substantial acreage loss of the tidal swamp and tidal marsh habitat types has reduced local inputs of macrodetritus, thereby converting the estuarine foodweb to a microdetritus base dominated by upriver reservoir inputs. Additionally, although ocean-type salmonids are typically associated with these shallow water, peripheral habitats, evidence suggests that stream-type salmonids also use these habitats.

Variables	Context
Strategies addressed	WS.S1, WS.S2, WS.S3, WS.S4, WS.S5, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of tidal and marsh habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of tidal marsh and swamp habitats would have a high benefit because they may increase food web productivity and provide resting habitat for stream-type salmonids.
Barriers to success	*Explanation:* Tidal marsh and swamp habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

WS.M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified lower mainstem, Western Oregon tributaries, estuary, and plume habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that emulate a more natural regime will help improve habitat conditions for salmonids and other resident fish and wildlife species.

Variables	Context
Strategies addressed	WS.S1, WS.S2, WS.S3, WS.S4, WS.S5, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit.
Barriers to success	*Explanation:* An annual allocation of water for salmonids will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

WS.M3. Maintain adequate water flows throughout migration periods.

Explanation: Prevents migration barriers, high temperatures in late summer, lack of resting habitats, and predation losses. Facilitates juvenile movement through the mainstem to the estuary.

Variables	Context
Strategies addressed	WS.S1, WS.S2, WS.S3, WS.S4, WS.S5, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for maintaining water flows during migration. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	Medium. *Explanation*: Maintenance of water flows during migration would have a medium benefit because of the significance of the subbasins as a migratory pathway and for juvenile rearing/smoltification.
Barriers to success	*Explanation:* Maintenance of water flows during migration will be possible through the modification of current water uses, which at present seems possible if current water budget is only modified for brief periods. Additionally, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

WS.M4. Restore connectedness between river and floodplain.

Explanation: Restoring the access to the floodplain increases juvenile salmonid access to shallow water, low velocity, peripheral habitats. Further, connection of the river and floodplain begins to restore the historical macrodetritus-based food web.

Variables	Context
Strategies addressed	WS.S1, WS.S2, WS.S3, WS.S4, WS.S5, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

WS.M5. Protect and restore riparian and wetland habitat condition and function.

Explanation: Riparian zones are critical habitats for many species. This measure incorporates a variety of tools including, local land use regulatory actions, acquisition, and restoration activities. This measure is inherently linked with measures 1 and 4.

Variables	Context
Strategies addressed	WS.S1, WS.S2, WS.S3, WS.S4, WS.S5, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective for *protecting* wetland and riparian habitats. The current programs cannot be expected to attain the physical objective for *restoring* wetland and riparian habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of riparian habitats would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Riparian and wetland habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

WS.M6. Restore impaired sediment transport processes affecting the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Sediment dynamics are a critical component of lower mainstem, Western Oregon tributaries, estuary, and plume habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation, and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	WS.S1, WS.S2, WS.S3, WS.S4, WS.S5, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

WS.M7. Mitigate channel dredging activities in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that alter habitat forming processes, reduce salmon population resilience, and inhibit recovery.

Explanation: Channel dredge activities affect the quality of the various lower mainstem, Western Oregon tributaries, estuary, and plume salmonid habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Indirectly, wakes from large ships increase erosion and can cause stranding of juvenile salmonids located along the shoreline. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context
Strategies addressed	WS.S1, WS.S2, WS.S3, WS.S4, WS.S5, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for mitigating dredging activity effects. The primary reason is that the sole purpose of the Channel Deepening BiOp is to protect ESA-listed salmonids and their habitat while allowing dredging activity to proceed.
Potential to contribute to biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects throughout the channel deepening process and beyond. However, there remains uncertainty as to the short- and long-term effects of channel modification on flow dynamics, sediment transport, and habitat forming processes.

WS.M8. Limit the effects of toxic contaminants on salmonid fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on salmonids, resident fish, or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	Context
Strategies addressed	WS.S4, WS.S7, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and estuary, as well as uncertainty in exposure risks to

	salmonids.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

WS.M-W8. Implement mitigation and enhancement measures to provide access to productive spawning and rearing habitat

Explanation: Watershed Assessments in the Western Oregon tributaries include in many cases fish passage surveys. Culverts and other passage barriers have been inventoried and prioritized.

Variables	Context
Strategies addressed	CoWS.S-W7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* While many passage barriers can be address through systematic review of passage barrier inventories, the current programs and/or projects cannot be expected to attain the physical objective for providing additional habitat. The primary reason is uncertainty on the best means for protecting against spreading disease past hatchery wiers.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of providing additional access to potentially productive habitat are significant, however uncertainty remains on the best means of protecting against desease.
Barriers to success	*Explanation:* Hatchery policies that manage the risk of spreading disease; financial means to address barriers in a systematic way

Introduced Species

WS.M9. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	WS.S3, WS.S4, WS.S7, WS.S8, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

WS.M10. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	WS.S7, WS.S8, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years

Variables	Context
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

WS.M11. Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon bycatch. The impacts of shad on salmon are unclear but the large shad population biomass has the potential for significant impacts. Elimination or control of shad is not a silver bullet for salmon recovery but the significance of interactions and opportunities for management warrant closer consideration.

Variables	Context
Strategies addressed	WS.S7, WS.S8, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing shad management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of shad.
Potential to contribute to	High.

Variables	Context
biological objectives	*Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

WS.M12. Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.

Explanation: Established populations may be managed to shape fishery benefits as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. Walleye fisheries can be managed with size regulations for instance to shape fishery benefits with no effect on salmonids.

Variables	Context
Strategies addressed	WS.S7, WS.S8, WS.S9, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing gamefish management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of gamefish.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Predators

WS.M13. Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikeminnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

Variables	Context
Strategies addressed	WS.S7, WS.S9, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing pikeminnow predation on juvenile salmonids. Currently, there are no plans to discontinue the pikeminnow management program.
Potential to contribute to biological objectives	High. *Explanation*: Continued management of pikeminnow predation will minimize predation effects on juvenile salmon.
Barriers to success	*Explanation:* The current pikeminnow management program has been successful at removing the large, predaceous pikeminnow from the population, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

WS.M14. Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where salmon predation might pose added risks.

Variables	Context
Strategies addressed	WS.S3, WS.S4, WS.S7, WS.S9, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing Caspian tern predation on juvenile salmonids. Currently, there are no plans to discontinue the Caspian tern relocation program.
Potential to contribute to biological objectives	High. *Explanation*: Caspian tern predation in the past has been substantial, thus, continued tern management will minimize predation effects on juvenile salmon.
Barriers to success	*Explanation:* The current Caspian tern relocation program has been successful at relocating the tern colony from Rice to East Sand Island, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

WS.M15. Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.

Explanation: Only after adoption of the U.S. Marine Mammal Protection Act have seals and sea lions begun to recover from historical low levels. Populations have expanded greatly and significant numbers now occur in the lower Columbia River.

Variables	Context
Strategies addressed	WS.S7, WS.S9, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs in place that are intended to quantify the amount and significance of pinniped predation on adults salmonids.
Potential to contribute to biological objectives	Low. *Explanation*: The significance of pinniped predation on adult salmonids is unclear but expected to be somewhat low.
Barriers to success	*Explanation:* Establishing regulatory control of pinnipeds to limit predation on adult salmonids is challenged by pinniped protection under the Marine Mammal Protection Act, however, some level of management is possible if warranted for salmon recovery.

Research

WS.M16. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of causal relationships between salmonids, resident fish, and wildlife species is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	WS.S2, WS.S3, WS.S5, WS.S7, WS.S8, WS.S9, WS.S10, and WS.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

WS.M17. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by ocean- and stream-type salmonids is poorly understood. The use of tagging and other marking studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	WS-W10.
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of salmonid behavior and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding salmonid life history diversity and mainstem/estuary/ plume habitat use will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

W.M19 Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Mainstem Lower Columbia River and Columbia River Estuary

Explanation: Identifying priority habitat for protection and restoration within the Mainstem Lower Columbia River and Columbia River Estuary should be a priority. The approach should be the development of both a tool and a process that could be used iteratively to provide an adaptive management framework for resource planners. In the Columbia basin tributaries, Ecosystem Diagnostic and Treatment (EDT) has provided planners with a quantitative method for determining prioritiesand for modeling likely outcomes. Such a tool has been difficult to apply to the estuary because many species with use the estuary for critical life stages do not produce in the estuary. The challenge will be to develop a tool that reflects the importance of the estuary that use it for important but non-productive portions of their life history.

Variables	Context
Strategies addressed	WS.S1, WS.S2, WS.S3, WS.S4, WS.S5, WS.S6, WS.S-W7, WS.S12, and WS.S11,
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are insufficient for determining where to target protection and restoration activities, although our understanding of the habitat forming processes and relationships between species and habitat attributes is growing significantly.
Potential to contribute to biological objectives	High. *Explanation*: While measures and strategies intended to effect positive change in the Mainstem Lower Columbia River and Columbia River Estuary are becoming clear, knowing where to apply these measures is uncertain. Tools that help target resources will increase all other measures chances of being successful.
Barriers to success	*Explanation:* A key goal of any desktop management goal should be to provide a means of predicting outcomes of restoration and protection activities, but standard measures of performance, for example, production and abundance are likely to occur out-of-basin, making expected outcomes a difficult measure to quantify.

Sustainable Fisheries

W.M20: Continue the Select Area Fisheries Project

Explanation: The project primarily utilizes existing hatchery facilities to spawn, hatch, and conduct initial rearing of juvenile salmonids for subsequent out planting to net pen facilities at each of the select area sites. Hatcheries providing production are South Fork Klaskanine (CEDC); Big Creek, Bonneville, Cascade, Gnat Creek, North Fork Klaskanine, Oxbow, Sandy, South Santiam, and Willamette (all ODFW); Cowlitz, Elochoman, and Gray's River (all WDFW), and Eagle Creek (USFWS). The Clatsop Count Economic Development Council (CEDC) Fisheries Project operates estuarine net-pen sites in Youngs Bay, Tongue Point, and Blind Slough. The Washington Department of Fish and Wildlife has net-pen sites at Deep River and Steamboat Slough. Fish are grown and released from these pens under varying management and grow-out regimes including two-week acclimation, over-winter, and full term net pen rearing. Annual releases for 2000-2003 have averaged 3.8 million coho, 1.0 million spring chinook, and 1.0 million select area bright fall chinook (includes ODFW's Restoration and Enhancement production). Ex-vessel values of 2000-2003 SAFE commercial fisheries were $408,000-$787,000, with state-level personal income impacts of $1.4 - $3.1 million dollars for al l regional fisheries combined.

Variables	Context
Strategies addressed	WS.S15
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Program Table (CEDC Fisheries)
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are sufficient for directing harvest of commercial and recreational fishers to targeted stocks of hatchery stocks of summer Chinook, fall Chinook, and Coho
Potential to contribute to biological objectives	High. *Explanation*: The Terminal Fisheries project has been demonstrated to be effectives for addressing the following objectives: Supports a healthy Columbia basin, Maintains biological diversity, Maintains genetic integrity, Increases run sizes or populations As these objectives are addressed by the measure, the wants, needs, and desires of the fishers can be met.
Barriers to success	*Explanation:* Barriers to success are very low, as most of the logistical and technical problems have been addressed. The project has addressed concerns about juvenile interactions, predation, and straying. The major barrier is that the program is not self-

	sustaining

.5.2.1.1.5.8 *Programs to implement strategies and measures*

Table 5-20. Existing programs and their connection to recovery measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	1, 4, 5
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; collaboration with these efforts is vital.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14
CEDC Fisheres	Manages Select Area Fishing project to direct harvest away from listed stocks, and mitigate for lack of harvest in the lower Columbia River	20
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	5
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	5
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	5
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	5
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	6
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	6
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	5
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	2, 3, 6
Washington State Conservation Commission/ Conservation	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify	1, 4

Program Name and Affiliation	Program Description	Measures Addressed
Districts	improvements needed, and publish and disseminate the information.	
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 4, 5, 6, 7, 8
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	1, 4, 5
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 5, 7
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	2, 3, 8
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 5, 8
Habitat Program – WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	1, 4, 5, 6, 10, 11, 12, 13, 16, 17

Program Name and Affiliation	Program Description	Measures Addressed
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	1, 4, 5
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 4, 5, 6, 8
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	The goal of the SRFB is to protect and restore salmon habitat. The board provides grant funds to protect or restore salmon habitat and assist related activities; it works closely with local watershed groups. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SRFB guides spending of funds targeted for salmon recovery activities and projects.	1, 4, 5, 6
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	8
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	1, 5
Partners for Fish and Wildlife	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
Program – USFWS	based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	16
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	16, 17
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	6, 7
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	6, 7
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	9, 10
Pikeminnow Management	The goal of the program is to manage annual pikeminnow predation on juvenile salmonids. The program pays rewards to anglers for harvesting pikeminnow	13

Program Name and Affiliation	Program Description	Measures Addressed
Program	over a prescribed size, thus providing an incentive to remove the large, predaceous pikeminnow from the population.	
Caspian Tern Relocation Project	The goal of the project was to relocate terns to another location in the estuary where tern predation on juvenile salmonids would be reduced but the viability of the tern population would be maintained.	14

5.2.1.1.6 Spring Chinook

.5.2.1.1.6.1 Background

Chinook salmon (Oncorhynchus tshawytscha) are the largest and most diverse of the Pacific salmon. Spring chinook typically return to freshwater in March and April and migrate into small headwater streams to spawn in late summer. Spring chinook exhibit a stream-type life history where juveniles rear in tributary streams for one year before rapidly migrating downstream on the spring freshet. Most adults return after 2 to 4 years in the ocean where they migrate far to the north off Canada and Alaska.

.5.2.1.1.6.2 Status

Lower Columbia River chinook populations were listed as threatened in 1999. Chinook salmon were historically present in all Washington lower Columbia tributaries; spring chinook were present in the larger Cascade subbasins. The Willamette/Lower Columbia Technical Recovery Team has identified 31 historical populations of chinook salmon in the Columbia River ESU. Washington accounts for 7 of 9 spring chinook populations in this ESU; the other chinook populations originate in Oregon waters. Spring chinook continue to return to the Cowlitz, Lewis, Kalama, and Little White Salmon Rivers, although current runs are dominated by hatchery-produced fish. All Washington lower Columbia spring chinook populations are below proposed recovery targets.

Table 5-21. Spring chinook salmon abundance estimates by life stage.

Life Stage	Historical Abundance	Current Abundance
Juvenile Rearing (out-of-subbasin populations)	Historical productivity of spring chinook was assumed to be 425 smolts per spawner (based on Upper NF Lewis River EDT template estimate), an estimated 63.75 million juveniles used the lower mainstem, Western Oregon tributaries, estuary, and plume (based on assumed lower and upper run escapement of 150,000).	Current productivity of spring chinook is assumed to be 175 smolts per spawner (Upper NF Lewis EDT patient estimate). Based on this level of productivity, juveniles using the lower mainstem, Western Oregon tributaries, estuary, and plume is estimated to be 48.1 million (assuming a lower and upper run escapement of 275,000). The 2002 passage index of age 1 chinook at Bonneville Power House #2 was

		3.3 million fish.
Adult Migration (out-of-subbasin populations)	Historical combined lower and upper river run size ranged from about 125,000 to 350,000.	The 2000 combined lower and upper river run size was about 275,000 (dominated by hatchery fish). The 2002 spring chinook passage count at Bonneville Dam totaled 275,290.

.5.2.1.1.6.3 Value statement

Lower Columbia River chinook and Snake River spring chinook are currently listed as threatened under the Endangered Species Act while Upper Columbia River spring chinook are listed as endangered. Additionally, spring chinook are culturally, economically, and ecologically important. Juvenile rearing in the lower mainstem, Western Oregon tributaries, estuary, and plume are a vital life history trajectory for spring chinook. The restoration goal for lower Columbia spring chinook is to increase the population to a self-sustaining, viable population that can provide for tribal, sport, and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage, it is likely that restoration efforts of spring chinook will achieve the highest success in the lower Columbia mainstem, the estuary, and the various tributaries below Bonneville Dam. However, recovery efforts of upriver spring chinook should continue to be pursued. Strategies and measures to return spring chinook populations to viability throughout the historical distribution are among the highest level of importance.

.5.2.1.1.6.4 Limiting factor

Spring chinook salmon in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume have threats to both life stages expressed in the combined subbasins and adjacent tributaries. Historically, spring chinook salmon populations were distributed throughout the Columbia River basin. Within the Lower Columbia River ESU, the Cowlitz and Lewis River subbasins likely supported the largest spring chinook populations, although historical escapement data are limited. Each of these subbasins has undergone development of hydroelectric facilities that have blocked access to a considerable amount of historical spring chinook spawning habitat. Downstream of Bonneville Dam, juvenile spring chinook have been impacted by low flows, disconnected or lost habitats, and predation losses. The period of estuarine residence may be a critical phase in the life history of spring chinook and thus plays a major role in determining the size of the subsequent adult run back to fresh water.

able 5-22. Spring chinook salmon limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Juvenile Rearing (out-of-subbasin populations)	SCh.LF.1 Microdetritus-based food web. The current microdetritus-based food web is expected to be less productive than the historical macrodetritus-based food web. Loss of wetland and side channel habitat has reduced the local macrodetritus inputs from terrestrial and riparian habitats that supported the historical food web. Present detrital inputs to the food web are dominated by microdetritus from upriver sources and are controlled primarily by reservoir production and flow rates from Bonneville Dam. Further, the microdetritus-based food web is thought to be limited to the spatially-confined estuary turbidity maximum region.	High/Medium
	SCh.LF.2 Loss of habitat connectivity. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids. As juveniles grow, they move across a spectrum of salinities, depths, and water velocities. Specifically, research suggests that proximity of feeding and refuge areas for stream-type salmonids may be important for survival and olfactory cues needed for a successful return migration.	High/High
	SCh.LF.3 Predation mortality. Current primary sources of predation on spring chinook are substantial, however, how current predation levels compare to those experienced historically is unknown. Primary predation sources on spring chinook include Caspian terns and pikeminnow.	High/High
	SCh.LF.4 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on salmonids. Exposure risks to spring chinook are not clear; contaminant uptake may be through contaminated diet items.	Medium/Medium
	SCh.LF.5 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on spring chinook are unknown but are expected to be negative.	High/Low
	SCh.LF.6 Density dependence. Density dependent mechanisms in the lower mainstem, Western Oregon tributaries, estuary, and plume may limit juvenile salmonid survival and productivity, however, the significance is unclear. NOAA Fisheries is currently conducting research intended to clarify this issue.	Low/Low
	SCh.LF.7 Fitness and timing of juvenile salmonids entering the subbasin. Juveniles entering the subbasin from upriver via barge releases or dam passage experience lower survival than historical mainstem emigration prior to hydrosystem development.	High/High
Adult Migration (out-of-subbasin populations)	SCh.LF.9 Dam passage. Spring chinook experience some mortality and delay associated with mainstem dam passage. For Lower Columbia River mainstem dams, average per dam survival rate estimate for spring chinook was 89%; this estimate includes fallback and re-entry.	Medium/High
	SCh.LF.10 Migration barriers/ lack of resting habitats. Elevated water temperature or high water flow may act as a temporary adult migration barrier. Additionally, high water flow likely reduces available resting habitat for migrating adults.	Low/High
	SCh.LF.11 Predation losses. Marine mammals (pinnepeds) prey on adult salmon, but the significance is unclear.	Low/Medium

.5.2.1.1.6.5 Biological objectives & working hypotheses

Biological objectives for spring chinook, based on desired environmental conditions, are formulated to support the value statement identified above. At present, we lack the ability to develop meaningful biological performance metrics to describe focal species response to subbasin habitat conditions in terms of productivity, capacity, abundance, or life history diversity. Spring chinook utilize the lower mainstem, Western Oregon tributaries, estuary, and plume subbasins primarily for migration, although evidence suggests that juvenile spring chinook feed as they migrate and that the brief mainstem and estuarine residence time is extremely important in the physiological transformation to smolts and in gathering olfactory cues needed for a successful return migration. Thus, actions within the lower mainstem and estuary subbasins (e.g. restored floodplain connectivity or predator management) can affect spring chinook survival within the subbasins, however, biological performance levels are likely determined by out-of-subbasin effects (e.g. spawning tributary conditions or mainstem/ tributary dam passage success).

Table 5-23. Spring chinook biological performance levels.

Metric[a]	Performance Level
Mortality[b]	Current mortality estimates range from 0.20 to 0.20 and average 0.20. Mortality estimates at population recovery goals can not be calculated based on insufficient data.

[a] Mortality metric applies to out of subbasin spring chinook populations.

[b] Mortality is based on preliminary analysis by the LCFRB based on comparison of EDT estimates of mainstem and estuary habitat effects on lower Columbia River spring chinook populations, current population abundance estimates, and population abundance recovery goals.

Table 5-24. Spring chinook desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
Juvenile Rearing (all juveniles in the Columbia River Basin)	SCh.PO.1 Protect existing rearing habitat to ensure no further net degradation. *Hypothesis Statement:* If current rearing habitat is protected, then juvenile rearing capacity and productivity in the lower mainstem, Western Oregon tributaries, estuary, and plume can be maintained. *Justification:* Protection and maintenance of existing rearing habitat will provide a base level of juvenile spring chinook production and diversity. Further, protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	SCh.PO.2 Restore connectivity between river and floodplain, as well as in-river habitats. *Hypothesis Statement:* If connectivity with the floodplain is restored, then juvenile spring chinook productivity in the estuary and mainstem will increase. *Justification:* Connectivity with the floodplain will restore macrodetrital inputs and alter the current food web. A macrodetritus-based food web will increase productivity and support greater life history diversity. Connectivity among in-river habitats can provide both resting and feeding habitats.	High	High/High
	SCh.PO.3 Reduce predation mortality on emigrating juveniles. *Hypothesis Statement:* If predation on juveniles is reduced, then juvenile spring chinook survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Predation on juvenile salmonids in the lower Columbia River and estuary has increased as a result of increased predator populations, such as northern pikeminnow or Caspian terns. Predator control and relocation programs have been successful at reducing predation, however, it is unclear how current levels of predation compare to historical levels.	Medium	High/High
	SCh.PO.4 Reduce contaminant exposure of emigrating juveniles. *Hypothesis Statement:* If contaminant exposure is reduced, then juvenile spring chinook survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Contaminants have been shown to have detrimental effects on juvenile salmonids, such as decreased immune function, disrupted physiological processes, and generally reduced fitness. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. Exposure routes are not certain and may be from contact with contaminated substrates or uptake through prey.	High	Medium/Medium
	SCh.PO.5 Document the interaction between emigrating juvenile spring chinook and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then juvenile spring chinook survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	High/Low

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	SCh.PO.6 Develop an understanding of emigrating juvenile spring chinook life history diversity and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of salmonid integration with the ecosystem increases, then management and recovery actions will proceed with greater certainty. *Justification:* Our current understanding of life history diversity and salmonid interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; ongoing research continues to increase our knowledge and reduce uncertainty.	High	High/Medium
	SCh.PO.7 Evaluate/improve survival of upriver juvenile spring chinook emigrating via barge or dam passage. *Hypothesis Statement:* If survival and fitness of emigrating upriver spring chinook improves, then these fish will be better prepared for emigration through the lower mainstem, Western Oregon tributaries, estuary, and plume. *Justification:* Current survival/fitness of upriver fish is lower than historical conditions. This lower fitness may predispose fish to predation as they enter the subbasin, delay attainment of threshold size needed for smoltification, or disrupt physiological processes that control smoltification.	High	High/High
Adult Migration (all adults in the Columbia River Basin)	SCh.PO.8 Maintain favorable water flow and temperature throughout mainstem migration period (approx. March-May). *Hypothesis Statement:* If extreme water flows or temperatures exist during migration, then spawning may be delayed or averted. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier that generally results in one of three outcomes: delayed arrival to spawning grounds, spawning activity in less than desirable locations, or no spawning. Each of these scenarios often results in decreased juvenile fitness or productivity.	Medium	Medium/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	SCh.PO.8 Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery derived stocks *Hypothesis Statement:* Continuation of Select Area (terminal) fishing opportunities in the lower Columbia River will support productive sport and commercial fisheries on harvestable stocks without negatively affecting rebuilding efforts directed at weak stocks. *Justification*: Commercial and recreational harvest in the lower Columbia River has the potential to negatively impact salmonid stocks, if not managed and directed. Harvesters are generally agreeable to targeting specific hatchery stocks, and the technology exists to manage fisheries with selectivity in the estuary without negatively impacting biological diversity and genetic integrity of wild stocks.		
	SCh.PO.9 Reduce predation mortality on migrating adults. *Hypothesis Statement:* If predation on adults is reduced, then spring chinook survival in the estuary and mainstem will increase. *Justification:* Marine mammal predation on adult salmonids in the lower Columbia River and estuary has been observed. Predation mortality may be significant and needs to be quantified.	High	Low/Medium

.5.2.1.1.6.6 Strategies

Habitat potential includes both quantity and quality. The properly functioning benchmark is less than the pristine historical condition. Properly functioning conditions (PFC) represent favorable habitat for salmon as defined by NOAA Fisheries. PFC generally represent a reasonable upper bound on the potential for habitat improvement although in some cases presume large-scale changes that would be difficult to implement (e.g. levee removal). As a general rule, populations may typically be considered viable when properly functioning conditions exist throughout the historical distribution. However, populations may also be viable where not all available habitat is properly functioning. Populations may sometimes fall short of viability despite properly functioning habitat conditions, if the historical range has been substantially reduced or other mortality factors are severe.

Healthy, harvestable salmon populations depend on favorable habitats for spawning and rearing. Salmon populations typically go extinct when periodic poor ocean conditions drive populations in poor habitat to low numbers from which they cannot rebound. High quality habitat increases fish population productivity which helps maintain adequate numbers even during poor ocean conditions and allows them to rebound quickly. Populations can typically withstand some combination of stream habitat degradation, mainstem and estuary habitat degradation, and other impacts such as fishing or hatchery domestication. Historical populations appeared to sustain very high fishing and hatchery impacts prior to the cumulative effects of widespread habitat declines. Conversely, no level of fishery or hatchery reductions will be sufficient to offset severe habitat declines.

Current habitat conditions in most areas are much less favorable than historical conditions and substantially less favorable than necessary to support viable wild salmon and steelhead populations. Assessments detailed in the Technical Foundation identified tributary habitat degradation as the largest single impact among the various limiting factors (i.e. the 4-Hs). Land and water use practices have contributed large decreases in habitat quality and quantity in all subbasins.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving salmon habitat conditions in some areas and will further improve salmon habitat over time, but additional changes are needed in many areas to support the recovery of wild populations. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on salmon and increased commitment to protect this resource. More fish-friendly practices have been implemented for many activities both before and after listing of salmon. Some changes have already produced effects; others will be expected to pay future dividends. Still others will be needed to offset the cumulative effects of years of habitat degradation.

A significant level of increased habitat protection and restoration will be required to just to arrest declining trends and ensure that population status does not decline further. Additional efforts will be required to make substantial gains. Recovery depends on arresting and reversing declining trends in salmon numbers. The size of the required change will depend on the steepness of the decline and the level of improvement needed to meet region-wide recovery goals. Projected human population growth in lower Columbia river subbasins will compound the

demands for increased habitat protection and restoration just to stabilize fish populations at current levels.

Salmon depend on suitable habitat conditions which in turn are regulated by conditions in adjacent and upstream watersheds. Local habitat activities can provide short term benefits but long-term improvements in habitat conditions will depend on restoration of functional watershed processes. Where watershed processes are not intact, habitat conditions rapidly revert to equilibrium with their surroundings.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue. For instance, riparian protection measures might require 50-150 years to provide full benefits based on the time it takes for trees to mature and restore shade and channel stability, then die and provide woody debris and channel diversity. Because of the required scale and delayed effects, watershed improvements typically provide limited prospects for immediate relief of acute extinction risks for salmon caused by current low numbers.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance. However, protection measures alone will not suffice to recover some species to viability, especially in light of future growth trends. The geographical distribution of some species overlaps significantly with areas that have been subjected to significant human disturbance, including urban development and agriculture. Active restoration in previously disturbed areas may be necessary for recovery.

Although effects may often be temporary, site-specific improvements in habitat conditions and access, in concert with non-habitat measures can help ameliorate immediate extinction risks in the interim, until underlying causes of stream habitat declines are addressed. Even where recent changes to land and water use patterns can be expected to provide suitable conditions for population viability in the long term, more immediate actions may be required to make sure that the fish are around to reap those long term benefits.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by salmon and steelhead populations to any given suite of actions. These uncertainties limit our ability to stipulate precise levels of improvement needed to achieve recovery. The recovery plan needs to recognize these uncertainties with adequate safety factors, contingences, and in-course corrections.

Habitat

SCh.S1. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Physical Objectives Addressed: SCh.PO.1, SCh.PO.2, and SCh.PO.8

Explanation: Important habitats in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

SCh.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Physical Objectives Addressed: SCh.PO.1, SCh.PO.2, and SCh.PO.8

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

SCh.S3. Avoid large-scale habitat changes where risks to salmon and steelhead are uncertain.

Physical Objectives Addressed: SCh.PO.1

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that things don't continue to get worse.

SCh.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: SCh.PO.1

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

SCh.S5. Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Physical Objectives Addressed: SCh.PO.1 and SCh.PO.2

Explanation: Salmonid recovery is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will require some restoration of areas that are substantially degraded but also provides significant flexibility in where habitat restoration efforts are distributed among and within subbasins.

SCh.S6. Utilize a combination of active and passive habitat restoration measures to provide near term and long term benefits.

Physical Objectives Addressed: SCh.PO.1, SCh.PO.2, and SCh.PO.8

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but effects are rarely lasting unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures in the riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions).

SCh.S7. Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Physical Objectives Addressed: SCh.PO.6

Explanation: Salmon are an integral component of both the freshwater and marine ecosystem of which they are a part. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the status of salmon. Many significant salmon predators including bull trout, eagles, and grizzly bears have declined concurrent with salmon declines, albeit for a variety of reasons. Large numbers of salmon returning to spawn streams also introduce significant amounts of marine-derived nutrients into freshwater systems. These nutrients may stimulate primary and secondary productivity when other appropriate habitat conditions exist; this increased productivity increases food for juvenile salmon as well as other species. Finally, salmon actually affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

Introduced Species

SCh.S8. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introducing species.

Physical Objectives Addressed: SCh.PO.5

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Predators

SCh.S9. As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Physical Objectives Addressed: SCh.PO.3 and SCh.PO.9

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Research

SCh.S10. Our understanding of the relationships between spring chinook and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: SCh.PO.1 through SCh.PO.9

Explanation: Emerging research and understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume are promising tools in the near future. Also needed are additional understanding about how spring chinook populations use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume. Additionally, future research should also focus on establishing clear relationships between spring chinook and the various predators or introduced species in the lower mainstem, Western Oregon tributaries, estuary, and plume.

SCh.S11. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: SCh.PO.1 through SCh.PO.9

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection, habitat restoration, and recovery measures are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

SCh.S12. Assess the Mainstem Lower Columbia River and Columbia River Estuary by discreet geographic reaches for restoration and protection priorities.

Physical Objectives Addressed: SCh.PO.1, SCh.PO.2, SCh.PO.3, SCh.PO.4, SCh.PO.5, SCh.PO.6, and SCh.PO.9

Explanation: A chronic problem exists in the information systems of resource planners who are unable, today, to accurately inventory where protection and restoration work has been completed or is ongoing, and where additional work is needed. Throughout the subbasin planning process, an urgent need was identified to develop a "desktop" triage tool to identify where measures should be applied, or where mitigation steps might be needed in response to some natural or anthropogenic system disturbance. A systematic way of identifying the protection and restoration potential of specific areas within the subbasin needs to be developed. Such a system could then provide a means for prioritizing actions.Measures to achieve strategies

Sustainable Fisheries

SCh.S15 Optimize continued harvest of healthy hatchery stocks while reducing harvest rates on weak, endangered stocks in mixed stock, mainstem fisheries.

Explanation: As native salmon runs on the Lower Columbia River diminished, the fishing community looked for a way to bolster the commercial industry, a backbone of the region's economy for generations of families. The goal was to were to create and expand known stock fisheries for high-quality salmon in the Columbia River Basin while providing greater protection for endangered stocks. In its 1993 Strategy For Salmon, the Northwest Power Planning Council recommended that select area (formerly terminal area) fishing sites be identified and developed to harvest abundant fish stocks while minimizing the incidental harvest of weak stocks. The Council, through its Fish and Wildlife Program, called on the BPA to: "Fund a study to evaluate potential terminal fishery sties and opportunities. Beginning in 1993, BPA initiated the Columbia River Terminal Fisheries Project (now the Columbia River Select Area Fishery Evaluation Project), a 10-year comprehensive program to investigate the feasibility of select area fisheries in Youngs Bay and other sites in Oregon and Washington (BPA 1996, Miller et al. 2002). Select area fisheries are being explored as a means to increase the sport and commercial harvest of hatchery fish while providing greater protection of weak wild salmon stocks. Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.

.5.2.1.1.6.7 Measures to Achieve Strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary.

Habitat

SCh.M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Loss of tidal swamp and marsh habitat has respectively resulted in an estimated 77% and 43% loss of these habitat types from 1870 to 1983. The substantial acreage loss of the tidal swamp and tidal marsh habitat types has reduced local inputs of macrodetritus, thereby converting the estuarine foodweb to a microdetritus base dominated by upriver reservoir inputs. Additionally, although ocean-type salmonids are typically associated with these shallow water, peripheral habitats, evidence suggests that stream-type salmonids also use these habitats.

Variables	Context
Strategies addressed	SCh.S1, SCh.S2, SCh.S3, SCh.S4, SCh.S5, SCh.S10, and SCh.S11
Short vs. long term implementation	<25 years

Variables	Context
(<25 years or >25 years)	
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of tidal and marsh habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of tidal marsh and swamp habitats would have a high benefit because they may increase food web productivity and provide resting habitat for stream-type salmonids.
Barriers to success	*Explanation:* Tidal marsh and swamp habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

SCh.M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified lower mainstem, Western Oregon tributaries, estuary, and plume habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that emulate a more natural regime will help improve habitat conditions for salmonids and other resident fish and wildlife species.

Variables	Context
Strategies addressed	SCh.S1, SCh.S2, SCh.S3, SCh.S4, SCh.S5, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to	High.

biological objectives	*Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit.
Barriers to success	*Explanation:* An annual allocation of water for salmonids will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

SCh.M3. Maintain adequate water flows throughout migration periods.

Explanation: Prevents migration barriers, high temperatures in late summer, lack of resting habitats, and predation losses. Facilitates juvenile movement through the mainstem to the estuary.

Variables	Context
Strategies addressed	SCh.S1, SCh.S2, SCh.S3, SCh.S4, SCh.S5, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for maintaining water flows during migration. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	Medium. *Explanation*: Maintenance of water flows during migration would have a medium benefit because of the significance of the subbasins as a migratory pathway and for juvenile rearing/smoltification.
Barriers to success	*Explanation:* Maintenance of water flows during migration will be possible through the modification of current water uses, which at present seems possible if current water budget is only modified for brief periods. Additionally, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

SCh.M4. Restore connectedness between river and floodplain.

Explanation: Restoring the access to the floodplain increases juvenile salmonid access to shallow water, low velocity, peripheral habitats. Further, connection of the river and floodplain begins to restore the historical macrodetritus-based food web.

Variables	Context
Strategies addressed	SCh.S1, SCh.S2, SCh.S3, SCh.S4, SCh.S5, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

SCh.M5. Protect and restore riparian and wetland habitat condition and function.

Explanation: Riparian zones are critical habitats for many species. This measure incorporates a variety of tools including, local land use regulatory actions, acquisition, and restoration activities. This measure is inherently linked with measures 1 and 4.

Variables	Context
Strategies addressed	SCh.S1, SCh.S2, SCh.S3, SCh.S4, SCh.S5, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective for *protecting* wetland and riparian habitats. The current programs cannot be expected to attain the physical objective for *restoring* wetland and riparian habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of riparian habitats would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Riparian and wetland habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

SCh.M6. Restore impaired sediment transport processes affecting the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Sediment dynamics are a critical component of lower mainstem, Western Oregon tributaries, estuary, and plume habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation, and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	SCh.S1, SCh.S2, SCh.S3, SCh.S4, SCh.S5, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

SCh.M7. Mitigate channel dredging activities in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that alter habitat forming processes, reduce salmon population resilience, and inhibit recovery.

Explanation: Channel dredge activities affect the quality of the various lower mainstem, Western Oregon tributaries, estuary, and plume salmonid habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Indirectly, wakes from large ships increase erosion and can cause stranding of juvenile salmonids located along the shoreline. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context
Strategies addressed	SCh.S1, SCh.S2, SCh.S3, SCh.S4, SCh.S5, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for mitigating dredging activity effects. The primary reason is that the sole purpose of the Channel Deepening BiOp is to protect ESA-listed salmonids and their habitat while allowing dredging activity to proceed.
Potential to contribute to biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects throughout the channel deepening process and beyond. However, there remains uncertainty as to the short- and long-term effects of channel modification on flow dynamics, sediment transport, and habitat forming processes.

SCh.M8. Limit the effects of toxic contaminants on salmonid fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on salmonids, resident fish, or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	Context
Strategies addressed	SCh.S4, SCh.S7, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and

Variables	Context
	estuary, as well as uncertainty in exposure risks to salmonids.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

Introduced Species

SCh.M9. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	SCh.S3, SCh.S4, SCh.S7, SCh.S8, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well

	as considerable uncertainty regarding pathways of invasive species introductions.

SCh.M10. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	SCh.S7, SCh.S8, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

SCh.M11. Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon bycatch. The impacts of shad on salmon are unclear but the large shad population biomass has the potential for significant impacts. Elimination or control of shad is not a silver bullet for salmon recovery but the significance of interactions and opportunities for management warrant closer consideration.

Variables	Context
Strategies addressed	SCh.S7, SCh.S8, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing shad management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of shad.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

SCh.M12. Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.

Explanation: Established populations may be managed to shape fishery benefits as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. Walleye fisheries can be managed with size regulations for instance to shape fishery benefits with no effect on salmonids.

Variables	Context
Strategies addressed	SCh.S7, SCh.S8, SCh.S9, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing gamefish management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of gamefish.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Predators

SCh.M13. Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikeminnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

Variables	Context
Strategies addressed	SCh.S7, SCh.S9, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing pikeminnow predation on juvenile salmonids. Currently, there are no plans to discontinue the pikeminnow management program.
Potential to contribute to biological objectives	High. *Explanation*: Continued management of pikeminnow predation will minimize predation effects on juvenile salmon.
Barriers to success	*Explanation:* The current pikeminnow management program has been successful at removing the large, predaceous pikeminnow from the population, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

SCh.M14. Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where salmon predation might pose added risks.

Variables	Context
Strategies addressed	SCh.S3, SCh.S4, SCh.S7, SCh.S9, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing Caspian tern predation on juvenile salmonids. Currently, there are no plans to discontinue the Caspian tern relocation program.
Potential to contribute to biological objectives	High. *Explanation*: Caspian tern predation in the past has been substantial, thus, continued tern management will minimize predation effects on juvenile salmon.
Barriers to success	*Explanation:* The current Caspian tern relocation program has been successful at relocating the tern colony from Rice to East Sand Island, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

SCh.M15. Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.

Explanation: Only after adoption of the U.S. Marine Mammal Protection Act have seals and sea lions begun to recover from historical low levels. Populations have expanded greatly and significant numbers now occur in the lower Columbia River.

Variables	Context
Strategies addressed	SCh.S7, SCh.S9, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs in place that are intended to quantify the amount and significance of pinniped predation on adults salmonids.
Potential to contribute to biological objectives	Low. *Explanation*: The significance of pinniped predation on adult salmonids is unclear but expected to be somewhat low.
Barriers to success	*Explanation:* Establishing regulatory control of pinnipeds to limit predation on adult salmonids is challenged by pinniped protection under the Marine Mammal Protection Act, however, some level of management is possible if warranted for salmon recovery.

Research

SCh.M16. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of causal relationships between salmonids, resident fish, and wildlife species is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	SCh.S2, SCh.S3, SCh.S5, SCh.S7, SCh.S8, SCh.S9, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

SCh.M17. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by ocean- and stream-type salmonids is poorly understood. The use of tagging and other marking studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	SCh.S7, SCh.S10, and SCh.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of salmonid behavior and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding salmonid life history diversity and mainstem/estuary/ plume habitat use will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

SCh.M18. Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Mainstem Lower Columbia River and Columbia River Estuary

Explanation: Identifying priority habitat for protection and restoration within the Mainstem Lower Columbia River and Columbia River Estuary should be a priority. The approach should be the development of both a tool and a process that could be used iteratively to provide an adaptive management framework for resource planners. In the Columbia basin tributaries, Ecosystem Diagnostic and Treatment (EDT) has provided planners with a quantitative method for determining prioritiesand for modeling likely outcomes. Such a tool has been difficult to apply to the estuary because many species with use the estuary for critical life stages do not produce in the estuary. The challenge will be to develop a tool that reflects the importance of the estuary that use it for important but non-productive portions of their life history.

Variables	Context
Strategies addressed	SCh.S1, SCh.S2, SCh.S3, SCh.S4, SCh.S5, SCh.S6, SCh.S9, SCh.S10, and SCh.S12,
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are insufficient for determining where to target protection and restoration activities, although our understanding of the habitat forming processes and relationships between species and habitat attributes is growing significantly.
Potential to contribute to biological objectives	High. *Explanation*: While measures and strategies intended to effect positive change in the Mainstem Lower Columbia River and Columbia River Estuary are becoming clear, knowing where to apply these measures is uncertain. Tools that help target resources will increase all other measures chances of being successful.
Barriers to success	*Explanation:* A key goal of any desktop management goal should be to provide a means of predicting outcomes of restoration and protection activities, but standard measures of performance, for example, production and abundance are likely to occur out-of-basin, making expected outcomes a difficult measure to quantify.

Sustainable Fisheries

SCh.M20: Continue the Select Area Fisheries Project

Explanation: The project primarily utilizes existing hatchery facilities to spawn, hatch, and conduct initial rearing of juvenile salmonids for subsequent out planting to net pen facilities at each of the select area sites. Hatcheries providing production are South Fork Klaskanine (CEDC); Big Creek, Bonneville, Cascade, Gnat Creek, North Fork Klaskanine, Oxbow, Sandy, South Santiam, and Willamette (all ODFW); Cowlitz, Elochoman, and Gray's River (all WDFW), and Eagle Creek (USFWS). The Clatsop Count Economic Development Council (CEDC) Fisheries Project operates estuarine net-pen sites in Youngs Bay, Tongue Point, and Blind Slough. The Washington Department of Fish and Wildlife has net-pen sites at Deep River and Steamboat Slough. Fish are grown and released from these pens under varying management and grow-out regimes including two-week acclimation, over-winter, and full term net pen rearing. Annual releases for 2000-2003 have averaged 3.8 million coho, 1.0 million spring

chinook, and 1.0 million select area bright fall chinook (includes ODFW's Restoration and Enhancement production). Ex-vessel values of 2000-2003 SAFE commercial fisheries were $408,000-$787,000, with state-level personal income impacts of $1.4 - $3.1 million dollars for al l regional fisheries combined.

Variables	Context
Strategies addressed	SCh.S15
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Program Table (CEDC Fisheries)
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are sufficient for directing harvest of commercial and recreational fishers to targeted stocks of hatchery stocks of summer Chinook, fall Chinook, and Coho
Potential to contribute to biological objectives	High. *Explanation*: The Terminal Fisheries project has been demonstrated to be effectives for addressing the following objectives: Supports a healthy Columbia basin, Maintains biological diversity, Maintains genetic integrity, Increases run sizes or populations As these objectives are addressed by the measure, the wants, needs, and desires of the fishers can be met.
Barriers to success	*Explanation:* Barriers to success are very low, as most of the logistical and technical problems have been addressed. The project has addressed concerns about juvenile interactions, predation, and straying. The major barrier is that the program is not self-sustaining

.5.2.1.1.6.8 Pograms to implement strategies and measures

Table 5-25. Existing programs and their connection to recovery measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	1, 4, 5
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; collaboration with these efforts is vital.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	5
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	5
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	5
CEDC Fisheres	Manages Select Area Fishing project to direct harvest away from listed stocks, and mitigate for lack of harvest in the lower Columbia River	20
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	5
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	6
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	6
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	5
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	2, 3, 6
Washington State Conservation Commission/	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable	1, 4

Program Name and Affiliation	Program Description	Measures Addressed
Conservation Districts	natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 4, 5, 6, 7, 8
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	1, 4, 5
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 5, 7
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	2, 3, 8
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 5, 8
Habitat Program – WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary	1, 4, 5, 6, 10, 11, 12, 13, 16, 17

Program Name and Affiliation	Program Description	Measures Addressed
	habitat conditions and distribution of salmonid stocks in Washington.	
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	1, 4, 5
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 4, 5, 6, 8
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	The goal of the SRFB is to protect and restore salmon habitat. The board provides grant funds to protect or restore salmon habitat and assist related activities; it works closely with local watershed groups. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SRFB guides spending of funds targeted for salmon recovery activities and projects.	1, 4, 5, 6
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	8
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	1, 5
Partners for Fish and	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
Wildlife Program – USFWS	Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	16
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	16, 17
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	6, 7
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	6, 7
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	9, 10
Pikeminnow	The goal of the program is to manage annual pikeminnow predation on juvenile	13

Program Name and Affiliation	Program Description	Measures Addressed
Management Program	salmonids. The program pays rewards to anglers for harvesting pikeminnow over a prescribed size, thus providing an incentive to remove the large, predaceous pikeminnow from the population.	
Caspian Tern Relocation Project	The goal of the project was to relocate terns to another location in the estuary where tern predation on juvenile salmonids would be reduced but the viability of the tern population would be maintained.	14

5.2.1.1.7 Summer Steelhead

.5.2.1.1.7.1 Background

Steelhead (Oncorhynchus mykiss) are rainbow trout that migrate to and from the ocean. Resident and anadromous life histories are often found in the same population. Steelhead exhibit tremendous variability in life history with juveniles rearing for 1 to 4 years in freshwater before migrating seaward and as adults spending 1 to 3 years in the ocean. Steelhead generally migrate northward along the coast of Canada and Alaska before dispersing far out into the North Pacific. Summer steelhead return from the ocean between May and October and generally spawn between late February and early April. Lower Columbia River subbasins that historically supported summer steelhead included the Kalama, North Fork Lewis, East Fork Lewis, Washougal, and Wind. Where winter and summer runs occur in the same stream, summer steelhead tend to spawn higher in the watershed than winter steelhead.

.5.2.1.1.7.2 Status

Lower Columbia River steelhead are listed as threatened under the ESA. The Willamette/Lower Columbia Technical Recovery Team has identified 23 historical populations of steelhead in the Lower Columbia River ESU. Washington accounts for 14 of 17 winter run steelhead and 5 of 6 summer run steelhead populations in this ESU. Small but significant steelhead populations remain in most Washington subbasins where they were historically present. All Washington lower Columbia summer steelhead populations are below proposed recovery planning targets with the possible exception of the Wind summer population.

Table 5-26. Summer steelhead abundance estimates by life stage.

Life Stage	Historical Abundance	Current Abundance
Juvenile Rearing (out-of-subbasin populations)	Historical productivity of summer steelhead was assumed to be 230 smolts per spawner (based on Kalama River EDT template estimate), an estimated 34.5 million juveniles used the lower mainstem, Western Oregon tributaries, estuary, and plume (based on assumed total Columbia River escapement of 150,000).	Current productivity of summer steelhead is assumed to be 85 smolts per spawner (Kalama River EDT patient estimate). Based on this level of productivity, juveniles using the lower mainstem, Western Oregon tributaries, estuary, and plume is estimated to be 21.25 million (assuming a total Columbia River escapement of 250,000). The 2002 passage index of steelhead (combined) at Bonneville Power House #2 was 1.5 million fish.
Adult Migration (out-of-subbasin populations)	Historical Columbia River total summer steelhead run has ranged from about 100,000 to 475,000.	The 2000 Columbia River total summer steelhead run was about 315,000, with 34,000 attributed to the lower river. The 2002 steelhead (combined) passage count at Bonneville Dam totaled 481,036; the 'wild' component was 143,032.

.5.2.1.1.7.3 Value statement

Lower Columbia River, Middle Columbia, Upper Willamette, and Snake River steelhead are currently listed as threatened under the Endangered Species Act while Upper Columbia River steelhead are listed as endangered. Additionally, summer steelhead are culturally, economically, and ecologically important. Juvenile rearing in the lower mainstem, Western Oregon tributaries, estuary, and plume are a vital life history trajectory for summer steelhead. The restoration goal for lower Columbia summer steelhead is to increase the population to a self-sustaining, viable population that can provide for tribal, sport, and commercial fishery harvest. Because hydroelectric facilities create substantial challenges for both upstream and downstream fish passage, it is likely that restoration efforts of summer steelhead will achieve the highest success in the lower Columbia mainstem, the estuary, and the various tributaries below Bonneville Dam. However, recovery efforts of upriver summer steelhead populations should still be pursued. Strategies and measures to return summer steelhead populations to viability throughout the historical distribution are among the highest level of importance.

.5.2.1.1.7.4 Limiting factor (Threats)

Summer steelhead in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume have threats to both life stages expressed in the combined subbasins and adjacent tributaries. Historically, summer steelhead populations were distributed throughout the Columbia River basin. Within the Lower Columbia River ESU, the Lewis and Kalama River subbasins likely supported the largest summer steelhead populations, although historical escapement data are limited. The Lewis River subbasin has undergone development of hydroelectric facilities that have blocked access to a considerable amount of historical summer steelhead spawning habitat. Downstream of Bonneville Dam, juvenile summer steelhead have been impacted by low flows, disconnected or lost habitats, and predation losses. The period of estuarine residence may be a critical phase in the life history of summer steelhead and thus plays a major role in determining the size of the subsequent adult run back to fresh water.

Table 5-27. Summer steelhead limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Juvenile Rearing (out-of-subbasin populations)	SS.LF.1 Microdetritus-based food web. The current microdetritus-based food web is expected to be less productive than the historical macrodetritus-based food web. Loss of wetland and side channel habitat has reduced the local macrodetritus inputs from terrestrial and riparian habitats that supported the historical food web. Present detrital inputs to the food web are dominated by microdetritus from upriver sources and are controlled primarily by reservoir production and flow rates from Bonneville Dam. Further, the microdetritus-based food web is thought to be limited to the spatially-confined estuary turbidity maximum region.	High/Medium
	SS.LF.2 Loss of habitat connectivity. Areas of adjacent habitat types distributed across the estuarine salinity gradient may be necessary to support annual migrations of juvenile salmonids. As juveniles grow, they move across a spectrum of salinities, depths, and water velocities. Specifically, research suggests that proximity of feeding and refuge areas for stream-type salmonids may be important for survival and olfactory cues needed for a successful return migration.	High/High

Life Stage	Limiting Factors	Impact/Certainty
	SS.LF.3 Predation mortality. Current primary sources of predation on summer steelhead are substantial, however, how current predation levels compare to those experienced historically is unknown. Primary predation sources on summer steelhead include Caspian terns and pikeminnow.	High/High
	SS.LF.4 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on salmonids. Exposure risks to summer steelhead are not clear; contaminant uptake may be through contaminated diet items.	Medium/Medium
	SS.LF.5 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on summer steelhead are unknown but are expected to be negative.	High/Low
	SS.LF.6 Density dependence. Density dependent mechanisms in the lower mainstem, Western Oregon tributaries, estuary, and plume may limit juvenile salmonid survival and productivity, however, the significance is unclear. NOAA Fisheries is currently conducting research intended to clarify this issue.	Low/Low
	SS.LF.7 Fitness and timing of juvenile salmonids entering the subbasin. Juveniles entering the subbasin from upriver via barge releases or dam passage experience lower survival than historical mainstem emigration prior to hydrosystem development.	High/High
Adult Migration (out-of-subbasin populations)	SS.LF.9 Dam passage. Summer steelhead experience some mortality and delay associated with mainstem dam passage. For Lower Columbia River mainstem dams, average per dam survival rate estimate for steelhead was 95%; this estimate includes fallback and re-entry.	Medium/High
	SS.LF.10 Migration barriers/ lack of resting habitats. Elevated water temperature or high water flow may act as a temporary adult migration barrier. Additionally, high water flow likely reduces available resting habitat for migrating adults.	Low/High
	SS.LF.11 Predation losses. Marine mammals (pinnepeds) prey on adult salmon, but the significance is unclear.	Low/Medium

.5.2.1.1.7.5 Biological objectives & working hypotheses

Biological objectives for summer steelhead, based on desired environmental conditions, are formulated to support the value statement identified above. At present, we lack the ability to develop meaningful biological performance metrics to describe focal species response to subbasin habitat conditions in terms of productivity, capacity, abundance, or life history diversity. Summer steelhead utilize the lower mainstem, Western Oregon tributaries, estuary, and plume subbasins primarily for migration, although evidence suggests that juvenile summer steelhead feed as they migrate and that the brief mainstem and estuarine residence time is extremely important in the physiological transformation to smolts and in gathering olfactory cues needed for a successful return migration. Thus, actions within the lower mainstem and estuary subbasins (e.g. restored floodplain connectivity or predator management) can affect summer steelhead survival within the subbasins, however, biological performance levels are likely determined by out-of-subbasin effects (e.g. spawning tributary conditions or mainstem/ tributary dam passage success).

Table 5-28. Summer steelhead biological performance levels.

Metric[a]	Performance Level
Mortality[b]	Current mortality estimates range from 0.04 to 0.59 and average 0.16. Mortality estimates at population recovery goals range from 0.04 to 0.59 and average 0.16.

[a] Mortality metric applies to out of subbasin summer steelhead populations.

[b] Mortality is based on preliminary analysis by the LCFRB based on comparison of EDT estimates of mainstem and estuary habitat effects on lower Columbia River summer steelhead populations, current population abundance estimates, and population abundance recovery goals.

Table 5-29. Summer steelhead desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
Juvenile Rearing (all juveniles in the Columbia River Basin)	SS.PO.1 Protect existing rearing habitat to ensure no further net degradation. *Hypothesis Statement:* If current rearing habitat is protected, then juvenile rearing capacity and productivity in the lower mainstem, Western Oregon tributaries, estuary, and plume can be maintained. *Justification:* Protection and maintenance of existing rearing habitat will provide a base level of juvenile summer steelhead production and diversity. Further, protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	SS.PO.2 Restore connectivity between river and floodplain, as well as in-river habitats. *Hypothesis Statement:* If connectivity with the floodplain is restored, then juvenile summer steelhead productivity in the estuary and mainstem will increase. *Justification:* Connectivity with the floodplain will restore macrodetrital inputs and alter the current food web. A macrodetritus-based food web will increase productivity and support greater life history diversity. Connectivity among in-river habitats can provide both resting and feeding habitats.	High	High/High
	SS.PO.3 Reduce predation mortality on emigrating juveniles. *Hypothesis Statement:* If predation on juveniles is reduced, then juvenile summer steelhead survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Predation on juvenile salmonids in the lower Columbia River and estuary has increased as a result of increased predator populations, such as northern pikeminnow or Caspian terns. Predator control and relocation programs have been successful at reducing predation, however, it is unclear how current levels of predation compare to historical levels.	Medium	High/High
	SS.PO.4 Reduce contaminant exposure of emigrating juveniles. *Hypothesis Statement:* If contaminant exposure is reduced, then juvenile summer steelhead survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Contaminants have been shown to have detrimental effects on juvenile salmonids, such as decreased immune function, disrupted physiological processes, and generally reduced fitness. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. Exposure routes are not certain and may be from contact with contaminated substrates or uptake through prey.	High	Medium/Medium
	SS.PO.5 Document the interaction between emigrating juvenile summer steelhead and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then juvenile summer steelhead survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	High/Low

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	SS.PO.6 Develop an understanding of emigrating juvenile summer steelhead life history diversity and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of salmonid integration with the ecosystem increases, then management and recovery actions will proceed with greater certainty. *Justification:* Our current understanding of life history diversity and salmonid interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; ongoing research continues to increase our knowledge and reduce uncertainty.	High	High/Medium
	SS.PO.7 Evaluate/improve survival of upriver juvenile summer steelhead emigrating via barge or dam passage. *Hypothesis Statement:* If survival and fitness of emigrating upriver summer steelhead improves, then these fish will be better prepared for emigration through the lower mainstem, Western Oregon tributaries, estuary, and plume. *Justification:* Current survival/fitness of upriver fish is lower than historical conditions. This lower fitness may predispose fish to predation as they enter the subbasin, delay attainment of threshold size needed for smoltification, or disrupt physiological processes that control smoltification.	High	High/High
Adult Migration (all adults in the Columbia River Basin)	SS.PO.8 Maintain favorable water flow and temperature throughout mainstem migration period (~ May-October). *Hypothesis Statement:* If extreme water flows or temperatures exist during migration, then spawning may be delayed or averted. *Justification:* Extreme (i.e. both high and low) water flow and temperature can serve as a migration barrier that generally results in one of three outcomes: delayed arrival to spawning grounds, spawning activity in less than desirable locations, or no spawning. Each of these scenarios often results in decreased juvenile fitness or productivity.	Medium	Medium/High

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	SS.PO.15 Protect genetic integrity and biological diversity and abundance of depressed salmonid stocks by directing effort of commercial harvesters in the estuary to alternative, hatchery derived stocks *Hypothesis Statement:* Continuation of Select Area (terminal) fishing opportunities in the lower Columbia River will support productive sport and commercial fisheries on harvestable stocks without negatively affecting rebuilding efforts directed at weak stocks. *Justification*: Commercial and recreational harvest in the lower Columbia River has the potential to negatively impact salmonid stocks, if not managed and directed. Harvesters are generally agreeable to targeting specific hatchery stocks, and the technology exists to manage fisheries with selectivity in the estuary without negatively impacting biological diversity and genetic integrity of wild stocks.		
	SS.PO.9 Reduce predation mortality on migrating adults. *Hypothesis Statement:* If predation on adults is reduced, then summer steelhead survival in the estuary and mainstem will increase. *Justification:* Marine mammal predation on adult salmonids in the lower Columbia River and estuary has been observed. Predation mortality may be significant and needs to be quantified.	High	Low/Medium

.5.2.1.1.7.6 Strategies

Habitat potential includes both quantity and quality. The properly functioning benchmark is less than the pristine historical condition. Properly functioning conditions (PFC) represent favorable habitat for salmon as defined by NOAA Fisheries. PFC generally represent a reasonable upper bound on the potential for habitat improvement although in some cases presume large-scale changes that would be difficult to implement (e.g. levee removal). As a general rule, populations may typically be considered viable when properly functioning conditions exist throughout the historical distribution. However, populations may also be viable where not all available habitat is properly functioning. Populations may sometimes fall short of viability despite properly functioning habitat conditions, if the historical range has been substantially reduced or other mortality factors are severe.

Healthy, harvestable salmon populations depend on favorable habitats for spawning and rearing. Salmon populations typically go extinct when periodic poor ocean conditions drive populations in poor habitat to low numbers from which they cannot rebound. High quality habitat increases fish population productivity which helps maintain adequate numbers even during poor ocean conditions and allows them to rebound quickly. Populations can typically withstand some combination of stream habitat degradation, mainstem and estuary habitat degradation, and other impacts such as fishing or hatchery domestication. Historical populations appeared to sustain very high fishing and hatchery impacts prior to the cumulative effects of widespread habitat declines. Conversely, no level of fishery or hatchery reductions will be sufficient to offset severe habitat declines.

Current habitat conditions in most areas are much less favorable than historical conditions and substantially less favorable than necessary to support viable wild salmon and steelhead populations. Assessments detailed in the Technical Foundation identified tributary habitat degradation as the largest single impact among the various limiting factors (i.e. the 4-Hs). Land and water use practices have contributed large decreases in habitat quality and quantity in all subbasins.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving salmon habitat conditions in some areas and will further improve salmon habitat over time, but additional changes are needed in many areas to support the recovery of wild populations. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on salmon and increased commitment to protect this resource. More fish-friendly practices have been implemented for many activities both before and after listing of salmon. Some changes have already produced effects; others will be expected to pay future dividends. Still others will be needed to offset the cumulative effects of years of habitat degradation.

A significant level of increased habitat protection and restoration will be required to just to arrest declining trends and ensure that population status does not decline further. Additional efforts will be required to make substantial gains. Recovery depends on arresting and reversing declining trends in salmon numbers. The size of the required change will depend on the steepness of the decline and the level of improvement needed to meet region-wide recovery goals. Projected human population growth in lower Columbia river subbasins will compound the

demands for increased habitat protection and restoration just to stabilize fish populations at current levels.

Salmon depend on suitable habitat conditions which in turn are regulated by conditions in adjacent and upstream watersheds. Local habitat activities can provide short term benefits but long-term improvements in habitat conditions will depend on restoration of functional watershed processes. Where watershed processes are not intact, habitat conditions rapidly revert to equilibrium with their surroundings.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue. For instance, riparian protection measures might require 50-150 years to provide full benefits based on the time it takes for trees to mature and restore shade and channel stability, then die and provide woody debris and channel diversity. Because of the required scale and delayed effects, watershed improvements typically provide limited prospects for immediate relief of acute extinction risks for salmon caused by current low numbers.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance. However, protection measures alone will not suffice to recover some species to viability, especially in light of future growth trends. The geographical distribution of some species overlaps significantly with areas that have been subjected to significant human disturbance, including urban development and agriculture. Active restoration in previously disturbed areas may be necessary for recovery.

Although effects may often be temporary, site-specific improvements in habitat conditions and access, in concert with non-habitat measures can help ameliorate immediate extinction risks in the interim, until underlying causes of stream habitat declines are addressed. Even where recent changes to land and water use patterns can be expected to provide suitable conditions for population viability in the long term, more immediate actions may be required to make sure that the fish are around to reap those long term benefits.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by salmon and steelhead populations to any given suite of actions. These uncertainties limit our ability to stipulate precise levels of improvement needed to achieve recovery. The recovery plan needs to recognize these uncertainties with adequate safety factors, contingences, and in-course corrections.

Habitat

SS.S1. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Physical Objectives Addressed: SS.PO.1, SS.PO.2, and SS.PO.8

Explanation: Important habitats in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

SS.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Physical Objectives Addressed: SS.PO.1, SS.PO.2, and SS.PO.8

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

SS.S3. Avoid large-scale habitat changes where risks to salmon and steelhead are uncertain.

Physical Objectives Addressed: SS.PO.1

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that things don't continue to get worse.

SS.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: SS.PO.1

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

SS.S5. Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.

Physical Objectives Addressed: SS.PO.1 and SS.PO.2

Explanation: Salmonid recovery is most feasibly accomplished in areas that already support significant fish production. It also makes sense to focus on currently marginal areas where the gap between existing and suitable conditions is relatively small. Attempts to restore severely degraded areas would require proportionately large costs relative to benefits. Recovery criteria will require some restoration of areas that are substantially degraded but also provides significant flexibility in where habitat restoration efforts are distributed among and within subbasins.

SS.S6. Utilize a combination of active and passive habitat restoration measures to

provide near term and long term benefits.

Physical Objectives Addressed: SS.PO.1, SS.PO.2, and SS.PO.8

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but effects are rarely lasting unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures in the riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions).

SS.S7. Recognize the significance of salmon to the productivity of other species and the salmon themselves.

Physical Objectives Addressed: SS.PO.6

Explanation: Salmon are an integral component of both the freshwater and marine ecosystem of which they are a part. Juvenile and adult salmon are eaten by a variety of other species and the status of these species is related to the status of salmon. Many significant salmon predators including bull trout, eagles, and grizzly bears have declined concurrent with salmon declines, albeit for a variety of reasons. Large numbers of salmon returning to spawn streams also introduce significant amounts of marine-derived nutrients into freshwater systems. These nutrients may stimulate primary and secondary productivity when other appropriate habitat conditions exist; this increased productivity increases food for juvenile salmon as well as other species. Finally, salmon actually affect physical habitat conditions. For instance, digging of salmon redds can help maintain suitable sediment-free spawning gravels.

Introduced Species

SS.S8. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introducing species.

Physical Objectives Addressed: SS.PO.5

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Predators

SS.S9. As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.

Physical Objectives Addressed: SS.PO.3 and SS.PO.9

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Research

SS.S10. Our understanding of the relationships between summer steelhead and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: SS.PO.1 through SS.PO.9

Explanation: Emerging research and understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume are promising tools in the near future. Also needed are additional understanding about how summer steelhead populations use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume. Additionally, future research should also focus on establishing clear relationships between summer steelhead and the various predators or introduced species in the lower mainstem, Western Oregon tributaries, estuary, and plume.

SS.S11. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: SS.PO.1 through SS.PO.9

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection, habitat restoration, and recovery measures are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

SS.S12. Assess the Mainstem Lower Columbia River and Columbia River Estuary by discreet geographic reaches for restoration and protection priorities.

Physical Objectives Addressed: SS.PO.1, SS.PO.2, SS.PO.3, SS.PO.4, SS.PO.5, SS.PO.6, SS.PO.9,

Explanation: A chronic problem exists in the information systems of resource planners who are unable, today, to accurately inventory where protection and restoration work has been completed or is ongoing, and where additional work is needed. Throughout the subbasin planning process, an urgent need was identified to develop a "desktop" triage tool to identify where measures should be applied, or where mitigation steps might be needed in response to some natural or anthropogenic system disturbance. A systematic way of identifying the protection and restoration potential of specific areas within the subbasin needs to be developed. Such a system could then provide a means for prioritizing actions.

Sustainable Fisheries

SS.S15 Optimize continued harvest of healthy hatchery stocks while reducing harvest rates on weak, endangered stocks in mixed stock, mainstem fisheries.

Explanation: As native salmon runs on the Lower Columbia River diminished, the fishing community looked for a way to bolster the commercial industry, a backbone of the region's economy for generations of families. The goal was to were to create and expand known stock fisheries for high-quality salmon in the Columbia River Basin while providing greater protection for endangered stocks. In its 1993 Strategy For Salmon, the Northwest Power Planning Council recommended that select area (formerly terminal area) fishing sites be identified and developed to harvest abundant fish stocks while minimizing the incidental harvest of weak stocks. The Council, through its Fish and Wildlife Program, called on the BPA to: "Fund a study to evaluate potential terminal fishery sties and opportunities. Beginning in 1993, BPA initiated the Columbia River Terminal Fisheries Project (now the Columbia River Select Area Fishery Evaluation Project), a 10-year comprehensive program to investigate the feasibility of select area fisheries in Youngs Bay and other sites in Oregon and Washington (BPA 1996, Miller et al. 2002). Select area fisheries are being explored as a means to increase the sport and commercial harvest of hatchery fish while providing greater protection of weak wild salmon stocks. Biological Opinions issued by NOAA Fisheries (NMFS 1998; NMFS 2003a; NMFS 2003b) have determined the project does not likely jeopardize the continued existence of listed salmonid stocks.

.5.2.1.1.7.7 Measures to achieve strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary.

Habitat

SS.M1. Restore tidal swamp and marsh habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Loss of tidal swamp and marsh habitat has respectively resulted in an estimated 77% and 43% loss of these habitat types from 1870 to 1983. The substantial acreage loss of the tidal swamp and tidal marsh habitat types has reduced local inputs of macrodetritus, thereby converting the estuarine foodweb to a microdetritus base dominated by upriver reservoir inputs. Additionally, although ocean-type salmonids are typically associated with these shallow water, peripheral habitats, evidence suggests that stream-type salmonids also use these habitats.

Variables	Context
Strategies addressed	SS.S1, SS.S2, SS.S3, SS.S4, SS.S5, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of tidal and marsh habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of tidal marsh and swamp habitats would have a high benefit because they may increase food web productivity and provide resting habitat for stream-type salmonids.
Barriers to success	*Explanation:* Tidal marsh and swamp habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

SS.M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows during periods of salmonid emigration, and restores tidal channel complexity in the estuary.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified lower mainstem, Western Oregon tributaries, estuary, and plume habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that emulate a more natural regime will help improve habitat conditions for salmonids and other resident fish and wildlife species.

Variables	Context
Strategies addressed	SS.S1, SS.S2, SS.S3, SS.S4, SS.S5, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit.
Barriers to success	*Explanation:* An annual allocation of water for salmonids will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

SS.M3. Maintain adequate water flows throughout migration periods.

Explanation: Prevents migration barriers, high temperatures in late summer, lack of resting habitats, and predation losses. Facilitates juvenile movement through the mainstem to the estuary.

Variables	Context
Strategies addressed	SS.S1, SS.S2, SS.S3, SS.S4, SS.S5, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for maintaining water flows during migration. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	Medium. *Explanation*: Maintenance of water flows during migration would have a medium benefit because of the significance of the subbasins as a migratory pathway and for juvenile rearing/smoltification.
Barriers to success	*Explanation:* Maintenance of water flows during migration will be possible through the modification of current water uses, which at present seems possible if current water budget is only modified for brief periods. Additionally, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

SS.M4. Restore connectedness between river and floodplain.

Explanation: Restoring the access to the floodplain increases juvenile salmonid access to shallow water, low velocity, peripheral habitats. Further, connection of the river and floodplain begins to restore the historical macrodetritus-based food web.

Variables	Context
Strategies addressed	SS.S1, SS.S2, SS.S3, SS.S4, SS.S5, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

SS.M5. Protect and restore riparian and wetland habitat condition and function.

Explanation: Riparian zones are critical habitats for many species. This measure incorporates a variety of tools including, local land use regulatory actions, acquisition, and restoration activities. This measure is inherently linked with measures 1 and 4.

Variables	Context
Strategies addressed	SS.S1, SS.S2, SS.S3, SS.S4, SS.S5, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective for *protecting* wetland and riparian habitats. The current programs cannot be expected to attain the physical objective for *restoring* wetland and riparian habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of riparian habitats would have a high benefit because of the addition of peripheral habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Riparian and wetland habitat can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

SS.M6. Restore impaired sediment transport processes affecting the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Sediment dynamics are a critical component of lower mainstem, Western Oregon tributaries, estuary, and plume habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation, and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	SS.S1, SS.S2, SS.S3, SS.S4, SS.S5, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

SS.M7. Mitigate channel dredging activities in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume that alter habitat forming processes, reduce salmon population resilience, and inhibit recovery.

Explanation: Channel dredge activities affect the quality of the various lower mainstem, Western Oregon tributaries, estuary, and plume salmonid habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Indirectly, wakes from large ships increase erosion and can cause stranding of juvenile salmonids located along the shoreline. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context
Strategies addressed	SS.S1, SS.S2, SS.S3, SS.S4, SS.S5, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for mitigating dredging activity effects. The primary reason is that the sole purpose of the Channel Deepening BiOp is to protect ESA-listed salmonids and their habitat while allowing dredging activity to proceed.
Potential to contribute to biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation and potential benefits in the plume environment.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects throughout the channel deepening process and beyond. However, there remains uncertainty as to the short- and long-term effects of channel modification on flow dynamics, sediment transport, and habitat forming processes.

SS.M8. Limit the effects of toxic contaminants on salmonid fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on salmonids, resident fish, or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	**Context**
Strategies addressed	SS.S4, SS.S7, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and estuary, as well as uncertainty in exposure risks to salmonids.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

Introduced Species

SS.M9. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	SS.S3, SS.S4, SS.S7, SS.S8, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

SS.M10. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	SS.S7, SS.S8, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

SS.M11. Consider the potential impacts of American shad on salmon as well as the feasibility and advisability of shad management measures.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon bycatch. The impacts of shad on salmon are unclear but the large shad population biomass has the potential for significant impacts. Elimination or control of shad is not a silver bullet for salmon recovery but the significance of interactions and opportunities for management warrant closer consideration.

Variables	Context
Strategies addressed	SS.S7, SS.S8, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing shad management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of shad.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

SS.M12. Avoid management or enhancement of established populations of introduced gamefish that pose significant predation or competition risks to salmon.

Explanation: Established populations may be managed to shape fishery benefits as long as risks to salmon are not exacerbated. For example, walleye are every bit as voracious a predator on salmon as pikeminnow but because the predation is concentrated among small walleye, fishing is not an effective means of control. Walleye fisheries can be managed with size regulations for instance to shape fishery benefits with no effect on salmonids.

Variables	Context
Strategies addressed	SS.S7, SS.S8, SS.S9, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for implementing gamefish management measures. The primary reason is a disagreement between State and Federal fish and wildlife agencies regarding the importance, desirability, and negative impacts of gamefish.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

Predators

SS.M13. Continue to manage the Northern pikeminnow fishery to help offset increased predation that resulted from habitat alteration.

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikeminnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

Variables	Context
Strategies addressed	SS.S7, SS.S9, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing pikeminnow predation on juvenile salmonids. Currently, there are no plans to discontinue the pikeminnow management program.
Potential to contribute to biological objectives	High. *Explanation*: Continued management of pikeminnow predation will minimize predation effects on juvenile salmon.
Barriers to success	*Explanation:* The current pikeminnow management program has been successful at removing the large, predaceous pikeminnow from the population, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

SS.M14. Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns and no new habitats are created in areas where salmon predation might pose added risks.

Variables	Context
Strategies addressed	SS.S3, SS.S4, SS.S7, SS.S9, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing Caspian tern predation on juvenile salmonids. Currently, there are no plans to discontinue the Caspian tern relocation program.
Potential to contribute to biological objectives	High. *Explanation*: Caspian tern predation in the past has been substantial, thus, continued tern management will minimize predation effects on juvenile salmon.
Barriers to success	*Explanation:* The current Caspian tern relocation program has been successful at relocating the tern colony from Rice to East Sand Island, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

SS.M15. Establish regulatory flexibility to manage seals and sea lions if and where increased predation poses significant risks to salmon recovery.

Explanation: Only after adoption of the U.S. Marine Mammal Protection Act have seals and sea lions begun to recover from historical low levels. Populations have expanded greatly and significant numbers now occur in the lower Columbia River.

Variables	Context
Strategies addressed	SS.S7, SS.S9, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs in place that are intended to quantify the amount and significance of pinniped predation on adults salmonids.
Potential to contribute to biological objectives	Low. *Explanation*: The significance of pinniped predation on adult salmonids is unclear but expected to be somewhat low.
Barriers to success	*Explanation:* Establishing regulatory control of pinnipeds to limit predation on adult salmonids is challenged by pinniped protection under the Marine Mammal Protection Act, however, some level of management is possible if warranted for salmon recovery.

Research

SS.M16. Improve understanding of interrelationships among fish, wildlife, and limiting habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of causal relationships between salmonids, resident fish, and wildlife species is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	SS.S2, SS.S3, SS.S5, SS.S7, SS.S8, SS.S9, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

SS.M17. Increase tagging and other marking studies to determine the origin, estuarine habitat use, survival, and migration patterns of various salmonid populations.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by ocean- and stream-type salmonids is poorly understood. The use of tagging and other marking studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	SS.S7, SS.S10, and SS.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of salmonid behavior and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding salmonid life history diversity and mainstem/estuary/ plume habitat use will have a high benefit and is vital to continued progress toward recovery.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

SS.M18. Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Mainstem Lower Columbia River and Columbia River Estuary

Explanation: Identifying priority habitat for protection and restoration within the Mainstem Lower Columbia River and Columbia River Estuary should be a priority. The approach should be the development of both a tool and a process that could be used iteratively to provide an adaptive management framework for resource planners. In the Columbia basin tributaries, Ecosystem Diagnostic and Treatment (EDT) has provided planners with a quantitative method for determining prioritiesand for modeling likely outcomes. Such a tool has been difficult to apply to the estuary because many species with use the estuary for critical life stages do not produce in the estuary. The challenge will be to develop a tool that reflects the importance of the estuary that use it for important but non-productive portions of their life history.

Variables	Context
Strategies addressed	SS.S1, SS.S2, SS.S3, SS.S4, SS.S5, SS.S6, SS.S9, SS.S10, and SS.S12
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are insufficient for determining where to target protection and restoration activities, although our understanding of the habitat forming processes and relationships between species and habitat attributes is growing significantly.
Potential to contribute to biological objectives	High. *Explanation*: While measures and strategies intended to effect positive change in the Mainstem Lower Columbia River and Columbia River Estuary are becoming clear, knowing where to apply these measures is uncertain. Tools that help target resources will increase all other measures chances of being successful.
Barriers to success	*Explanation:* A key goal of any desktop management goal should be to provide a means of predicting outcomes of restoration and protection activities, but standard measures of performance, for example, production and abundance are likely to occur out-of-basin, making expected outcomes a difficult measure to quantify.

Sustainable Fisheries

SS.M20: Continue the Select Area Fisheries Project

Explanation: The project primarily utilizes existing hatchery facilities to spawn, hatch, and conduct initial rearing of juvenile salmonids for subsequent out planting to net pen facilities at each of the select area sites. Hatcheries providing production are South Fork Klaskanine (CEDC); Big Creek, Bonneville, Cascade, Gnat Creek, North Fork Klaskanine, Oxbow, Sandy, South Santiam, and Willamette (all ODFW); Cowlitz, Elochoman, and Gray's River (all WDFW), and Eagle Creek (USFWS). The Clatsop Count Economic Development Council (CEDC) Fisheries Project operates estuarine net-pen sites in Youngs Bay, Tongue Point, and Blind Slough. The Washington Department of Fish and Wildlife has net-pen sites at Deep River and Steamboat Slough. Fish are grown and released from these pens under varying management and grow-out regimes including two-week acclimation, over-winter, and full term net pen rearing. Annual releases for 2000-2003 have averaged 3.8 million coho, 1.0 million spring chinook, and 1.0 million select area bright fall chinook (includes ODFW's Restoration and Enhancement production). Ex-vessel values of 2000-2003 SAFE commercial fisheries were $408,000-$787,000, with state-level personal income impacts of $1.4 - $3.1 million dollars for al l regional fisheries combined.

Variables	Context
Strategies addressed	SS.S15
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Program Table (CEDC Fisheries)
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are sufficient for directing harvest of commercial and recreational fishers to targeted stocks of hatchery stocks of summer Chinook, fall Chinook, and Coho
Potential to contribute to biological objectives	High. *Explanation*: The Terminal Fisheries project has been demonstrated to be effectives for addressing the following objectives: Supports a healthy Columbia basin, Maintains biological diversity, Maintains genetic integrity, Increases run sizes or populations As these objectives are addressed by the measure, the wants, needs, and desires of the fishers can be met.
Barriers to success	*Explanation:* Barriers to success are very low, as most of the logistical and technical problems have been addressed. The project has addressed concerns about juvenile interactions, predation, and straying. The major barrier is that the program is not self-

	sustaining

.5.2.1.1.7.8 Programs to implement strategies and measures

Table 5-30. Existing programs and their connection to recovery measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	1, 4, 5
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; collaboration with these efforts is vital.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	5
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	5
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	5
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	5
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	6
CEDC Fisheres	Manages Select Area Fishing project to direct harvest away from listed stocks, and mitigate for lack of harvest in the lower Columbia River	20
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	6
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	5
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	2, 3, 6
Washington State Conservation Commission/ Conservation Districts	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	1, 4
Columbia	CREST is a council of local governments serving as a forum for collaboration	1, 4, 5, 6,

Program Name and Affiliation	Program Description	Measures Addressed
River Estuary Study Taskforce (CREST)	and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	7, 8
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	1, 4, 5
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 5, 7
Washington State Department of Agriculture (SSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The SSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	2, 3, 8
Environmental Services - Washington State Department of Transportation (SSDOT)	The Environmental Services Department of SSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 5, 8
Habitat Program – WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	1, 4, 5, 6, 10, 11, 12, 13, 16, 17
State Lands Management Program –	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFSS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
DNR	Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 4, 5, 6, 8
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	The goal of the SRFB is to protect and restore salmon habitat. The board provides grant funds to protect or restore salmon habitat and assist related activities; it works closely with local watershed groups. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SRFB guides spending of funds targeted for salmon recovery activities and projects.	1, 4, 5, 6
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, 15, 16, 17
Environmental Contaminants Program – US Fish and Wildife Service (USFSS)	The USFSS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	8
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	1, 5
Partners for Fish and Wildlife Program – USFSS	The program is the USFSS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
	species on private lands.	
Washington State Ecosystem Conservation Program – USFSS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFSS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	16
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	16, 17
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	6, 7
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	6, 7
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	9, 10
Pikeminnow Management Program	The goal of the program is to manage annual pikeminnow predation on juvenile salmonids. The program pays rewards to anglers for harvesting pikeminnow over a prescribed size, thus providing an incentive to remove the large, predaceous pikeminnow from the population.	13
Caspian Tern Relocation Project	The goal of the project was to relocate terns to another location in the estuary where tern predation on juvenile salmonids would be reduced but the viability of the tern population would be maintained.	14

5.2.1.1.8 Sturgeon

.5.2.1.1.8.1 Background

.5.2.1.1.8.1.1 White

White sturgeon (Acipenser transmontanus) live in large rivers along the Pacific coast of North America and move freely between freshwater and the ocean where they may remain for variable but prolonged periods. Large sizes (over 12 feet and 1000 pounds) and long life spans (100 years or more) allow them to negotiate heavy current and outlast good and bad periods. These fish are bottom-oriented feeders that eat primarily shrimp and clams as young but graduate to a live fish diet as they get larger.

Sturgeon are an ancient order of fishes that have existed for hundreds of millions of years. Sturgeon species are found in most major river systems of the Northern Hemisphere but have been widely decimated by over fishing and dam construction. Their long lifespan and late age of maturity make sturgeon particularly susceptible to over fishing. Columbia River white sturgeon were severely over fished during the late 1800's prior to the adoption of significant fishery restrictions and recovery required decades. Mainstem dams block movements, fragment the habitat, and reduce anadromous prey. Sturgeon rarely use fish ladders which were engineered to pass the more surface-oriented salmon.

.5.2.1.1.8.1.2 Green

Green sturgeon (Acipenser medirostris) is an anadromous species that spawn in several West Coast rivers but spend most of their life in near-shore marine and estuarine waters from Mexico to southeast Alaska. While green sturgeon do not spawn in the Columbia Basin, significant populations of subadults and adults are present in the estuary during summer and early fall. Green sturgeon are occasionally observed as far upriver as Bonneville Dam. Reasons for concentrations in the Columbia River are unclear; no spawning occurs in the system and all of the green sturgeon stomachs examined to date have been empty. These fish may be seeking warmer summer river waters in the northern part of their range.

Adult green sturgeon typically migrate into fresh water beginning in late February. Spawning occurs in deep turbulent river mainstems. Klamath and Rogue River populations appear to spawn within 100 miles of the ocean, while the Sacramento spawning run may travel over 200 miles. Spawning occurs from March–July, with peak activity from April–June.

.5.2.1.1.8.2 Status

.5.2.1.1.8.2.1 White

Within the Columbia River basin, white sturgeon historically ranged all the way to the Canadian headwaters of the Columbia River and to Shoshone Falls in the upper Snake River. The lower Columbia population is among the largest and most productive sturgeon populations in the world and sustains excellent sport and commercial fisheries. However, many upriver populations have declined or disappeared. Bonneville reservoir continues to support a significant

white sturgeon population although numbers and sizes are substantially less than in the lower river. Only the Kootenai River subpopulation of white sturgeon has been listed under the Endangered Species Act (endangered).

Harvest records are a poor indicator of white sturgeon abundance in the lower Columbia River because of variability in harvest regulations and fishing effort. However, to date, harvest records are the only long-term data set that provide some insight into white sturgeon abundance trends.

Table 5-31. White sturgeon abundance estimates by life stage.

Life Stage	Historical Abundance	Current Abundance
Egg Incubation (in-basin population)	Unknown	Unknown
Juvenile Rearing (in-basin population)	Unknown	Unknown
Adult Abundance (in-basin population)	Historical white sturgeon total catch in the Columbia River below Bonneville Dam has ranged from about 11,000 to 72,000. Abundance estimates of the 36-72 inch size class have ranged from about 175,000 to 450,000 during 1987-1998.	The 2000 white sturgeon total catch in the Columbia River below Bonneville Dam was about 51,000.

.5.2.1.1.8.2.2 Green

Green sturgeon occur in the lower Columbia River but do not typically range far upstream from the estuary. NOAA Fisheries completed a status review for green sturgeon in 2003 and determined that listing under the Endangered Species Act was not warranted.

Harvest records are a poor indicator of green sturgeon abundance in the lower Columbia River; green sturgeon are often harvested in white sturgeon or salmonid targeted fisheries. Because fishing effort in these fisheries has been extremely variable over time, green sturgeon catch has also varied. However, to date, harvest records are the only long-term data set that provide some insight into green sturgeon abundance trends.

Table 5-32. Green sturgeon abundance estimates.

Life Stage	Historical Abundance	Current Abundance
Adult Abundance (in-basin population)	Historical green sturgeon commercial catch in the Columbia River below Bonneville Dam has ranged from about 1,000 to 6,000.	The 2000 green sturgeon commercial catch in the Columbia River below Bonneville Dam was about 1,000.

.5.2.1.1.8.3 *Value statement*

.5.2.1.1.8.3.1 White

White sturgeon are culturally, economically, and ecologically important. The restoration goal for lower Columbia River white sturgeon is to maintain or increase the population to a self-sustaining, viable population that can meet the continued cultural, economic, and ecological needs. Strategies and measures to maintain the white sturgeon population at viable levels are among the highest importance.

.5.2.1.1.8.3.2 Green

Green sturgeon are culturally and economically (less so than white sturgeon) important. The ecological importance of green sturgeon in the lower Columbia River and estuary is unclear. The restoration goal for lower Columbia River green sturgeon is to maintain or increase the population to a self-sustaining, viable population that can meet the continued cultural, economic, and ecological needs. Strategies and measures to maintain the green sturgeon population at viable levels are among the highest importance.

.5.2.1.1.8.4 *Limiting factor (Threats)*

.5.2.1.1.8.4.1 White

White sturgeon in the Columbia River estuary and lower mainstem may have threats to all three life stages in the combined subbasins, but the significance of these threats is unclear. The lower Columbia River downstream of Bonneville Dam has the most productive white sturgeon population in the species' range. Factors most responsible for favorable production include access to marine areas, abundant food resources, and favorable hydrologic conditions during the spawning period. Elsewhere in the Columbia River, white sturgeon populations are

not as productive as the lower river population, primarily as a result of habitat fragmentation from dam construction, recruitment failure from a loss or degradation of spawning, incubation, or early rearing habitats, or fishery overexploitation. Downstream of Bonneville dam, adult white sturgeon are impacted by harvest, while eggs and juveniles are impacted by sedimentation (egg suffocation), hypoxia (low dissolved oxygen to eggs), predation, direct losses to dredging, and sublethal effects of parasites/contaminants.

Table 5-33. White sturgeon limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Egg Incubation	WhS.LF.1 Sedimentation of spawning substrates. Deposition of fine sediments in the preferred spawning habitats (i.e. deepwater, rocky substrates) results in egg suffocation. Fine sediment sources include adjacent tributary subbasins as well as migration of sediments from mainstem deposits.	Medium/High
	WhS.LF.2 Egg hypoxia. Hypoxia may have disproportionate negative effects on sturgeon compared to other fish because of their limited capacity to osmoregulate at low dissolved oxygen concentrations. Dissolved oxygen levels may be low for any number of reasons. Delivery of oxygenated water is decreased through sedimentation.	Medium/High
	WhS.LF.3 Predation mortality. Demersal white sturgeon embryos are vulnerable to predation. If predation mortality is substantial, recruitment failure can result.	Medium/Medium
	WhS.LF.4 Direct dredging mortality. Although, white sturgeon prefer to spawn in rocky substrates with sufficient interstitial spaces, spawning has been observed in sands and fine sediments. Additionally, eggs broadcast among rocky substrates may disperse downstream and settle among sands or fine sediments. Dredging activities in areas where embryos are present results in direct mortality.	Medium/Low
	WhS.LF.5 Contaminant/parasite exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on development and physiological processes.	Medium/Low
Juvenile Rearing	WhS.LF.6 Predation mortality. Juvenile white sturgeon losses to predation are probably low because of the protective scutes, benthic habitats, and fast growth. Predation needs to be evaluated.	Low/Low
	WhS.LF.7 Direct dredging mortality. White sturgeon association with benthic habitats make them susceptible to suction dredging effects. There is speculation that dredging operations may attract white sturgeon, compounding potential losses. Dredging activities in areas where juveniles are present can result in direct mortality.	Medium/Low
	WhS.LF.8 Contaminant/parasite exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on growth and physiological processes.	Medium/Low
	WhS.LF.9 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on white sturgeon are unknown and may be offsetting. For example, shad have become an important food source for adult sturgeon while shad and gamefish may compete for food sources with juvenile sturgeon.	Medium/Low

Life Stage	Limiting Factors	Impact/Certainty
Adult Abundance	WhS.LF.10 Fishing mortality. At present, size restrictions in the sport fishery are allowing for sturgeon survival to older ages, thus maintaining adequate abundance of spawning adults. Fishery regulations, fishing effort, harvest levels, and population response needs to be monitored closely to ensure adult spawning abundance is maintained.	Low/High
	WhS.LF.11 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on white sturgeon are unknown and may be offsetting. For example, shad have become an important food source for adult sturgeon while shad and gamefish may compete for food sources with juvenile sturgeon.	Medium/Low
	WhS.LF.12 Incidental mortality. Operations at Bonneville Dam, specifically dewatering of turbines, can entrain white sturgeon and result in mortality. Significance of this mortality factor needs to be evaluated.	Low/Low

.5.2.1.1.8.4.2 Green

Green sturgeon in the Columbia River estuary and lower mainstem may have threats to the adult life stage in the combined subbasins. Green sturgeon presence in the lower Columbia River mainstem and estuary is limited to subadults and adults during summer and early fall; reasons for green sturgeon use of the lower Columbia River is unclear. Green sturgeon are impacted by harvest, generally as a result of incidental harvest during targeted white sturgeon or salmonid fisheries.

Table 5-34. Green sturgeon limiting factors.

Life Stage	Limiting Factors	Impact/Certainty
Adult Abundance	GrS.LF.1 Fishing mortality. At present, size restrictions in the sport fishery are allowing for sturgeon survival to older ages, thus maintaining adequate abundance of spawning adults. Fishery regulations, fishing effort, harvest levels, and population response needs to be monitored closely to ensure adult spawning abundance is maintained.	Low/Medium
	GrS.LF.2 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on green sturgeon are unknown as green sturgeon connection to the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is not clear.	Medium/Low
	GrS.LF.3 Incidental mortality. Operations at Bonneville Dam, specifically dewatering of turbines, can entrain green sturgeon and result in mortality. Significance of this mortality factor needs to be evaluated.	Low/Low

.5.2.1.1.8.5 Biological objectives & working hypotheses (White and Green)

Biological objectives for white sturgeon, including both biological performance and the corresponding environmental conditions, are formulated to support the value statement identified above. It is understood that indices of historical and current white sturgeon population numbers are uncertain, given the assumptions in data collection and the variability that governs population dynamics. As a result, the numeric biological objective goals for the lower mainstem and estuary should be viewed as "order of magnitude" estimates and interim in nature until more certainty can be achieved in abundance estimates and more specific goals can be quantified. Further, because adequate green sturgeon data are not available, we assume that the desired environmental conditions for adult white sturgeon are also applicable to green sturgeon.

Table 5-35. White sturgeon biological performance levels.

Metric	Performance Level
Productivity	>1 recruit per spawner
Abundance of 36-72 inch size class	> 400,000; abundance estimates of this size class in the 1990s approached 450,000, which represents modern day record numbers
Harvest levels	~ 50,000; manage population to maintain recent harvest levels while maintaining spawner abundance

Table 5-36. White sturgeona desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Egg Incubation	WhS.PO.1 Protect existing spawning habitat to ensure no future net degradation. *Hypothesis Statement:* If current spawning habitat is protected, then productivity and population recruitment in the estuary and mainstem can be maintained. *Justification:* Protection and maintenance of existing deepwater, rocky substrate spawning habitat will maintain the current level of embryo survival and population productivity. Sedimentation and dissolved oxygen delivery are two important concerns with developing embryos; concerns are minimized in rocky substrates. Protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High
	WhS.PO.2 Reduce predation mortality on developing embryos. *Hypothesis Statement:* If predation on embryos is reduced, then white sturgeon embryo survival in the estuary and mainstem will increase. *Justification:* Current levels of predation in the lower Columbia is unknown and needs to be quantified.	Medium	Medium/Medium
	WhS.PO.3 Reduce contaminant exposure. *Hypothesis Statement:* If contaminant exposure is reduced, then embryo survival in the estuary and mainstem will increase. *Justification:* Contaminants have been shown to have detrimental effects, such as delayed development or disrupted physiological processes. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms.	High	Medium/Low
	WhS.PO.4 Avoid direct dredging mortality. *Hypothesis Statement:* If suction dredging activities occur in the presence of white sturgeon embryos, then direct mortality will result. *Justification:* White sturgeon embryos may be present among sand and fine sediments as a result of dispersal mechanisms. Suction dredging of these sands and fine sediments results in entrainment and mortality. Dredge operations should avoid known areas of developing white sturgeon embryos.	Low	Medium/Low

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	WhS.PO.5 Develop an understanding of spawning habitat characteristics in the lower mainstem and estuary. *Hypothesis Statement:* If our understanding of spawning habitat increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of known spawning sites and specific spawning habitat characteristics in the lower mainstem and estuary ecosystem is limited; research is needed to increase our knowledge and reduce uncertainty.	Low	Medium/Low
Juvenile Rearing	WhS.PO.6 Reduce contaminant exposure. *Hypothesis Statement:* If contaminant exposure is reduced, then juvenile survival in the estuary and mainstem will increase. *Justification:* Contaminants have been shown to have detrimental effects, such as reduced growth or disrupted physiological processes. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. Reduced contaminant exposure will help maintain current levels of population recruitment.	High	Medium/Low
	WhS.PO.7 Avoid direct dredging mortality. *Hypothesis Statement:* If suction dredging activities occur in the presence of white sturgeon juveniles, then direct mortality will result. *Justification:* More than 100 years of channel maintenance has drastically altered the environemetn for white sturgeon. White sturgeon juveniles may be present among sand and fine sediments as a result of a benthic existence. Suction dredging of these sands and fine sediments results in entrainment and mortality. Dredge operations should avoid known areas of white sturgeon juveniles.	Low	Medium/Low
	WhS.PO.8 Document the interaction between juvenile white sturgeon and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then juvenile white sturgeon survival in the estuary and mainstem may be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	Medium/Low

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	WhS.PO.9 Develop an understanding of juvenile white sturgeon habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of white sturgeon integration with the ecosystem increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of white sturgeon interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; research is needed to increase our knowledge and reduce uncertainty.	Low	Medium/Low
Adult Abundance	WhS.PO.10 Protect population from overexploitation. *Hypothesis Statement:* If current fisheries are properly managed, then adult spawning abundance in the estuary and mainstem can be maintained. *Justification:* Longevity, slow growth, and delayed maturation make sturgeon susceptible to fishery overexploitation. Fishery restrictions (such as size limits) and constant population monitoring can help maintain the current level of spawner abundance.	Medium	High/High
	WhS.PO.11 Avoid incidental operations and maintenance mortality at Bonneville Dam. *Hypothesis Statement:* If Bonneville Dam operations are properly managed, then white sturgeon incidental mortality can be minimized. *Justification:* Turbine dewatering operations at Bonneville Dam have been observed to entrain white sturgeon and result in mortality. This, and other operations at Bonneville and elsewhere in the subbasins, needs to be monitored to determine the significance to the lower Columbia white sturgeon population.	Medium	Low/Low
	WhS.PO.12 Document the interaction between white sturgeon and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then white sturgeon survival in the estuary and mainstem may be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	Medium/Low

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	WhS.PO.13 Develop an understanding of white sturgeon habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of white sturgeon integration with the ecosystem increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of white sturgeon interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; research is needed to increase our knowledge and reduce uncertainty.	High	Medium/Low

[a] The adult white sturgeon desired environmental conditions are assumed to be applicable to green sturgeon as well.

.5.2.1.1.8.6 Strategies (White and Green)

Healthy, harvestable sturgeon populations depend on favorable habitats for spawning and rearing. High quality habitat increases fish population productivity which helps maintain adequate numbers. Populations can typically withstand some combination of mainstem and estuary habitat degradation and other impacts such as fishing. Historical populations could not sustain very high fishing impacts but have since stabilized after size limit restrictions. Current sturgeon habitat conditions in the lower mainstem and estuary appear to be similar to historical conditions because of the current population productivity.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving habitat conditions for salmonids, but the effects on sturgeon habitat are not clear. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on fish populations and increased commitment to protect this resource. More fish-friendly practices have been implemented for many activities.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by sturgeon populations to any given suite of actions. Finally, because adequate green sturgeon data are not available, we assume that the strategies for adult white sturgeon are also applicable to green sturgeon.

Habitat

WhS.S1. Protect functioning habitats while also restoring impaired habitats.

Physical Objectives Addressed: WhS.PO.1, WhS.PO.5, WhS.PO.9, and WhS.PO.13

Explanation: Important habitats in the Columbia River estuary and lower mainstem that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

WhS.S2. Strive to understand, protect, and restore habitat-forming processes in the

Columbia River estuary and lower mainstem.

Physical Objectives Addressed: WhS.PO.1, WhS.PO.5, WhS.PO.9, and WhS.PO.13

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

WhS.S3. Avoid large-scale habitat changes where risks to sturgeon are uncertain.

Physical Objectives Addressed: WhS.PO.1, WhS.PO.5, WhS.PO.9, and WhS.PO.13

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that habitat conditions don't continue to get worse.

WhS.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: WhS.PO.1, WhS.PO.5, WhS.PO.9, and WhS.PO.13

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

WhS.S5. Limit the effects of toxic contaminants in the Columbia River estuary, lower mainstem, and nearshore ocean.

Physical Objectives Addressed: WhS.PO.3 and WhS.PO.6

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on fish or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Introduced Species

WhS.S6. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introduced species.

Physical Objectives Addressed: WhS.PO.8 and WhS.PO.12

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Predators

WhS.S7. Evaluate the level of predation mortality during the embryo and juvenile life stages to determine the extent of predation-related recruitment failure.

Physical Objectives Addressed: WhS.PO.2

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Other Mortality Factors

WhS.S8. Avoid incidental mortality of embryos and juveniles during dredging operations.

Physical Objectives Addressed: WhS.PO.4 and WhS.PO.7

Explanation: Developing embryos or juvenile white sturgeon may be present among sand or fine substrates throughout the lower Columbia River. Suction dredging in these areas results in direct mortality. Dredge operations should avoid areas of known white sturgeon presence.

WhS.S9. Manage Columbia River fisheries at sustainable levels, maintaining a viable population through adequate spawner abundance.

Physical Objectives Addressed: WhS.PO.10

Explanation: Longevity, slow growth, and delayed maturation make sturgeon susceptible to fishery overexploitation. Columbia River sturgeon fisheries should continue to be managed in such a way as to ensure sufficient abundance of fish attaining older ages, thus maintaining adequate spawner abundance.

WhS.S10. Avoid incidental mortality as a result of Bonneville Dam operations.

Physical Objectives Addressed: WhS.PO.11

Explanation: Dewatering of turbines at Bonneville Dam has been documented to entrain white sturgeon, resulting in mortality. Operations at Bonneville, and elsewhere in the subbasins, need to be evaluated to minimize sturgeon mortality.

Research

WhS.S11. Our understanding of the relationships between white sturgeon and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: WhS.PO.1 through WhS.PO.13

Explanation: Future research is needed to develop an understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume as they relate to white sturgeon. Also needed are additional understanding about how white sturgeon populations use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume. Additionally, future research should also focus on establishing clear relationships between white sturgeon and the various predators or introduced species in the lower mainstem, Western Oregon tributaries, estuary, and plume.

WhS.S12. Use existing processes and programs wherever possible to take maximum

advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: WhS.PO.1 through WhS.PO.13

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection and restoration are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

WhS.S13. Assess the Mainstem Lower Columbia River and Columbia River Estuary by discreet geographic reaches for restoration and protection priorities.

Physical Objectives Addressed: WhS.PO1, WhS.PO2, WhS.PO3, WhS.PO4, WhS.PO5, WhS.PO6, WhS.PO7, and WhS.PO9,

Explanation: A chronic problem exists in the information systems of resource planners who are unable, today, to accurately inventory where protection and restoration work has been completed or is ongoing, and where additional work is needed. Throughout the subbasin planning process, an urgent need was identified to develop a "desktop" triage tool to identify where measures should be applied, or where mitigation steps might be needed in response to some natural or anthropogenic system disturbance. A systematic way of identifying the protection and restoration potential of specific areas within the subbasin needs to be developed. Such a system could then provide a means for prioritizing actions.

.5.2.1.1.8.7 Measures to achieve strategies (White and Green)

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary. Finally, because adequate green sturgeon data are not available, we assume that the measures for adult white sturgeon are also applicable to green sturgeon.

Habitat

WhS.M1. Maintain deepwater, rocky substrate spawning habitat in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Spawning substrate used by white sturgeon varies considerably, although they appear to prefer deepwater, rocky habitats with sufficient interstitial spaces to provide adequate water flow and predator protection during embryonic development. At present, there is limited information as to the available acreage of preferred sturgeon habitat or as to whether acreage of this habitat type is increasing or decreasing. Based on the recent productivity of the white sturgeon population, there is currently no indication that white sturgeon are spawning habitat limited. However, because of our present lack of information regarding the lower

Columbia population, an inventory of white sturgeon spawning locations, habitat characteristics, and habitat availability would be beneficial.

Variables	Context
Strategies addressed	WhS.S1, WhS.S2, WhS.S3, WhS.S4, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no known programs and/or projects addressing the physical objective for maintenance of spawning habitats.
Potential to contribute to biological objectives	High. *Explanation*: Current levels of sturgeon spawning habitat appear to be sufficient for maintaining high population productivity, thus, maintenance of existing spawning habitats will maintain current productivity and abundance.
Barriers to success	*Explanation:* There is no indication that spawning habitat acreage is decreasing, thus habitat may be maintained through no action. Hoevcer, There is concern that construction activities below Bonneville Dam could be influencing spawning habitat Although, little is known about sturgeon spawning habitats and locations, and an inventory is necessary.

WhS.M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows, and restores tidal channel complexity in the estuary.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuary and mainstem habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River estuary and lower mainstem that emulate a more natural regime will help improve habitat conditions for resident fish and wildlife species.

Variables	Context
Strategies addressed	WhS.S1, WhS.S2, WhS.S3, WhS.S4, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* Conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control will make it difficult to attain the physical objective for allocating water to restore the

Variables	Context
	historical hydrograph with existing programs.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would address important limiting factors and thus have a high benefit.
Barriers to success	*Explanation:* An annual allocation of water for sturgeon will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

WhS.M3. Restore connectivity between river and floodplain.

Explanation: Restoring connection of the river and floodplain begins to restore the historical macrodetritus-based food web, which is expected to be more productive than the present day microdetritus-based food web.

Variables	Context
Strategies addressed	WhS.S1, WhS.S2, WhS.S3, WhS.S4, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

WhS.M4. Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.

Explanation: Sediment dynamics are a critical component of estuary and lower mainstem habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation, and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	WhS.S1, WhS.S2, WhS.S3, WhS.S4, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the effects on natural habitat formation.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

WhS.M5. Limit the effects of toxic contaminants on sturgeon fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on fish or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	Context
Strategies addressed	WhS.S5
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* It is uncertain whether the current programs and/or projects can be expected to attain the physical objective for limiting contaminant effects.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

Introduced Species

WhS.M6. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	WhS.S6, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between

Variables	Context
	native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

WhS.M7. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intention species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	WhS.S6, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

WhS.M8. Consider the potential opposite impacts of American shad on different life stages of white sturgeon.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon bycatch. The impacts of shad on the lower Columbia River mainstem and estuary ecosystem are unclear but the large shad population biomass has the potential for significant impacts. Juvenile shad may consume similar food items as juvenile sturgeon, thus introducing some potential level of competition. Conversely, returning adult shad may be a substantial food source for subadult and adult white sturgeon.

Variables	Context
Strategies addressed	WhS.S6, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating shad effects on sturgeon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency. Shad/sturgeon interactions are essentially unknown and considerable research is needed to define any relationships.

WhS.M9. Evaluate gamefish predation or competition risks to sturgeon; avoid management or enhancement of introduced gamefish populations that pose significant threats to sturgeon.

Explanation: The effects of gamefish (such as walleye, smallmouth bass, or channel catfish) on white sturgeon are unknown and need to be evaluated. Juvenile gamefish may compete with juvenile sturgeon for food or habitat. Adult gamefish may prey on juvenile sturgeon. Gamefish may be a prey item of subadult or adult sturgeon. These, and other sturgeon/gamefish relationships, need to be clarified.

Variables	Context
Strategies addressed	WhS.S6, WhS.S7, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating gamefish effects on sturgeon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency. Gamefish/sturgeon interactions are essentially unknown and considerable research is needed to define any relationships.

Predators

WhS.M10. Identify predators of sturgeon embryos and juveniles; reduce predation mortality.

Explanation: Predators of sturgeon embryos and juveniles in the lower Columbia River are unknown and need to be identified. Elsewhere in the Columbia River, substantial predation on sturgeon embryos has been observed. The potential for predation-related recruitment failure exists.

Variables	Context
Strategies addressed	WhS.S7, WhS.S11, and WhS.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating predator effects on sturgeon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating predator effects on sturgeon are high; significant predation can result in recruitment failure.
Barriers to success	*Explanation:* Predator effects on sturgeon are

Variables	Context
	unknown and considerable research is needed to define any relationships.

Other Mortality Factors

WhS.M11. Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes and result in direct sturgeon mortality.

Explanation: Channel dredge activities affect the quality of the various estuary and lower mainstem habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Suction dredging activities in the presence of sturgeon embryos or juveniles results in direct mortality. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context
Strategies addressed	WhS.S1, WhS.S2, WhS.S3, WhS.S4, WhS.S8, and WhS.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are not expected to attain the physical objective for mitigating dredging activity effects. The Channel Deepening Biological Assessment and resulting BiOp focus on ESA-listed species; dredging effects on white sturgeon have not been adequately addressed.
Potential to contribute to biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects on ESA-listed species throughout the channel deepening process and beyond. However, there remains uncertainty as how these mitigation efforts will benefit white and green sturgeon.

WhS.M12. Closely monitor Columbia River fisheries harvest levels to maintain sturgeon spawner abundance.

Explanation: Current fishery regulations, particularly size limits, have allowed sturgeon to survive to older ages, thereby maintaining the spawning portion of the population. Harvest levels and fishery regulations should be closely monitored to ensure that adequate spawning adult abundance is maintained.

Variables	Context
Strategies addressed	WhS.S9
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the objective for managing sturgeon fisheries. Current fishery management has been successful and there is currently no reason to believe this will not continue in the future.
Potential to contribute to biological objectives	High. *Explanation*: Fishery management actions have successfully maintained population productivity levels in conjunction with harvest; continued fishery management can maintain current levels of population productivity and abundance.
Barriers to success	*Explanation:* Fishery management efforts have resulted in high sturgeon harvest and angler effort, while maintaining high spawner abundance. Successful fishery management is expected to continue.

WhS.M13. Evaluate and mitigate Bonneville Dam operations that result in direct sturgeon mortality.

Explanation: Dewatering of turbines at Bonneville Dam can result in direct sturgeon mortality through entrainment. The degree and significance of this mortality factor needs to be identified. Measures to mitigate impacts resulting from these activities should be identified and implemented.

Variables	Context
Strategies addressed	WhS.S10
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no known programs and/or projects focused on evaluating Bonneville

Variables	Context
	Dam operations effects on sturgeon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating Bonneville Dam operations effects on sturgeon are high; there is a lack of information regarding current mortality levels.
Barriers to success	*Explanation:* Sturgeon mortality resulting from Bonneville Dam operations need to be defined; there is limited focused effort to define any relationships.

Research

WhS.M14. Improve understanding of interrelationships among fish, wildlife, and habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of biological relationships among species in the lower Columbia River and estuary is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	WhS.S2, WhS.S6, and WhS.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit although the level of focused white and green sturgeon research is uncertain.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships; applicability to white and green sturgeon is unknown. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

WhS.M15. Increase tagging and other marking studies to determine the mainstem and estuarine habitat use, survival, and migration patterns of white sturgeon.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by sturgeon is poorly understood. The use of tagging and other marking studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	WhS.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating sturgeon behavior and habitat use.
Potential to contribute to biological objectives	High. *Explanation*: Understanding sturgeon habitat use will have a high benefit given our current level of understanding.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships; applicability to white and green sturgeon is unknown. In the near-term, this research will allow for more educated management and recovery decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships. Sturgeon behavior and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume are poorly understood and considerable research is needed to define any relationships.

WhS.M16. Develop desktop "triage" tool for determining restoration and protection potential of distinct geographic areas within the Mainstem Lower Columbia River and Columbia River Estuary

Explanation: Identifying priority habitat for protection and restoration within the Mainstem Lower Columbia River and Columbia River Estuary should be a priority. The approach should be the development of both a tool and a process that could be used iteratively to provide an adaptive management framework for resource planners. In the Columbia basin tributaries, Ecosystem Diagnostic and Treatment (EDT) has provided planners with a quantitative method for determining prioritiesand for modeling likely outcomes. Such a tool has been difficult to apply to the estuary because many species with use the estuary for critical life stages do not produce in the estuary. The challenge will be to develop a tool that reflects the importance of the estuary that use it for important but non-productive portions of their life history.

Variables	Context
Strategies addressed	WhS.S1, WhS.S2, WhS.S3, WhS.S4, WhS.S5, WhS.S8, WhS.S11, and WhS.S13
Short vs. long term implementation (<25 years or >25 years)	Both <25
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs in the Mainstem Lower Columbia River and Columbia River Estuary are insufficient for determining where to target protection and restoration activities, although our understanding of the habitat forming processes and relationships between species and habitat attributes is growing significantly.
Potential to contribute to biological objectives	High. *Explanation*: While measures and strategies intended to effect positive change in the Mainstem Lower Columbia River and Columbia River Estuary are becoming clear, knowing where to apply these measures is uncertain. Tools that help target resources will increase all other measures chances of being successful.
Barriers to success	*Explanation:* A key goal of any desktop management goal should be to provide a means of predicting outcomes of restoration and protection activities, but standard measures of performance, for example, production and abundance are likely to occur out-of-basin, making expected outcomes a difficult measure to quantify.

.5.2.1.1.8.8 Programs to implement strategies and measures (White and Green)

Table 5-37. Existing programs and their connection to measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	3
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; little consideration has been provided for sturgeon.	
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	3, 4
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	3, 4
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	3
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	3, 4, 5
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	4
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	4
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	3, 4
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	2, 3, 4
Washington State Conservation Commission/ Conservation Districts	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	2, 3, 4
Columbia River Estuary Study	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from	1, 2, 3, 4, 5, 11, 14

Program Name and Affiliation	Program Description	Measures Addressed
Taskforce (CREST)	river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	3, 4
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	3, 4, 11
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	2, 3, 4, 5
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 2, 3, 4
Habitat Program – WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	1, 6, 7, 8, 9, 10, 12, 14, 15
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements	3, 4

Program Name and Affiliation	Program Description	Measures Addressed
	for the RMZ on certain water types affected by timber harvest activities.	
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	2, 3, 4, 5
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	In addition to protecting and restoring salmon habitat, the SRFB also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat.	3, 4
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 11, 14
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	5
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	3, 4
Partners for Fish and Wildlife Program – USFWS	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	3, 4
Washington	The program is responsible for developing and implementing Habitat	3, 4, 14

Program Name and Affiliation	Program Description	Measures Addressed
State Ecosystem Conservation Program – USFWS	Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	4, 5, 11
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	4, 5, 11
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	6, 7, 14

5.2.1.1.9 Lamprey

.5.2.1.1.9.1 Background

Pacific lamprey (Lampetra tridentata) are a native anadromous inhabitant of Pacific Northwest rivers including the Columbia. Adult Pacific lamprey entry into freshwater can vary from February to September. Lamprey spawn in small tributaries, historically as far upstream as

Idaho and British Columbia, and die after spawning. Young lamprey, called ammocoetes, are algae filter feeders that burrow in sandy stream margins and side channels for up to 6 years before downstream migration. Adults are predators that feed only in the ocean and attach themselves to their prey with suction mouths.

Lamprey were historically an important food source for native peoples and a significant component of the Columbia River ecosystem. Spawning adults are a source of marine-derived nutrients in the freshwater and an important prey item for sturgeon and marine mammals. In fresh water, aquatic and avian species prey on juvenile lamprey.

.5.2.1.1.9.2 Status

Relatively little is known about status and biology of Pacific lamprey. Most data suggests that populations in the Columbia River basin have been declining concurrent with hydroelectric development and other habitat changes. Although adult lamprey can negotiate natural waterfalls, they apparently have difficulty in dam passage. Juvenile lamprey migrating downstream do not appear to benefit from passage systems design to pass juvenile salmonids.

Table 5-38. Pacific lamprey abundance estimates by life stage.

Life Stage	Historical Abundance	Current Abundance
Juvenile Rearing	Unknown	Unknown
Adult Migration	Annual passage counts at Bonneville Dam averaged 109,000 from 1938-1969; passage counts for the same period ranged from 26,000 to 380,000.	From 1997 to 2002, annual passage counts at Bonneville Dam averaged 39,000 and ranged from 19,000 to 100,000; the 2002 passage count was about 100,000.

.5.2.1.1.9.3 Value statement

Pacific lamprey are culturally and ecologically important. Culturally, they are important to many tribes throughout the Columbia River basin. Ecologically, they are an important food source for many Columbia River estuary and mainstem species (e.g. sturgeon, pinnipeds). Because Pacific lamprey pass hydroelectric facilities with poor efficiency, it is likely that lamprey restoration efforts will achieve the highest success in the lower Columbia mainstem, the estuary, and the various tributaries below Bonneville Dam. Therefore, strategies and measures to return selected historic lamprey populations in these areas to viability are among the highest levels of importance. The goal for Columbia River Pacific lamprey is to reverse the decreasing abundance trend and increase the population to a self-sustaining, viable population that can provide for cultural and ecological needs.

.5.2.1.1.9.4 Limiting factor (Threats)

Pacific Lamprey in the Columbia River estuary and lower mainstem have threats to both life stages in the combined subbasins. Historically, Pacific lamprey populations were distributed throughout the Columbia River basin; they currently extend inland to Chief Joseph and Hells Canyon Dam, although the upriver populations are thought to be quite small. The development of upstream hydroelectric facilities was detrimental to these upstream populations primarily because of the lamprey's inability to migrate through fish ladders; further, juvenile lamprey do

not appear to benefit from juvenile salmonid passage structures. Downstream of Bonneville Dam, Pacific lamprey may be impacted by decreased peak flows, disconnected or lost habitats, and predation losses. The lower Columbia River mainstem and estuary appear to serve primarily as a migration route for juvenile and adult Pacific lamprey; little is known about the significance of these subbasins to the life history of Pacific lamprey.

Table 5-39. Pacific lamprey limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Juvenile Rearing and Migration	PL.LF.1 Flow alteration. Juvenile Pacific lamprey are poor swimmers and rely on flow to carry them toward the ocean. Flow alterations in the Columbia River basin (hydrosystem operations, water withdrawal) have decreased peak flows in the lower Columbia River mainstem, as well as created inundated habitats throughout the basin. Flow reductions may delay downstream migration, disrupting the synchrony of physiological development and downstream migration timing.	Medium/Medium
	PL.LF.2 Direct dredging mortality. Juvenile Pacific lamprey are closely associated with fine sediments where they burrow and filter feed. Dredging activities in areas where juveniles are present results in direct mortality; an estimated 3-26% of juvenile lamprey passed through a dredge survived.	Medium/Low
	PL.LF.3 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on aquatic organisms. Juvenile Pacific lamprey are closely associated with fine sediments where contaminants commonly accumulate.	Medium/Low
	PL.LF.4 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on Pacific lamprey are unknown.	Low/Low
	PL.LF.5 Predation mortality. Juvenile Pacific lamprey losses to predation are unknown and need to be evaluated.	Medium/Low
Adult Migration	PL.LF.6 Dam passage. Pacific lamprey are often unable or unwilling to migrate through fish ladders. Thus, Bonneville Dam, as well as many tributary or other mainstem dams, has limited upstream migration of Pacific lamprey to historical upriver spawning areas.	High/High
	PL.LF.7 Predation losses. Because of their high caloric value, Pacific lamprey are an important food source for marine mammals (pinnepeds) and sturgeon (and potentially others) in the lower Columbia River. The significance of predation on Pacific lamprey needs to be quantified.	Medium/Medium
	PL.LF.8 Harvest mortality. Historically, tribes harvested lamprey throughout the Columbia basin for food, ceremonial, medicinal, and trade purposes. Today, harvest is limited primarily to Willamette Falls and Sherars Falls (Deschutes River). Because of limitations on lamprey harvest (i.e. fishing effort, legal gear types, area closures, seasonal restrictions, diel restrictions), harvest may not be a major mortality factor.	Low/High
	PL.LF.9 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on Pacific lamprey are unknown.	Medium/Low

.5.2.1.1.9.5 Biological objectives & working hypotheses

Biological objectives for Pacific lamprey, including both biological performance and the corresponding environmental conditions, are formulated to support the value statement identified above. It is understood that indices of historical and current Pacific lamprey population numbers are uncertain, given the assumptions in data collection and the variability that governs population dynamics. As a result, the numeric biological objective goals for the lower mainstem and estuary should be viewed as "order of magnitude" estimates and interim in nature until more certainty can be achieved in abundance estimates and more specific goals can be quantified.

Table 5-40. Pacific lamprey biological performance levels.

Metric	Performance Level
Adult Abundance	Minimum of 100,000 adults passing Bonneville Dam annually (represents the 1938-1969 average)

Table 5-41. Pacific lamprey desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Juvenile Rearing and Migration	PL.PO.1 Restore spring peak flows in lower Columbia River. *Hypothesis Statement:* If peak flows are restored, then juvenile lamprey physiological development and downstream migration timing will remain synchronized. *Justification:* Restoration and maintenance of historical peak flows will provide a consistent mechanism for juvenile lamprey downstream migration.	High	Medium/Medium
	PL.PO.2 Avoid direct dredging mortality. *Hypothesis Statement:* If suction dredging activities occur in the presence of juvenile Pacific lamprey, then direct mortality will result. *Justification:* Juvenile Pacific lamprey are closely associated with sand and fine sediments. Suction dredging of these sands and fine sediments results in entrainment and mortality. Dredge operations should avoid known areas of burrowing juvenile Pacific lamprey.	Low	Medium/Low

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	PL.PO.3 Reduce contaminant exposure of emigrating juveniles. *Hypothesis Statement:* If contaminant exposure is reduced, then juvenile Pacific lamprey survival in the estuary and mainstem will increase. *Justification:* Contaminants have been shown to have detrimental effects on aquatic organisms. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. Juvenile Pacific lamprey may be particularly susceptible to contaminant exposure because they are closely associated with fine sediments where contaminants are known to accumulate.	High	Medium/Low
	PL.PO.4 Document the interaction between juvenile Pacific lamprey and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then juvenile Pacific lamprey survival in the estuary and mainstem will be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	Low/Low
	PL.PO.5 Develop an understanding of juvenile Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of lamprey integration with the ecosystem increases, then management and recovery actions will proceed with greater certainty. *Justification:* Our current understanding of life history diversity and lamprey interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; future research is needed to increase our knowledge and reduce uncertainty.	High	High/Low
Adult Migration	PL.PO.6 Improve dam passage. *Hypothesis Statement:* If dam passage conditions are improved, then lamprey will benefit basin-wide. *Justification:* Adult Pacific lamprey navigate hydrosystem dams with poor efficiency. Thus, lamprey access to historical spawning and rearing areas has been limited.	High	High/High

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	PL.PO.7 Reduce predation mortality on migrating adults. *Hypothesis Statement:* If predation on adults is reduced, then lamprey survival in the estuary and mainstem will increase. *Justification:* Marine mammals and sturgeon prey on adult lamprey in the lower Columbia River and estuary. Other predators may exist. Predation mortality may be significant and needs to be quantified.	High	Medium/Medium
	PL.PO.8 Protect population from overexploitation. *Hypothesis Statement:* If current fisheries are properly managed, then impacts to lamprey can be minimized. *Justification:* At present levels of fishing effort and fishery restrictions, lamprey harvest is relatively low and unlikely a major limiting factor.	Medium	Low/High
	PL.PO.9 Document the interaction between Pacific lamprey and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then Pacific lamprey survival in the estuary and mainstem may be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	Medium/Low
	PL.PO.10 Develop an understanding of Pacific lamprey habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of lamprey integration with the ecosystem increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of Pacific lamprey interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; research is needed to increase our knowledge and reduce uncertainty.	High	High/Low

.5.2.1.1.9.6 Strategies

Healthy, harvestable Pacific lamprey populations depend on favorable habitats for spawning and rearing. High quality habitat increases fish population productivity which helps maintain adequate numbers. Populations can typically withstand some combination of mainstem and estuary habitat degradation and other impacts such as fishing. Condition of current lamprey habitat in the lower mainstem and estuary are uncertain, because little is known regarding habitat use or preference in these subbasins.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving habitat conditions for salmonids, but the effects on lamprey habitat are not clear. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on fish populations and increased commitment to protect this resource. More fish-friendly practices have been implemented for many activities.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by Pacific lamprey populations to any given suite of actions.

Habitat

PL.S1. Protect functioning habitats while also restoring impaired habitats.

Physical Objectives Addressed: PL.PO.1, PL.PO.5, PL.PO.6, and PL.PO.10

Explanation: Important habitats in the Columbia River estuary and lower mainstem that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

PL.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River estuary and lower mainstem.

Physical Objectives Addressed: PL.PO.1, PL.PO.5, and PL.PO.10

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

PL.S3. Avoid large-scale habitat changes where risks to lamprey are uncertain.

Physical Objectives Addressed: PL.PO.1, PL.PO.5, and PL.PO.10

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that habitat conditions don't continue to get worse.

PL.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: PL.PO.1, PL.PO.5, and PL.PO.10

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

PL.S5. Limit the effects of toxic contaminants in the Columbia River estuary, lower mainstem, and nearshore ocean.

Physical Objectives Addressed: PL.PO.3

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on fish or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes. Juvenile lamprey may be particularly susceptible to contaminant effects because of their sediment burrowing habits.

Introduced Species

PL.S6. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introduced species.

Physical Objectives Addressed: PL.PO.4 and PL.PO.9

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Predators

PL.S7. Evaluate the level of predation mortality during juvenile and adult migrations.

Physical Objectives Addressed: PL.PO.4, PL.PO.5, and PL.PO.7

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Other Mortality Factors

PL.S8. Avoid incidental mortality of juveniles during dredging operations.

Physical Objectives Addressed: PL.PO.2

Explanation: Juvenile Pacific lamprey are closely associated with sand or fine substrates throughout the lower Columbia River. Suction dredging in these areas results in direct mortality. Dredge operations should avoid areas of known juvenile lamprey presence.

PL.S9. Manage lamprey fisheries at sustainable levels.

Physical Objectives Addressed: PL.PO.8

Explanation: Pacific lamprey fisheries should continue to be managed in such a way as to maintain a viable population.

PL.S10. Evaluate and improve passage conditions at mainstem and tributary dams, insuring no negative effects on salmonid passage.

Physical Objectives Addressed: PL.PO.6

Explanation: Adult Pacific lamprey have difficulty in dam passage and juveniles migrating downstream do not appear to benefit from juvenile salmonid passage systems.

Research

PL.S11. Our understanding of the relationships between Pacific lamprey and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: PL.PO.1 through PL.PO.10

Explanation: Future research is needed to develop an understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume as they relate to Pacific lamprey. Also needed are additional understanding about how Pacific lamprey populations use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume. Additionally, future research should also focus on establishing clear relationships between Pacific lamprey and the various predators or introduced species in the lower mainstem, Western Oregon tributaries, estuary, and plume.

PL.S12. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: PL.PO.1 through PL.PO.10

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection and restoration are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

.5.2.1.1.9.7 Measures to achieve strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary.

Habitat

PL.M1. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge and increases the variability of flows during periods of lamprey emigration.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuary and mainstem habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River estuary and lower mainstem that emulate a more natural regime will help improve emigration conditions for juvenile Pacific lamprey.

Variables	Context
Strategies addressed	PL.S1, PL.S2, PL.S3, PL.S4, PL.S11, and PL.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would have a high benefit because of the improvement of juvenile lamprey emigration conditions.
Barriers to success	*Explanation:* An annual allocation of water for juvenile lamprey will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

PL.M2. Limit the effects of toxic contaminants on Pacific lamprey fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on fish or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Variables	Context
Strategies addressed	PL.S5
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and estuary, as well as uncertainty in exposure risks to lamprey.
Potential to contribute to biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

Introduced Species

PL.M3. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	PL.S6, PL.S11, and PL.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

PL.M4. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intention species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	PL.S6, PL.S11, and PL.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to

Variables	Context
	be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

PL.M5. Evaluate gamefish predation or competition risks to lamprey; avoid management or enhancement of introduced gamefish populations that pose significant threats to lamprey.

Explanation: The effects of gamefish (such as walleye, smallmouth bass, or channel catfish) on Pacific lamprey are unknown and need to be evaluated. Gamefish may prey on juvenile lamprey; other possible lamprey/gamefish relationships need to be clarified.

Variables	Context
Strategies addressed	PL.S6, PL.S7, PL.S11, and PL.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating gamefish effects on lamprey.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency. Gamefish/lamprey interactions are unknown and considerable research is needed to define any relationships.

Predators

PL.M6. Identify predators of juvenile and adult lamprey; reduce predation mortality.

Explanation: Predators of juvenile lamprey in the lower Columbia River are unknown and need to be identified. Adult lamprey are considered important food items for sturgeon and pinnepeds; other potential adult lamprey predators need to be evaluated.

Variables	Context
Strategies addressed	PL.S7, PL.S11, and PL.S12
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating predator effects on lamprey.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating predator effects on lamprey are high based on the limited knowledge of current relationships.
Barriers to success	*Explanation:* Predator effects on lamprey are essentially unknown and considerable research is needed to define any relationships.

Other Mortality Factors

PL.M7. Mitigate channel dredging activities in the Columbia River estuary and lower mainstem to minimize direct lamprey mortality.

Explanation: Suction dredging activities in the presence of juvenile Pacific lamprey results in direct mortality. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context
Strategies addressed	PL.S8 and PL.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are not expected to attain the physical objective for mitigating dredging activity effects. The Channel Deepening Biological Assessment and resulting BiOp focus on ESA-listed species; dredging effects on Pacific lamprey have not been adequately addressed.
Potential to contribute to	High.

Variables	Context
biological objectives	*Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural habitat formation.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects on ESA-listed species throughout the channel deepening process and beyond. However, there remains uncertainty as how these mitigation efforts will benefit Pacific lamprey.

PL.M8. Closely monitor Pacific lamprey fisheries harvest levels to maintain population viability.

Explanation: Current fishery restrictions and level of effort maintain harvest at relatively low levels. Harvest levels and fishery regulations should be closely monitored to ensure that population viability is maintained.

Variables	Context
Strategies addressed	PL.S9
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the objective for managing lamprey fisheries. Current fishery management has been successful and there is currently no reason to believe this will not continue in the future.
Potential to contribute to biological objectives	High. *Explanation*: Fishery management restrictions have help maintained population viability in conjunction with low levels of harvest; continued fishery management can help maintain current levels of population viability and abundance.
Barriers to success	*Explanation:* Fishery management regulations have resulted in low lamprey harvest while maintaining population viability. Success of fishery management actions is expected to continue.

PL.M9. Modify passage structures at dams to improve juvenile and adult passage efficiency.

Explanation: Pacific lamprey access to historical spawning and rearing habitats has been limited because of their inability to navigate fish ladders designed for salmonid passage. Additionally, juvenile lamprey do not appear to benefit from juvenile salmonid passage systems. Passage modifications need to proceed with caution; negative effects on salmonid passage need to be prevented.

Variables	Context
Strategies addressed	PL.S10
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently (?) no known programs and/or projects focused on improving dam passage for lamprey.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of improving lamprey passage are high, based in their inability to access historical spawning areas.
Barriers to success	*Explanation:* Because of differing swimming abilities of lamprey and salmonids, it may be difficult to improve lamprey passage without affecting salmonids.

Research

PL.M10. Improve understanding of interrelationships among fish, wildlife, and habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of biological relationships among species in the lower Columbia River and estuary is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	PL.S2, PL.S6, PL.S7, PL.S11, and PL.S12
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries,

Variables	Context
	estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships; applicability to Pacific lamprey is unknown. In the near-term, this research will allow for more educated management decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.

PL.M11. Increase research efforts to determine the mainstem and estuarine habitat use, survival, and migration patterns of Pacific lamprey.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by lamprey is poorly understood. The use of monitoring studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	PL.S11
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The Pacific Lamprey Research and Restoration Project evaluated lamprey behavior and habitat use, however, this project is not currently active?
Potential to contribute to biological objectives	High. *Explanation*: Understanding lamprey habitat use will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Lamprey behavior and habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume are poorly understood and considerable research is needed to define any relationships. At present, future research effort levels are uncertain.

PL.M12. Determine olfactory capabilities and site fidelity of returning Pacific lamprey adults.

Explanation: Homing capabilities and site fidelity of lamprey is poorly understood. Future research can significantly improve our limited understanding and improve management decisions and recovery efforts.

Variables	Context
Strategies addressed	PL.S10 and PL.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The Pacific Lamprey Research and Restoration Project evaluated lamprey migration, however, this project is not currently active? Other one-time studies have investigated adult lamprey migration capabilities.
Potential to contribute to biological objectives	High. *Explanation*: Understanding lamprey migration will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Lamprey migration capabilities in the lower mainstem, Western Oregon tributaries, estuary, and plume are poorly understood and considerable research is needed to define any relationships. At present, future research effort levels are uncertain.

PL.M13. Rectify difficulties in Pacific lamprey abundance estimates because of repeated up and downstream movement at mainstem counting facilities.

Explanation: Standard dam counts are not a reliable index of Pacific lamprey abundance and are complicated by repeated up and downstream movement of adult lamprey. Electrofishing and radiotelemetry methods have been evaluated as possible abundance estimation tools. Both methods show promise, but have not yet been refined to a level of replacing historical dam counts. These methods may be used in the development of a correction factor for the historical dam counts that could prove useful in estimating lamprey abundance.

Variables	Context
Strategies addressed	PL.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The Pacific Lamprey Research and Restoration Project acknowledged this abundance

Variables	Context
	estimation challenge, however, this project is not currently active? Other sampling efforts have attempted to calibrate dam counts.
Potential to contribute to biological objectives	High. *Explanation*: Accurately estimating lamprey abundance will have a high benefit, given our current level of difficulty in estimating lamprey abundance with methods applicable to other fishes.
Barriers to success	*Explanation:* Lamprey abundance is poorly understood and considerable research is needed to establish accurate abundance estimators. At present, future research effort levels are uncertain.

.5.2.1.1.9.8 Programs to implement strategies and measures

Table 5-42. Existing programs and their connection to recovery measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps; little consideration has been provided for lamprey.	
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	2
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	
Skamania National	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	

Program Name and Affiliation	Program Description	Measures Addressed
Scenic Areas Ordinance		
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	1
Washington State Conservation Commission/ Conservation Districts	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	1
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 2, 7, 10, 11
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	7
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	1, 2
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES.	

Program Name and Affiliation	Program Description	Measures Addressed
	The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	
Habitat Program – WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	1, 3, 4, 5, 6, 8, 10, 11, 12, 13
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	2
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	In addition to protecting and restoring salmon habitat, the SRFB also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat.	
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	2
PacFish – The	PacFish is an ecosystem-based, aquatic habitat and riparian-area management	

Program Name and Affiliation	Program Description	Measures Addressed
U.S. Forest Service and the Bureau of Land Management	strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	
Partners for Fish and Wildlife Program – USFWS	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	2, 7
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any	2, 7

Program Name and Affiliation	Program Description	Measures Addressed
	other work involving the discharge of fill or dredged material.	
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	3, 4, 5, 10
Pacific Lamprey Research and Restoration Project	Funded in the late 1990s, the project was a cooperative effort of the Confederated Tribes of the Umatilla Indian Reservation, Columbia River Inter-Tribal Fish Commission, and Oregon State University designed to investigate the status and biology of Pacific lamprey in the Columbia River basin.	10, 11, 12, 13
Columbia Basin Pacific Lamprey Technical Work Group	This multi-agency workgroup was established in 1996 at the request of the Northwest Power Planning Council too coordinate lamprey research projects and prioritize lamprey research needs.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Radiotelemetry of Adult Pacific Lamprey in LCR	The study evaluated passage of radio-tagged adults above and below Bonneville Dam. Additionally, lab studies were conducted to evaluate upstream movement through simulated fishway structures.	9, 11, 12
Characteristics of Pacific Lamprey Upstream Migration	The study evaluated maturation and physiology of adult lamprey collected at Bonneville Dam.	9, 11
Effects of Swimming and Exhaustive Stress in Pacific Lamprey	The study evaluated swimming performance, metabolic condition, and exhaustive stress to assess efficacy of Bonneville Dam upstream passage facilities.	9, 11
Tagging Techniques for Juvenile Lamprey	The study evaluated juvenile survival and tag retention of visible implant and PIT tags in juvenile Pacific lamprey.	9, 11
Aging Techniques for Juvenile Lamprey	The study compared statolith-based aging techniques among laboratory and wild lamprey samples.	11
Pacific Lamprey Genetic Analysis	The study served as a baseline for genetic data.	11

5.2.2 *Terrestrial Focal*

5.2.2.1 CWT Deer

5.2.2.1.1 Background

The Columbia white-tailed deer (Odocoileus virginianus leucurus), is one of thirty-eight recognized subspecies of O. virginianus. One of the largest terrestrial mammals connected to the Columbia River estuary, the Columbia white-tailed deer is a non-migratory species that once ranged from Puget Sound to southern Oregon, where it lived in floodplain and riverside habitat. The deer, one of the nation's first protected species, was once thought to be extinct. Today the deer exists in the historic floodplain areas of the lower Columbia River. The once vast population was formerly distributed throughout the bottomlands and prairie woodlands of the lower Columbia, Cowlitz, Willamette, and Umpqua River basins in Oregon and southern Washington. In 1978 300-400 animals were estimated in Clastsop, Columbia, Cowlitz, and Wahkiakum Counties in Oregon. In 1978 a Douglas County population in Roseburg, Oregon was estimated at 900-1000 animals. The two populations are divided geographically by 200 miles of unsuitable or discontinuous habitat.

Currently, only two significant populations of whitetail exist west of the Cascade Mountains. One, known as the lower Columbia River population, is located along the lower Columbia River in Clatsop and Columbia Counties, Oregon, and Wahkiakum and Cowlitz Counties, Washington. The other known as the Roseburg population, is located in Douglas County, Oregon. In total, the lower Columbia white-tails comprise five sub-populations: The Mainland and Tenasillahe Island Units of the Julia Butler Hansen Refuge for the Columbian White-tailed Deer (JBHR), Puget Island, Westport/Wallace Island, and the Crims/Fisher/Lord Island complex. Due to declines in the population the deer were listed as endangered in 1967, six years prior to the establishment of the Endangered Species Act (ESA). In 1973, with the authorization of ESA, the deer were listed as endangered. The Columbian White-tailed Deer National Wildlife Refuge was established in 1972 and its name was later changed to Julia Butler Hansen Refuge for the Columbian White-tailed Deer. In 1973, The Oregon Department of Fish and Wildlife (ODFW) estimated the Roseburg population at 200-230 deer. In 1999 ODFW estimated the population at 5,000-7,000. At that time, approximately 9,586 total acres of land was considered suitable habitat for the population. Suitable habitat is defined as habitat considered secure on federal, county, and private lands.

5.2.2.1.2 Status

In 1999, the United States Fish and Wildlife Service (USFWS) proposed to delist the Roseburg population. Public concern over the impact new housing developments would pose on the herd caused USFWS to withdraw the proposal. In July of 2003 the Roseburg population, which today estimates greater than 9,000 deer, was delisted. The lower Columbia population has increased to current numbers of approximately 500-700 animals. Five sub-populations of the lower Columbia Deer exist. The criteria for delisting are that a minimum of 400 deer exist in three viable sub-populations on secure habitat. There have long been two sub-populations on secure habitat - the Tenasillahe Island and Mainland Units of JBHR. Recently, deer were reintroduced to the Crims/Fisher/Lord Island complex to form a third sub-population on secure habitat. In the Fall of 2003, Columbia Land Trust, a non-profit organization based in Vancouver, Washington, acquired 473 acres of deer habitat on Crims Island. The Land Trust is in the process of transferring this land to the JBHR. The State of Oregon owns another 120 acres of the 730-acre Island. Crims Island deer numbers are estimated at two dozen animals. Fisher and Lord

Islands are owned by the states of Washington and Oregon, respectively. Deer were reintroduced there in 2003 and 2004. It is not yet known if they will thrive..

5.2.2.1.3 Value Statements

The Columbia white-tailed deer was once considered to be abundant in the Willamette, Columbia valleys. The clearing of riparian lands for agriculture and un-restricted hunting had reduced the population of Columbia white-tails to a low of 200 to 400 animals early in the 1900's. The Columbia white-tail thrived under the protection of these refuges and were even considered to be candidates for down-listing in 1995. But, in February of 1996, both Tenasillahe Island and the mainland deer refuge experienced severe flooding. As a result of these floods, half of the Washington population of Columbia white-tailed deer was lost.

The Columbia white-tailed deer carries both legal and management status. It also carries cultural importance as the largest of 38 subspecies and the western-most subpopulation. As such, the goal for the Columbian White-tailed deer is to reach and maintain manageable populations (with acceptable level of depredation).

5.2.2.1.4 Threats

Columbia White-tailed deer populations are negatively impacted by loss of available habitat, lack of continuity between suitable habitats, and occasional low productivity. The loss of viable habitat has created a situation of overcrowding, which has in turn pushed the habitat at carrying capacity. This is suggested by the increase in parasites (liver flukes, stomach worms, etc) but parasite incidence is considered moderate. Necrobacillosis (foot-rot) is suspected as the probable major debilitating factor contributing to mortality of adult deer. At one time locally common in riparian areas along the major rivers, deer populations declined rapidly with the arrival and settlement of pioneers in the fertile river valleys. Conversion of vital brushy riparian habitat to agriculture, urbanization, uncontrolled sport and commercial hunting, and other factors contributed to nearly completely rooting out this deer over most of its range by 1900. Although the Roseburg population has been increasing, the lower Columbia population has declined somewhat over the last 10 years or so. Flooding caused by high rain in 1996 and high coyote predation on fawns contributed to this decline. Over the long term, Extensive habitat losses have also occurred due to diking, deforestation, and urbanization. Most of the bottomlands have been cleared of trees and brush, and seeded to grasses and forbs that provided feed for beef and dairy cattle. USFWS reported both natural and anthropogenic factors contribute to loss of consistent white-tailed deer population and their habitat. These factors include:

- Degradation of riparian habitats through logging and brush removal
- Removal of cottonwood and alder for marina development
- Removal of riparian habitat for livestock production
- Automobile collisions
- Poaching
- Entanglement in barbed fences
- Competition with livestock
- Major flooding
- High tides which are limiting factor on undiked islands of the lower river
- Foot rot and parasites

- Competition with Roosevelt elk on the mainland portion of the JBHR
- Direct competition with black tail deer for food sources and by hybridization

5.2.2.1.5 Limiting Factors

Table 5-43: Columbia White-tailed Deer limiting factors

Limiting Factors	Impact
CWTD.LF.1 Availability of preferred habitat (i.e. riparian habitat, communities that provide both forage and cover). Columbia White-tailed Deer in the lower Columbia use brushy woodlots associated with tidal lowlands that are characterized by cottonwood, willow, alder, spruce, and dogwood. Dense forested swamps and tall tidal shrubs are needed for suitable habitat. Deer forage on annuals, forbs, and shrub. There has been extensive loss riparian habitat throughout the mainstem and estuary as a result of water regulation, dike construction, and urban and agricultural development.	High
CWTD.LF.2 High tides in undiked areas or failed dikes. Some of the greatest recent losses of deer have been due to flooding.	High
CWTD.LF.3 Lack of continuity between suitable habitats. Much of the habitat is unsuitable or disconnected due to channels and structures.	High
CWTD.LF.4 Predation mortality. Greatest losses of fawns are due to coyotes. Adult losses due to predation are due to poaching.	High
CWTD.LF.5 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on Columbia white-tailed deer are loss of foraging habitat.	Medium
CWTD.LF.6 Available habitat. Overcrowding has led to higher numbers of parasites and diseases such as foot rot.	Unknown
CWTD.LF.7 Hybridization and competition with black tailed deer. Direct competition with black tailed deer impacts white tailed deer resources.	Medium
CWTD.LF.8 Fencing for cattle and agriculture. Deer losses have been recorded due to entanglement in barbed wire.	Low
CWTD.LF.9 Collisions with cars. Losses have been due to automobile collisions.	Unknown

5.2.2.1.6 Biological objectives & working hypotheses

Biological objectives for Columbia White-tailed Deer, including both biological performance and the corresponding environmental conditions, are formulated to support the value statement identified above. The Roseburg population has been delisted. The lower Columbia population has five sub-populations, two of which are located on a national wildlife refuge. The two refuge sub-populations typically contain 100-200 deer each. The Puget Island and Westport/Wallace Island sup-populations, which occupy mostly private land, are of similar size. The Crims/Fisher/Lord Island subpopulation, which is in the process of being established by reintroduction, occupies mostly refuge and state lands. This new sub-population is presently

small (~50 deer on secure habitat), but the habitat should be capable of supporting approximately 100 deer in the future. In 2003, 473 acres on Crims Island, with a population of about two dozen deer, was procured by Columbia Land Trust with funding from Bonneville Power Administration. This land will be transferred to the Julia Butler Hansen Refuge. Although the population is far smaller than it was historically, it should continue to exist provided it is carefully monitored and managed. Reintroductions to areas with suitable habitat within the deer's historical range offer the potential to expand both the population size and range.

Table 5-44: Columbia White-tailed Deer biological performance levels

Metric	Performance Level	
Productivity		
Abundance[a]	Mainland Refuge	~150
	Tenasillahe Island	~150
	Crims/Fisher/Lord Islands	~50

[a] Abundance performance levels represent adult deer.

Table 5-45: Columbia White-tailed Deer desired environmental conditions

Physical Objective	Difficulty	Benefit
CWTD.PO.1 Protect and enhance existing foraging habitat to insure no further net degradation. Hypothesis Statement: If current foraging habitat is protected, then breeding, rearing, and foraging capacity and productivity in the estuary and mainstem can be maintained. Justification: Protection and maintenance of existing riparian habitat will provide a base level of Columbia White-tailed deer production and genetic diversity. Further, protection and enhancement of existing habitat is often more cost effective than restoration of former habitat.	Low	High
CWTD.PO.2 Increase forested areas in lowlands and floodplain with hardwood and some coniferous riparian species. Hypothesis Statement: Establishing riparian forest will increase the deer's habitat. Justification: Columbia White-tailed viable populations are closely associated with forested habitats in the estuary and lower mainstem.	High	High
CWTD.PO.3 Increase the number of overflow channels, lakes, ponds, backwaters, wetlands, and sloughs in floodplain. Hypothesis Statement: Opening were likely associated with the wet areas, accreting lands or lands having recently experienced a scouring flood. Justification: Reducing damage due to floods will reduce mortality and out migration of deer due to floods.	High	High

Physical Objective	Difficulty	Benefit
CWTD.PO.4 Reduce predation mortality on fawns Hypothesis Statement: If predation on fawns is reduced, then Columbia White-tailed Deer survival in the estuary and mainstem will increase. Justification: Predation on fawns in the lower Columbia River and estuary has increased as a result of increased predator populations, such as coyotes. Predation on Columbia White-tailed Deer mortality may be significant and needs to be quantified.	Medium	High
CWTD.PO.5 Decrease conversion of pastures and woodlots to intensive development. Hypothesis Statement: If less habitat is lost to development, then habitat and in turn the Columbian White-tailed Deer will have a greater survival in the estuary and mainstem during uncontrollable floods and the population will increase. Justification: Floods, such as the 1996 flood, have claimed some of the highest moralities of adult deer populations in protected areas. .	High	High
CWTD.PO.6 Increase availability of habitat Hypothesis Statement: Increased acreage of habitat will increase survival rate and population size of Columbia White-tailed Deer and will decrease instances of parasites and disease. Justification: The greatest single man-caused threat and natural threat to Columbia White-tailed deer is the continued degradation of habitat. Overcrowding has been linked to the presence of parasites and foot-rot disease in Columbia White-tailed Deer.	High	High
CWTD.PO.7 reintroduce deer to suitable habitat. *Hypothesis Statement:* Reintroducing deer to suitable habitat will increase survival and population numbers. *Justification:* Deer cannot easily pioneer new habitat. Therefore, deer have to be reintroduced for range expansion to occur.	Medium	High

5.2.2.1.7 Strategies

The United States Fish and Wildife Service (USFWS) appointed a recovery team to develop a recovery plan for Columbian White-tailed deer. The recovery plan was developed in 1978 and revised in 1983. Recovery goals and objectives of this plan have guided efforts to recover the species. The team, comprised of personnel from USFWS, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, and Oregon State University faculty, outlined steps toward the creation of three stable, secure, viable sub-populations of Columbia White-tailed deer so that delisting may proceed. Plan components include need for new habitat acquisitions, transplanting of existing populations to create new populations, enforcement of hunting riles, and management of publicly owned lands.

Increased quantity of high quality habitat increases deer population productivity, which helps to maintain sufficient numbers even during years of unforeseen natural disasters (i.e.

flooding). White-tailed deer are adapted to marsh and tidally influenced habitat. They can therefore, withstand some degree of flooding and corresponding habitat degradation due to flooding. Current habitat conditions and population size, although smaller than historical numbers, are considered sufficient to justify delisting provided that a recently reintroduced sub-population thrives. Continued management of refuge habitat, current deer populations, rehabilitating current unsuitable habitat to conditions favorable to deer, and continuing to acquire suitable habitat for future deer populations will insure this species recovery.

Habitat

CWTD.S1. Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.

Physical Objectives Addressed: CWTD.PO 1,2,3,5

Explanation: Important habitats in the Columbia River estuary and lower mainstem that are currently functioning for Columbia White-tailed Deer should be protected, where feasible. Important habitats, such as the Julia Butler Hansen Refuge, should be maintained. Important habitats that are impaired should be restored, especially when restoring these habitat processes is beneficial to more than one species.

CWTD.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River estuary and lower mainstem.

Physical Objectives Addressed: CWTD.PO 3

Explanation: Changes to habitat forming processes have resulted from natural events (i.e. flooding) and human actions (i.e. urbanization). Theses changes impact the interconnected processes of the ecosystem. When possible ecosystem management should be applied to maintain a well balanced, diverse, and healthy fish and wildlife population within the Columbia River estuary and lower mainstem.

CWTD.S3. Avoid large-scale habitat changes where risks to Columbia White-tailed deer are uncertain.

Physical Objectives Addressed: CWTD.PO 1, 8

Explanation: This follows sustainable resource use practices and applies the globally accepted management method of thePrecautionary Principle which states, in areas where potential negative outcomes are unknown avoid large scale changes that may cause harm.

CWTD.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: CWTD.PO 1,5

Explanation: The cumulative effect of local small-scale changes can be significant over ime. For example, if continued building occurs in the flood plain, measures should be taken to alleviate potential flooding.

CWTD.S5. Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope of improvement, adjacent areas of marginal habitat where realistic level of improvement can restore conditions suitable for wildlife, and areas where multiple species benefit.

Physical Objectives Addressed: CWTD.PO 1,8

Explanation: Continued Columbia White-tailed Deer recovery would receive the greatest benefit in areas that already support production or are marginal. Attempts to restore severely degraded areas would require large costs and exhibit relatively few benefits.

CWTD.S6 Utilize a combination of active and passive habitat restoration measures to provide near and long term benefits.

Physical Objectives Addressed: CWTD.PO 2, 3

Explanation: Active habitat restoration measures provide near-term improvements in habitat conditions to address immediate viability risks but effects are rarely lasting unless related habitat forming processes in the watershed are functional. Passive habitat restoration measures in the riparian zone or surrounding watershed do not typically address immediate viability risks but provide longer lasting effects because they address underlying causes of problems (habitat processes) rather than the symptoms (habitat conditions).

CWTD.S7 Secure existing and potential Columbian White-tailed Deer habitat through acquisition or conservation easements by public agencies or conservation organizations.

Physical Objectives Addressed: CWTD.PO 1, 2, 5, 6, 7

Explanation: Securing habitat will protect it from development and ensure its availability to the deer. Securing potential habitat will provide a place for reintroducing the deer.

Predators

CWTD.S8 As a continued recovery action, increased management of coyote populations should be considered to increase the productivity of the population.

Physical Objectives Addressed: CWTD.PO 4

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

Reintroduction

CWTD.S9 Reintroduce Columbia White Tailed Deer where suitable habitat exists

Physical Objectives Addressed: CWTD.PO 7

Explanation: Suitable, but unoccupied, habitat for the Columbian White-tailed deer still exists in the lower Columbia floodplain, particularly on relatively undeveloped river islands. Reintroducing deer to these areas will expand the population's size and range and will reduce the probability of extinction.

5.2.2.1.8 Measures and programs to achieve strategies

The measures and projects for the CWTD should be derived from the recovery plan and annual updates.

5.2.2.2 Bald eagle

5.2.2.2.1 Background

The number of bald eagles (Haliaeetus leucocephalus) nesting along the lower Columbia River has doubled in the last ten years, yet many of these pairs are not reproducing normally.

Productivity averages are below statewide values for eagles nesting in other areas of Oregon and Washington, but improving. The lower Columbia River population is currently experiencing a rapid increase in eagle pairs, although the breeding success of these eagles is still somewhat lower than in other areas of Oregon and Washington. Eagles along the Columbia depend upon the river for food as well as habitat for nesting, roosting, and wintering. Eagles that nest along the river are considered residents because they do not migrate. In contrast, the wintering population of eagles remains along the river for a short period of time. Wintering eagles fly in from as far off as Montana, typically arriving in November, and remain around the river until February or early March.

Although total productivity has increased due to the success of new nesting pairs moving into the region, results indicate that organochlorine contaminants continue to impact the breeding success of lower Columbia River eagles. The greatest impact appears to occur at older breeding territories, which were located predominantly in the lower estuary below river mile 60. Eagles nesting toward the mouth of the river may be at greater risk of exposure to some dioxin-like compounds, and the reproductive success of some new pairs nesting in this area could be impacted in the future.

Additional background information on Bald Eagles is available in the subbasin assessment and the Species Technical Foundation (Appendix A).

5.2.2.2.2 Status

In 1994, the USFWS proposed to reclassify the bald eagle from endangered to threatened throughout its range; this reclassification was finalized in 1995. In 1999, the USFWS proposed to delist the bald eagle throughout its range, however, this delisting has not been finalized. While productivity of the Columbia River resident Bald Eagles is lower than average, nesting success in other areas of the two states is close to the goals established to delist the species from the Federal Endangered Species list.

Table 5-46:Bald Eagle in the Lower Columbia

Historical Abundance	Current Abundance
Biologists estimate that there were at least 700-1000 pairs of Bald eagles in Oregon and along the Columbia River. Few studies were done prior to the 1960s It is thought that the number of Bald eagles began to go down in the 1800s, dropping more significantly between 1947 and 1970	More than 105 resident nesting pairs; more than 100 during migration

5.2.2.2.3 Threats

Threats to the population identified at the time of listing include:

- reproductive failure caused by organochlorine pesticides
- widespread loss of suitable nesting habitat resulting from logging
- increased demand for housing development and recreational opportunities
- persecution (primarily illegal shooting (USFWS 1978 as cited in Stinson et al. 2001). XXX

Table 5-47: Bald Eagle limiting factors

Limiting Factors	Impact
BE.LF.1 Continued presence of organochlorine contaminants impacting the breeding success in the lower Columbia River. The greatest impact appears to occur at older breeding territories, which were located predominantly in the lower estuary below river mile 60.	High
BE.LF.2 Human disturbance to nesting habitat: typically very old Douglas fir or sitka spruce on shorelines and large cottonwoods or spruce on Columbia River islands.	High
BE.LF.3 persecution (primarily illegal shooting (USFWS 1978 as cited in Stinson et al. 2001	Medium

5.2.2.2.4 Value Statement

The Bald Eagle carries significant status both legally and culturally. Bald Eagles are an indicator of the habitat with large, mature trees. They also serve as indicators for detecting changes in contaminants over time, and for evaluating contaminant exposure and toxic impacts in fish eating birds and mammals. As such, the goal of the Bald eagle plan is to increase the viability of local populations. Successes with regional management planning for Bald Eagles should not override efforts to improve the reproductive successes of local populations.

5.2.2.2.5 Biological Objectives

Biological objectives for Bald eagle in the lower Columbia mainstem and estuary are formulated to support the value statement identified above. Habitat protection and management, the ban on use of DDT, and reduced direct predation due to education efforts have been followed by recent population increases. The reproductive capabilities Bald Eagle in these subbasins (particularly on the lower 60 miles of the river) lags behind those in the broader Oregon and Washington State region, though this situation appears to be improving. Therefore, strategies and measures to return Bald Eagles in the lower Columbia River mainstem and estuary subbasins to values indicative of healthy populations (one young per occupied nest) (Sprunt et al. 1973). are of importance.

Table 5-48: Bald eagle desired environmental conditions.

Physical Objective	Difficulty	Benefit
BE.PO.1 Identify and Protect existing nesting and foraging areas to ensure no population declines. *Hypothesis Statement:* If current bald eagle habitats are protected, then Bald Eagle recovery in the estuary and mainstem can be maintained. *Justification:* During the early stages of breeding activity and incubation, Bald Eagles are very sensitive to disturbances such as approaching humans or boats, which can cause nest abandonement of their nest and loss of young. Enormous recreational and development pressures, if not managed carefully, threaten to undermine recovery progress	Medium	High
BE.PO.2 Continue to and reduce, monitor and understand contaminant sources in the Lower Columbia River *Hypothesis Statement:* If bioaccumulative contaminants in the Bald Eagle become less prevalent in the Eagle food sources, successful reproduction efforts will increase over time. *Justification:* Productivity at new breeding sites is much higher than at old breeding sites suggesting that pairs at the older sites (particularly those in the lower 60 miles of the river) or impacted by contaminants to a greater level. Although the number of Bald eagles nesting along the river is increasing, continued foraging on contaminated prey form the LCR and subsequent bioaccumulation of contaminants could limit future productivity of some newer pairs as the chemical bioaccumulate in the adult birds with age.	Medium	Medium
BE.PO3 Reduce threats from physical hazards and persecution *Hypothesis Statement:* If these hazards are reduced, population will remain stable or increase *Justification:* Though significantly less than 30 years ago, death caused by electrocution and injuries caused by power lines, lead poisoning and shooting remain as problems for Bald Eagles.	Medium	Medium

5.2.2.2.6 Strategies to Address Biological and Physical Objectives

Strategies are already in place as part of statewide recovery plans. Over the last 15 years, these have been successful in restoring populations in the two-state region to poupluations worthy of delisting considerations. The reproductive capabilities Bald Eagle in these Lower Columbia subbasins (particularly on the lower 60 miles of the river) lag behind those in the broader Oregon and Washington State region, though this situation appears to be improving. This being the case, the following strategies are recommended:

BE.S1. Continue education, outreach and conservation measures

Physical Objectives Addressed: BE.PO1, BE PO3

BE.S2. Continue with habitat improvements for tidal flat and shallow water areas

Physical Objectives Addressed: BE.PO1

BE.S3. Limit entry of contaminants into Columbia River and tributaries

Physical Objectives Addressed: BE.PO2

BE.S4. Minimize disturbances to existing contaminated sediments

Physical Objectives Addressed: BE.PO1, BE PO2

BE.S5 Develop basin-wide strategies for controlling point source pollution for agriculture, forested industrial and urban areas

Physical Objectives Addressed: BE.PO1, BE PO2

BE S6 Establish and enforce water quality management plans to achieve TMDLs

Physical Objectives Addressed: BE.PO2

BE.S7. Establish buffer zones along riparian areas in agricultural and timber harvest areas for the Columbia River and Tributaries

Physical Objectives Addressed: BE.PO1, BE PO2

BE.S8. Explore further reductions of dioxin and furan point source discharges and identification of other sources

Physical Objectives Addressed: BE PO2

BE.S9. Establish TMDLs for compounds exhibiting dioxin-like activity other than TCDD

Physical Objectives Addressed: BE PO2

BE.S10. Gather information regarding the contribution of natural flood events and/or dredging and disposal activities toward total availability of contaminants to fish and wildlife in the Lower Columbia

Physical Objectives Addressed: BE PO2

Explanation: Efforts to implement the strategies of the Bald Eagle Management Plan have been successful to date in restoring populations in the Northwest region generally and in the Lower Columbia and Estuary subbasins area. Though reproductive rates along the lower Columbia populations have not exceeded objectives over a five-year average, the have exceeded them monitoring over the last two years.

Continued efforts in these areas will be needed to maintain populations and ensure that progress does not backslide.

5.2.2.2.7 Measures and programs to achieve strategies

The measures and projects for the Bald Eagle should be derived from the recovery plan and annual updates.

Table 5-49: Programs relevant to bald eagle measures

Program Name and Affiliation	Program Description	Measures Addressed
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of	4

Program Name and Affiliation	Program Description	Measures Addressed
	the United States, and applies to all structures.	
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	4
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	1, 4

5.3 Species of Ecological Interest (N. Pikeminnow, Shad, Eulachon, Caspian Tern, Osprey, Yellow Warbler, Red-eyed Vireo)

5.3.1.1 Overview

This category of species is intended to inform subbasin planners on the general health of the estuary/mainstem in terms of quality of the environment, habitat diversity, or management issues. Native species include: northern pikeminnow, eulachon, river otter, Caspian tern, osprey, yellow warbler, and red-eyed vireo; non-native species include American shad. To the extent possible, species-specific information has been included regarding each species' background, status, threats, value statement, and biological objectives. Conversely, the strategies and measures have been formulated to apply to the category of species on the whole.

Because of the diversity of ecological interest species and their subsequent life history requirements, the potential for conflict exists among suggested strategies and measures within this species categories as well as between this category and the focal species group or the other species of interest categories. If conflicts arise, planning and policy decisions will dictate which strategies and measures are implemented, based on species prioritization. However, the strategies and measures suggested within this management plan have been formulated to minimize conflict among species-specific strategies and measures. For example, northern pikeminnow and Caspian terns are important species within the lower Columbia mainstem and estuary subbasins; they are also perceived to have substantial predation impacts on ESA-listed salmonids. Strategies and

measures for these species have been formulated to minimize any predation impacts while promoting population viability and abundance. In the case of northern pikeminnow, strategies and measures suggest limiting older, larger pikeminnow which have the greatest predation impact on salmonids; this can be accomplished while maintaining pikeminnow population viability and abundance. In the case of Caspian terns, the suggested strategies and measures support ongoing efforts to relocate terns to suitable breeding areas where salmonids do not comprise a major diet item; these strategies and measures should maintain Caspian tern population abundance and may increase viability by decreasing the breeding population's susceptibility to catastrophic events.

American shad also may have potential conflicts with other species, particularly because they are non-native and have increased to record abundance in the Columbia River in recent years. However, very little is known about how American shad interact with native species or the Columbia River ecosystem. There may potentially be substantial predation or competition effects on native species; conversely, mortality of adult shad in freshwater may potentially have positive effects on food web productivity based on the input of marine-derived nutrients. Thus, American shad strategies and measures have been formulated to support future research to define any relationships between shad and the lower Columbia River and estuary ecosystem.

Some strategies and measures suggested for ecological interest species may also benefit focal species. For example, strategies and measures for yellow warbler and red-eyed vireo promote the acquisition of riparian and wetland habitat within the lower Columbia River floodplain. These strategies and measures are consistent with those suggested for focal species and thus, may benefit many species.

Eulachon are an integral part of the lower Columbia River and estuary ecosystem. They have unique spawning and incubation habitat requirements that need to be protected. Additionally, they may be highly susceptible to direct and indirect dredging effects. Strategies and measures to minimize direct and indirect dredging effects are similar to those for focal species and are most consistent with suggested strategies and measures for sturgeon and Pacific lamprey. Eulachon also experience challenges with Columbia River mainstem migration and dam passage, which are similar to migration challenges for Pacific lamprey. Thus, strategies and measures to promote eulachon migration are consistent with those suggested for lamprey; however, because of the differential swimming capabilities between these two species and most salmonids, passage improvements for eulachon and lamprey are challenged by potential negative effects on salmonids.Background

Northern Pikeminnow

The northern pikeminnow *(Ptychocheilus oregonensis)* is native to freshwater lakes and rivers of the Pacific slope of western North America from Oregon to northern British Columbia. This opportunistic species has flourished with habitat changes in the mainstem Columbia River and its tributaries. Pikeminnow are of particular interest for their predation on juvenile salmon. Salmonids are an important food for large pikeminnow and millions of juvenile salmonids are estimated to fall prey each year. Predation can be especially intense in dam forebays and tailraces where normal smolt migration behavior is disrupted by dam passage. A pikeminnow management program has been implemented in the Columbia and Snake rivers in an attempt to reduce predation mortality by reducing numbers of the large, old pikeminnow that account for most of the predation losses. A bounty fishery program for recreational anglers is aimed at balancing pikeminnow numbers rather than eliminating the species and has also stimulated development of a popular fishery.

Eulachon

Eulachon is the official common name for smelt (*Thaleichthys pacificus*) which swarm into the lower Columbia River and tributaries to spawn during winter and early spring. Eulachon are a small, anadromous forage fish inhabiting the northeastern Pacific Ocean from Monterey Bay, California, to the Bering Sea and the Pribilof Islands. Adults are typically 5 to 8 inches long and 3 to 5 years old. Most eulachon die after spawning. Eulachon typically enter the Columbia River system from December to May with peak entry and spawning during February and March. Water temperature plays an important role in upstream migration for spawning eulachon. Past studies have shown that the optimum water temperature for upstream migration is 40 °F; the colder the water, the longer the delay for spawning runs. Huge schools of smelt spawn in the Columbia and Cowlitz mainstems during most years. Pulses of spawners are also seen sporadically in other tributaries including the Grays, Lewis, and Sandy Rivers.

Eulachon support a popular sport and commercial dip net fishery in the tributaries, as well as a commercial gillnet fishery in the Columbia. They are used for food and are also favored as sturgeon bait. Smelt are also eaten in large numbers by other fishes including sturgeon, birds, and marine mammals.

River Otter

The river otter (*Lutra canadensis*) is a top predator of most aquatic food chains that has adapted to a wide variety of aquatic habitats, from marine environments to high mountain lakes of North America. The river otter is a year-round resident of the lower Columbia River mainstem and estuary, although field observations and trapper data indicate that population numbers are relatively low. Otters on the lower Columbia River concentrate their time in shallow, tidal influenced back waters, sloughs, and streams throughout the estuary. River otters exhibit differing degrees of social and spatial structure based on available habitat, shelter, and food. Otter home ranges (approximately 11 river miles) are largely defined by local topography and overlap extensively within and among sexes, exhibiting varying degrees of mutual avoidance and tolerance depending on seasonal dispersion and availability of food and shelter. However, otters do maintain territories within home ranges that are delineated by scent marking and latrine sites. Areas within territories are used almost exclusively by the defending otter. Female river otters mate during the months of March and April, with estrous lasting up to 46 days. Fertilized eggs may delay implantation for up to 10 months; duration of pregnancy after implantation occurs is approximately 2 months. Otter diets vary seasonally and generally consist of a wide variety of fish species and aquatic invertebrates such as crabs, crayfish, and mussels.

Caspian Tern

Caspian terns (*Sterna caspia*) are highly migratory species that are distributed throughout the world and are currently present in large numbers in the Columbia River estuary. The species is not listed, but is of conservation concern because there are relatively few breeding sites and because of significant predation of listed Columbia River salmonids.

Caspian terns have become increasingly abundant in the Columbia River estuary in recent years, becoming the largest breeding colony in North America. Breeding colony preference is for newly formed, flat, sandy, mid-channel islands, such as those formed via dredge spoils or accretion. There is considerable concern regarding Caspian tern consumption of juvenile salmonids, however, we have no mechanism to measure whether current tern predation differs significantly from historical predation. Further, management actions to discourage

breeding on Rice Island and encourage breeding on East Sand Island appears to be decreasing the amount of tern predation on juvenile salmonids.

Spring migrants first arrive at breeding sites between mid-March to mid-May depending on latitude, elevation, and coastal or interior location. The timing of southward migration varies with region; typically, the peak of fall migration occurs between mid-July and mid-September with stragglers leaving by the end of November.

Caspian terns are piscivorous; fish may constitute up to 98% of the diet, particularly during periods of high fish abundance such as the peak of smolt outmigration. Breeding Caspian terns require one-third of their body weight of fish per day during the nesting season, which also coincides with the peak of smolt migration. Diet of the Rice Island colony is dominated by juvenile salmonids while diet of the East Sand Island colony was primarily non-salmonid fishes. Studies in 1990 and 1991 revealed that eggs of Caspian terns nesting at Rice and East Sand Islands were contaminated with organochlorine compounds, including PCBs, DDE, dioxins, and furans, suggesting that their food source (primarily juvenile salmonids) may be contaminated with these compounds as well.

Osprey

The osprey (*Pandion haliaetus*) is a large piscivorous bird of prey that nests and feeds along the lower Columbia River in spring and summer. Ospreys have nearly worldwide breeding distribution; birds that breed in the Pacific Northwest migrate to wintering grounds in southern Mexico and northern Central America. Ospreys nest in forested riparian areas along lakes, rivers, or coastlines; nests are situated atop trees, rock pinnacles, or artificial structures such as channel markers or power/light poles. Adult pairs are thought to mate for life and return to the same area annually for breeding. Generally, adults spend approximately one month on the breeding grounds before egg laying; egg incubation takes about 5 weeks and nestlings are ready to fly approximately 7-8 weeks after hatching. Ospreys feed almost exclusively on fish and are not particular about the species of fish they consume. In the lower Columbia and Willamette Rivers, largescale suckers are an important part of the osprey's diet; ospreys remain close to the nest for feeding.

Yellow Warbler

The yellow warbler (*Dendroica petechia*) is a long-distance neotropical migrant; spring migrants begin to arrive in the Pacific Northwest region in April but the peak of spring migration in the region is in late May. Southward migration begins in late July, and peaks in late August to early September; very few migrants remain in the region in October. The yellow warbler is a riparian obligate species most strongly associated with wetland habitats that contain Douglas spirea and deciduous tree cover. Yellow warbler preferred habitat in the lowlands of western Oregon and western Washington is described as: >70% cover in shrub layer (<3 m) and subcanopy layer (>3 m and below the canopy foliage) with subcanopy layer contributing >40% of the total; shrub layer cover 30-60% (includes shrubs and small saplings); and a shrub layer height >2 m. Yellow warblers capture and consume a variety of insect and arthropod species, as well as wild berries, by gleaning from subcanopy vegetation

Red-eyed Vireo

The red-eyed vireo (*Vireo olivaceus*) is a long-distance neotropical migrant; it breeds throughout North America and winters in South America. The red-eyed vireo is locally common in riparian growth and strongly associated with tall, somewhat extensive, closed canopy forests

of cottonwood, maple, or alder in the Puget Lowlands and along the Columbia River in Clark, Skamania, and Klickitat Counties; presence in the Columbia River estuary is not well documented. Red-eyed vireo preferred habitat in the lowlands of western Oregon and western Washington is described as: mean canopy tree height >50 ft (15 m), mean canopy closure >60%, young (recruitment) sapling trees >10% cover in the understory, and riparian woodland >164 ft (50 m) wide. Vireos are primarily insectivorous, with 85% of their diet composed of insects and only 15% of vegetable material, mostly fruits and berries eaten in August–October.

American Shad

American shad (*Alosa sapidissima*) have grown to substantial populations since introduction into the Columbia River system in 1885. The completion of the Dalles Dam in 1956 (and subsequent inundation of Celilo Falls) extensively expanded the range of American shad into the upper Columbia and Snake Rivers. Further, the transition of the estuarine food web from a macrodetritus to microdetritus base (i.e. increased importation of plankton from upstream reservoirs) has benefited zooplanktivores, including American shad. In the Columbia River estuary, American shad are described as year-round residents.

A pattern is slowly emerging that suggests the existence of American shad is changing trophic relationships with the Columbia River. Because of their abundance, consumption rates and patterns of American shad may have modified the estuarine food web. One study found that in the Columbia River estuary and lower mainstem (up to RKm 62) shad diet overlapped with subyearling salmonid diets, which may indicate competition for food. Juvenile shad and subyearling salmonids also utilize similar heavily-vegetated backwater habitats. Another study examined the abundance of shad as prey on the faster growth rates of northern pikeminnow, which in turn are significant predators of juvenile salmonids.

Commercial harvest has been considered as a means to reduce the abundance of American shad in the Columbia River, however, harvest has been restricted because the shad spawning run coincides with the timing of depressed runs of summer and spring chinook, sockeye, and summer steelhead.

5.3.1.2 Status

Northern Pikeminnow

In the Columbia River downstream from its confluence with the Snake River, northern pikeminnow abundance is highest in the approximately 186 miles (300 km) from the estuary to the Dalles Dam (2,580-3,020 fish/km) and decreases significantly in the 100 miles (161 km) from the Dalles Dam to McNary Reservoir (550-690 fish/km). The widespread distribution and resiliency of northern pikeminnow is likely a result of their relatively broad spawning and rearing habitat requirements.

Eulachon

Prior to the completion of Bonneville Dam, eulachon were reported as far upstream as Hood River, Oregon; today, most eulachon are limited to areas below Bonneville Dam because of dam passage problems.

Smelt numbers and run patterns can be quite variable and low runs during the 1990's were a source of considerable concern by fishery agencies. Current patterns show a substantial

increase in run size compared to the 1990's. The low returns in the 1990's are suspected to be primarily a result of low ocean productivity.

The best available long-term data on Columbia River eulachon returns are historical commercial landings in the Columbia River and its tributaries. Unfortunately, commercial landings are a poor index of eulachon run size because the economic market can dictate the harvest amount. Annual commercial harvest from 1936 to 2002 has averaged 2 million pounds.

Eulachon are listed as a state candidate species on WDFW's Species of Concern list. A species will be considered for designation as a state candidate if sufficient evidence suggests that its status may meet the listing criteria defined for state endangered, threatened, or sensitive. In 1999, the NMFS received a petition to list the Columbia River populations of eulachon as an endangered or threatened species and to designate critical habitat under the ESA. The NMFS determined the petition did not present enough substantial evidence to warrant the listing of eulachon.

River Otter

Little is known about river otter abundance in the lower Columbia River and estuary. Evidence suggests that river otter abundance has always been relatively low; otter abundance appears to be highest in the Cathlamet Bay area.

Caspian Tern

There were no Caspian terns in the estuary before 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds moved to Rice Island in 1987. Recent management actions have successfully discouraged breeding on Rice Island while encouraging breeding on other estuary islands, particularly East Sand Island. The total Columbia River estuary colony is estimated at approximately 10,000 pairs (the largest colony in North America).

Osprey

Along the lower 410 km of the Columbia River during 1997 and 1998, a total of 94 and 103 occupied nests were observed, respectively. Osprey productivity was estimated at 1.64 young/active nest, which is higher than the generally recognized 0.80 young/active nest needed to maintain a stable population.

Yellow Warbler

Yellow warblers are a locally common breeder at lower elevations along rivers and creeks in the Columbia Basin, although only possible breeding evidence has been observed along the lower Columbia River mainstem and estuary. Within Washington, yellow warblers are apparently secure and are not of conservation concern. Yellow warblers are an excellent indicator of riparian zone structure and function.

Red-eyed Vireo

The red-eyed vireo is common in western Washington. This songbird has been one of the most abundant birds in North America, although its numbers seem to have declined recently, possibly as a result of the destruction of wintering habitat in the neotropics, fragmentation of northern breeding forests, or other causes. The red-eyed vireo is secure, particularly in the eastern United States. Within Washington, the red-eyed vireo is common, more widespread in northeastern and southeastern Washington, and not a conservation concern. The red-eyed vireo is an excellent indicator of riparian zone structure and function.

American Shad

American shad have grown to substantial populations since introduction into the Columbia River system in 1885; in recent years, 2-4 million adults have been counted annually at Bonneville Dam. Although the construction of dams in shad-producing streams has been blamed in part for the decimation of East Coast stocks of American shad, evidence suggests that dams in the Columbia River system may partially be responsible for the shad's rapid population growth. Shad are currently distributed throughout the Columbia and Snake River basins.

5.3.1.3 Value statement

Northern Pikeminnow

Northern pikeminnow are a native fish with ecological, cultural, and economic importance. With their increased abundance in response to Columbia River habitat alterations, pikeminnow have become an integral part of the Columbia River mainstem ecosystem. Northern pikeminnow are an important predator of juvenile salmonids. The goal for northern pikeminnow in the lower Columbia River is to maintain a viable population while minimizing the number older, larger, predaceous individuals.

Eulachon

Eulachon are a species with ecological, cultural, economic, and fishery management importance. They are an anadromous species that utilize unique spawning habitat in the estuary and lower mainstem. The goal for eulachon in the lower Columbia River is to maintain or increase annual population to some carrying capacity level (which is currently unknown) to provide forage value for estuary and lower mainstem species and to provide annual harvest opportunities similar to the historic annual average (i.e. 2 million pounds).

River Otter

River otter are a species with ecological importance and are considered an indicator of general environmental health.

Caspian Tern

Caspian terns are a colonial nesting species protected under the Federal Migratory Bird Treaty. They are perceived to be a significant predator of juvenile salmonids and have become a significant part of the estuarine ecosystem, based on their abundance and consumptive needs during the breeding season. Salmon recovery efforts should evaluate potential effects on Caspian terns. Goals for the Columbia River estuary population are to maintain population viability region-wide and decrease the population's vulnerability to catastrophic events, consistent with objectives emerging from the Caspian Tern Working Group and USFWS EIS process.

Osprey

Osprey in the lower Columbia River mainstem and estuary are ecologically significant; they are considered an indicator of environmental contaminants. The goal for the estuary and lower mainstem osprey population is to improve population viability by increasing reproductive success.

Yellow Warbler

Yellow warblers in the lower Columbia River mainstem and estuary are ecologically significant; they are considered an indicator of dense riparian shrub habitat. The goal for the estuary and lower mainstem warbler population is to improve population viability, although little is known about current population abundance and productivity.

Red-eyed Vireo

Red-eyed vireos in the lower Columbia River mainstem and estuary are ecologically significant; they are considered an indicator of tall, closed canopy riparian habitat. The goal for the estuary and lower mainstem vireo population is to improve population viability, although little is known about current population abundance and productivity.

American Shad

American shad are an introduced species with ecological, management, and minor economic value. They are perceived to have an impact on salmonids, through both competition and predation impacts. Because of their abundance, shad have become an integral part of the Columbia River mainstem and estuary ecosystem and may be an important food source for native fish such as sturgeon. The goal for the Columbia River shad population is to maintain a viable population (a minimum between 700,000-1,000,000) while defining and reducing potential adverse impacts on other species of interest, particularly ESA-listed salmonids.

5.3.1.4 Limiting factor (Threats)

Northern Pikeminnow

Northern pikeminnow have successfully evolved in a range of dynamic lentic and lotic ecosystems and successfully adapted to their varied habitat conditions; they are considered opportunistic generalists that inhabit slow to moderately flowing streams and lakes. There are no known threats to northern pikeminnow in the lower Columbia River estuary and mainstem, however, the larger individuals in the population are considered a threat to emigrating juvenile salmonids. Habitat restoration efforts for salmonids, as suggested in other chapters of this Management Plan, may have negative effects on northern pikeminnow.

Eulachon

Eulachon are an understudied species and considerable research is needed to ascertain its biology and life history requirements. Eulachon in the lower Columbia River mainstem, estuary, and plume may have threats to all three life stages in the combined subbasins, but the significance of these threats is unclear. Adult eulachon are impacted by harvest and may be affected by spawning habitat availability or migration barriers such as dams or water temperature. Ocean survival of juvenile eulachon is thought to be important, but little is known about survival rates or factors in ocean survival. Incubating eggs and developing juveniles are likely impacted by sedimentation (egg suffocation), hypoxia (low dissolved oxygen to eggs), predation, direct losses to dredging, and sublethal effects of parasites/contaminants.

Table 5-50. Suspected eulachon limiting factors by life stage.

Life Stage	Limiting Factors	Impact/Certainty
Egg Incubation	**Eu.LF.1** Sedimentation of spawning substrates. Deposition of fine sediments in the preferred spawning habitats (i.e. coarse sands) can result in egg suffocation. Fine sediment sources include adjacent tributary subbasins as well as migration of sediments from mainstem deposits.	High/Low

Life Stage	Limiting Factors	Impact/Certainty
	Eu.LF.2 Egg hypoxia. Dissolved oxygen levels may be low for any number of reasons. Delivery of oxygenated water is decreased through sedimentation.	High/Low
	Eu.LF.3 Predation mortality. Eulachon eggs may be vulnerable to predation. Eggs have been documented as an important food item of juvenile sturgeon in the lower mainstem. Eulachon eggs comprised up to 25% of stomach contents for sturgeon ≤350mm; the percentage increased to 51% for sturgeon 351-724mm.	Medium/Medium
	Eu.LF.4 Direct dredging mortality. Dredging activities in areas where eggs or developing larvae are present results in direct mortality. Also, evidence suggests that dredging activity in the vicinity of spawning areas makes the substrate too unstable for egg incubation.	Medium/Low
	Eu.LF.5 Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to have detrimental effects on development and physiological processes.	Medium/Low
Juvenile Migration	**Eu.LF.6** Predation mortality. Juvenile eulachon losses to predation are unknown and need to be evaluated. Predation could be substantial because juvenile eulachon have poor swimming ability and emigrate at the mercy of river currents.	High/Low
	Eu.LF.7 Near ocean survival. Mortality upon ocean entry is unknown, but may be substantial.	High/Low
Adult Abundance	**Eu.LF.8** Fishing mortality. At present, fishery regulations, fishing effort, and harvest levels appear to be at sustainable levels; population response needs to be monitored closely to ensure population viability.	Low/High
	Eu.LF.9 Predation mortality. Eulachon are an important food item for many estuary and lower mainstem species. Large congregations of avian predators accompany eulachon runs into spawning areas. Pinnepeds prey on eulachon as they migrate through the estuary; pinnepeds may also follow eulachon runs to spawning areas.	Medium/High
	Eu.LF.10 Migration barriers. Eulachon do not navigate fish passage structures well, thus Bonneville Dam restricts access to historical spawning areas. Optimal water temperature for upstream migration is about 40 °F; below this temperature, migration will be delayed.	Medium/High
	Eu.LF.11 Interaction with introduced species. Hundreds of species introductions, both intentional and unintentional, have occurred in the lower Columbia mainstem and estuary. Effects on eulachon are unknown.	High/Low

River Otter

River otter are an understudied species and considerable research is needed to identify threats to the lower Columbia River mainstem and estuary population. At the recommendation of technical resources for River Otter, and approved by Planning Group members, this species was dropped as a species of interest for this plan.

Caspian Tern

The U.S. Fish and Wildife Service, U.S. Army Corps of Engineers, and NOAA Fisheries are preparing an Environmental Impact Statement (EIS) for Caspian Tern management in the Columbia River estuary. The purpose of the EIS is to explore options to reduce the level of tern predation on Columbia River salmonids while insuring the protection and conservation of Caspian terns in the Pacific Coast/Western region (California, Oregon, Washington, Idaho, and Nevada). Threats to and from Caspian terns are expected to be part of the EIS, which is scheduled for release in the near future.

Federal and State agencies and non-governmental organizations have agreed to explore options for restoring, creating, and enhancing nesting habitat for Caspian terns throughout portions of the Pacific Coast/Western region. The potential benefits of this proposed action would reduce the level of tern predation on emigrating juvenile salmonids in the Columbia River, and lower the vulnerability of a significant portion of breeding Caspian terns in the Pacific Coast/Western region to catastrophic events such as disease, oil spills, or storm events.

Osprey

Osprey in the lower Columbia River and estuary subbasins have threats to the reproductive success of the population based on potential contaminant effects and the availability of forest habitat with adequate nest/roost trees. However, in 1997-98, lower Columbia River (410km) osprey productivity was estimated at 1.64 young/active nest, which is higher than the generally recognized 0.80 young/active nest needed to maintain a stable population. Contaminants do play a role in Columbia River osprey productivity; higher young survival was observed when contaminant concentrations in osprey eggs were low (i.e. 1.70 young per active nest) compared to when contaminant concentrations were high (i.e. 1.14 young per active nest).

Table 5-51. Suspected limiting factors to osprey reproductive success.

Life Stage	Limiting Factors	Impact/Certainty
Reproductive Success	**Os.LF.1** Contaminant exposure. Contaminants have been documented throughout the lower mainstem and estuary. Contaminants are known to decrease eggshell thickness, which affects survival. Columbia River osprey eggs contained the highest concentration of DDE reported in North America in the late 1980s and 1990s.	Medium/High
	Os.LF.2 Availability of nesting habitat. Osprey prefer mature forest habitats with adequate nest and roost trees in close proximity to abundant fish resources. Osprey appear to be adaptable and have been observed nesting on artificial structures such as channel markers or power poles.	Low/Medium

Yellow Warbler

Yellow warblers are a locally common breeder at lower elevations along rivers and creeks in the Columbia Basin, and within Washington, are apparently secure and not of conservation concern. Yellow warblers are an indicator of riparian shrub habitat characterized by a dense deciduous shrub layer 1.5-4 m (5-13.3 ft), with edge and with small patch size (i.e. heterogeneity). Habitat suitability for warblers is correlated with the percent of deciduous shrub canopy comprised of hydrophytic shrubs; warbler abundance is positively associated with deciduous tree basal area and negatively associated with closed canopy and cottonwood proximity. Thus, loss of this specific habitat type would be a threat to yellow warblers in the lower Columbia River and estuary, although the extent of habitat loss is not clear.

Red-eyed Vireo

The red-eyed vireo is common in western Washington. The red-eyed vireo is an indicator of forested riparian habitat characterized by tall, closed canopy forests of deciduous trees (cottonwood, maple, or alder and ash), with a deciduous understory, forest stand sizes larger than 50 acres (20 ha), and riparian corridor widths greater than 50 m (164 feet). Thus, loss of this specific habitat type would be a threat to red-eyed vireos in the lower Columbia River and estuary. Evidence suggests that considerable forest wetland habitat has been lost compared to historical conditions, however, the extent to which these lost habitats satisfied the specific red-eyed vireo habitat requirements is unknown.

American Shad

American shad have flourished in the altered lower Columbia River ecosystem. Hydrologic changes resulting from hydrosystem development appear to benefit American shad. There are no known threats to American shad in the lower Columbia River estuary and mainstem. Habitat restoration efforts for salmonids, as suggested in other chapters of this Management Plan, may have negative effects on American shad.

5.3.1.5 Biological objectives & working hypotheses

Biological objectives for the species of ecological interest, including both biological performance and the corresponding environmental conditions, are formulated to support the value statements identified above. It is understood that indices of historical and current population numbers are uncertain, given the assumptions in data collection and the variability that governs population dynamics. As a result, the numeric biological objective goals for the

lower mainstem and estuary should be viewed as "order of magnitude" estimates and interim in nature until more certainty can be achieved in abundance estimates and more specific goals can be quantified.

Table 5-52. Species of ecological interest[a] biological performance levels.

Metric	Performance Level
Eulachon	
Annual harvest level	~ 2million pounds, which represents average harvest from 1938-2002
Caspian Tern	
Breeding Colony Abundance	~10,000 pairs; maintain regional abundance at current levels
Osprey	
Young Productivity	>1.5 young per active nest (0.8 young per active nest needed for stable population)
Breeding Population Size	>100 active nest sites in lower 410 km of Columbia River
American Shad	
Columbia River Adult Population Size	700,000 to 1,000,000

[a] Not all species in this category are represented in this table, based on a lack of available data.

Table 5-53. Northern pikeminnow desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Population Structure	**NP.PO.1** Minimize the number of large, predaceous individuals in the population. *Hypothesis Statement:* If individuals in the larger size classes are minimized, then negative impacts to salmonids can be reduced without jeopardizing pikeminnow population viability. *Justification:* Large predaceous pikeminnow are the primary source of predation on emigrating juvenile salmonids. Existing pikeminnow control programs have successfully minimized salmonid predation and maintained the pikeminnow population. To the extent possible, the historical predator-prey relationship between pikeminnow and salmonids should be restored.	Medium	High/High

Table 5-54. Eulachon desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Egg Incubation	**Eu.PO.1** Protect existing spawning habitat to ensure no future net degradation. *Hypothesis Statement:* If current spawning habitat is protected, then productivity and population recruitment in the estuary and mainstem can be maintained or increased. *Justification:* Protection and maintenance of existing stable coarse sand substrate spawning habitat will maintain the current level of population productivity. Dredging in the vicinity of eulachon spawning areas can make the substrate too unstable for successful egg incubation. Protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/Low
	Eu.PO.2 Reduce predation mortality on eggs. *Hypothesis Statement:* If predation on eggs is reduced, then eulachon egg survival in the estuary and mainstem will increase. *Justification:* Predation on eulachon eggs by white sturgeon can be substantial; other predators may exist. Eulachon eggs comprised 51% of stomach samples from sturgeon 351-724mm in the Skamania area.	High	Medium/Medium
	Eu.PO.3 Reduce contaminant exposure. *Hypothesis Statement:* If contaminant exposure is reduced, then egg survival in the estuary and mainstem will increase. *Justification:* Contaminants have been shown to have detrimental effects, such as delayed development or disrupted physiological processes. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms.	High	Medium/Low
	Eu.PO.4 Avoid direct dredging mortality. *Hypothesis Statement:* If suction dredging activities occur in the presence of eulachon eggs, then direct mortality will result. *Justification:* Eulachon eggs are deposited among coarse sands. Suction dredging of these sands results in entrainment and mortality. Dredge operations should avoid known areas of developing eulachon eggs.	Medium	Medium/Low
	Eu.PO.5 Develop an understanding of spawning habitat characteristics in the lower mainstem and estuary. *Hypothesis Statement:* If our understanding of spawning habitat increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of known spawning sites and specific spawning habitat characteristics in the lower mainstem and estuary ecosystem is limited; research is needed to increase our knowledge and reduce uncertainty.	High	High/Low

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Juvenile Migration	**Eu.PO.6** Reduce predation mortality. *Hypothesis Statement:* If predation mortality is reduced, then juvenile survival in the lower mainstem, Western Oregon tributaries, estuary, and plume will increase. *Justification:* Juvenile eulachon have poor swimming capability. Predation on emigrating juvenile eulachon may be substantial and needs to be quantified.	High	High/Low
	Eu.PO.7 Develop an understanding of near shore ocean juvenile survival; attempt to increase if necessary. *Hypothesis Statement:* If our understanding of juvenile eulachon near shore survival increases, then management actions will proceed with greater certainty. *Justification:* Little is known about near shore survival of juvenile eulachon. In historical (1946) plankton hauls off the mouth of the Columbia River, all captured juvenile eulachon had yolk sacs attached, indicating no feeding/rearing in the mainstem or estuary. Juvenile eulachon are small and survival is uncertain; newly hatched larvae are usually 4-7mm and juveniles reaching the river mouth are unlikely much larger.	High	High/Low
Adult Abundance	**Eu.PO.8** Protect population from overexploitation. *Hypothesis Statement:* If current fisheries are properly managed, then adult spawning abundance in the estuary and mainstem can be maintained. *Justification:* Fishery regulations and constant population monitoring can help maintain sustainable harvest levels.	Low	Medium/High
	Eu.PO.9 Reduce predation mortality. *Hypothesis Statement:* If predation mortality is reduced, then adult survival in the estuary and mainstem will increase. *Justification:* Eulachon are an important food item for many estuary and mainstem species. Large congregations of avian predators have been observed in eulachon spawning areas and pinnepeds may follow eulachon runs in the mainstem.	High	Medium/High
	Eu.PO.10 Improve migration conditions. *Hypothesis Statement:* If migration conditions are optimized, then historical adult survival, distribution, and timing in the estuary and mainstem can be restored. *Justification:* Eulachon navigate fish passage structures poorly and access to historical spawning areas are restricted by Bonneville Dam. Preferred migration water temperature is 40 °F; cooler temperatures will delay migration.	High	Medium/High

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	Eu.PO.11 Document the interaction between eulachon and introduced species; minimize negative interactions. *Hypothesis Statement:* If introduced species continue to thrive, then eulachon survival in the lower mainstem, Western Oregon tributaries, estuary, and plume may be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	High/Low
	Eu.PO.12 Develop an understanding of eulachon habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of eulachon integration with the ecosystem increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of eulachon interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; research is needed to increase our knowledge and reduce uncertainty.	High	High/Low

Table 5-55. River otter desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Population Abundance	**RO.PO.1** Protect existing preferred habitat to ensure no future net degradation. *Hypothesis Statement:* If current river otter preferred habitat is protected, then productivity and population abundance in the estuary and mainstem can be maintained. *Justification:* Protection and maintenance of existing shallow, tidal-influenced backwater, slough, and stream habitats will maintain the current level of population productivity and abundance. Protection of existing habitat is often more cost effective than restoration of former habitat.	High	High/Medium

Table 5-56. Caspian tern desired environmental conditions[a].

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Population Abundance and Resilience	**CT.PO.1** Encourage breeding colony distribution among multiple breeding sites, preferably in locations where non-salmonid food sources are plentiful. *Hypothesis Statement:* If the Caspian tern colony is more widely distributed, then the tern colony will be less vulnerable to disturbance. *Justification:* Occurrence of the Caspian tern breeding colony in one breeding location makes the colony susceptible to a catastrophic event such as disease or storms. Additionally, distribution of the colony to areas where non-salmonid food sources are available should decrease predation on ESA-listed salmonids while maintaining colony abundance.	Medium	High/High

[a] The Caspian tern desired environmental conditions should be consistent with goals of the Caspian Tern Working Group and the USFWS EIS; the EIS is scheduled for release in the near future and desired environmental conditions may be modified to reflect EIS findings.

Table 5-57. Osprey desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Reproductive Success	**Os.PO.1** Protect existing nesting habitat to ensure no future net degradation. *Hypothesis Statement:* If current nesting habitat is protected, then productivity and population viability in the estuary and mainstem can be maintained. *Justification:* Protection and maintenance of existing mature forest nesting habitat with adequate nest/roost sites will help maintain the current population level. Protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/Medium

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	Os.PO.2 Reduce contaminant exposure. *Hypothesis Statement:* If contaminant exposure is reduced, then reproductive success in the estuary and mainstem will increase. *Justification:* Contaminants have been shown to have detrimental effects, such as eggshell thinning which decreases reproductive success. Numerous contaminants have been detected throughout the lower Columbia River and estuary at concentrations known to have detrimental effects on aquatic organisms. DDE concentrations in osprey eggs collected along the lower Columbia River had the highest concentration of DDE reported in North America in the late 1980s and 1990s.	High	High/High

Table 5-58. Yellow warbler desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Population Abundance/ Productivity	**YW.PO.1** Protect existing preferred habitat to ensure no future net degradation. *Hypothesis Statement:* If current preferred riparian habitat is protected, then productivity and population viability in the estuary and mainstem can be maintained. *Justification:* Protection and maintenance of existing riparian shrub habitat characterized by a dense shrub layer 1.5-4 m and heterogeneity will help maintain the current population level. Protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/Medium

Table 5-59. Red-eyed vireo desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Population Abundance/ Productivity	**ReV.PO.1** Protect existing preferred habitat to ensure no future net degradation. *Hypothesis Statement:* If current preferred riparian habitat is protected, then productivity and population viability in the estuary and mainstem can be maintained. *Justification:* Protection and maintenance of existing forested riparian habitat characterized by tall, closed canopy deciduous forests with a deciduous understory, patch sizes larger than 50 acres, and riparian corridor widths greater than 50 m will help maintain the current population level. Protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/Medium

Table 5-60. American shad desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Juvenile Rearing	**AS.PO.1** Document the interaction between juvenile American shad and ESA-listed salmonids; minimize negative interactions. *Hypothesis Statement:* If American shad continue to thrive, then juvenile salmonid survival in the lower mainstem, Western Oregon tributaries, estuary, and plume may be negatively affected. *Justification:* Evidence indicates there is habitat and diet overlap of shad and salmonids, suggesting potential competition effects. Also, juvenile shad may be an important food source for known salmonid predators, such as northern pikeminnow. These relationships are complex and may be offsetting; for example, shad abundance may increase pikeminnow growth rates, thereby increasing the abundance of larger, predaceous pikeminnow that prey on salmonids. Conversely, larger pikeminnow may selectively prey on the abundant juvenile shad, thereby decreasing predation on salmonids. Effects on ESA-listed salmonids are generally unknown, may be significant, and need to be quantified.	High	High/Medium
	AS.PO.2 Develop an understanding of juvenile shad habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of shad integration with the ecosystem increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of shad interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; research is needed to increase our knowledge and reduce uncertainty.	High	High/Medium
Adult Abundance	**AS.PO.3** Document the interaction between adult American shad and ESA-listed salmonids; minimize negative interactions. *Hypothesis Statement:* If American shad continue to thrive, then salmonid survival in the lower mainstem, Western Oregon tributaries, estuary, and plume may be negatively affected. *Justification:* Adult American shad may prey upon juvenile salmonids; likelihood of predation may be higher for repeat spawning shad. Also, the sheer abundance of recent shad returns causes crowding at fish ladders and can delay salmonid upstream migrations. Effects on salmonids are generally unknown, may be significant, and need to be quantified.	High	High/Low

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	AS.PO.4 Develop an understanding of adult American shad habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume. *Hypothesis Statement:* If our understanding of American shad integration with the ecosystem increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of American shad interaction with the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems is limited; research is needed to increase our knowledge and reduce uncertainty.	High	High/Low

5.3.1.6 Strategies

Healthy populations depend on favorable habitats for reproduction and viability. High quality habitat increases population productivity which helps maintain adequate abundance. Populations can typically withstand some combination of mainstem and estuary habitat degradation and other impacts. Current habitat conditions in the lower mainstem and estuary have likely deteriorated compared to historical conditions for some species of ecological interest (i.e. eulachon, river otter, osprey, yellow warbler, and red-eyed vireo) while habitat conditions appear to have improved for other species of ecological interest (i.e. northern pikeminnow, Caspian tern, and American shad).

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving habitat conditions for species of ecological interest. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on fish and wildlife populations and increased commitment to protect these resources. More environmental-friendly practices have been implemented for many activities.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by species of ecological interest to any given suite of actions. Finally, the strategies have been

developed for wide applicability to this diverse group of species; where applicable, we have noted where strategies are species-specific.

Habitat

EI.S1. Protect functioning habitats while also restoring impaired habitats.

Physical Objectives Addressed: Eu.PO.1, Eu.PO.5, Eu.PO.7, Eu.PO.10, Eu.PO.12, RO.PO.1, Os.PO.1, YW.PO.1, and ReV.PO.1

Explanation: Important habitats in the Columbia River estuary and lower mainstem that are currently functioning for fish and wildlife species should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to fish and wildlife species while habitat-forming processes are improving.

EI.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River estuary and lower mainstem.

Physical Objectives Addressed: Eu.PO.1, Eu.PO.5, Eu.PO.7, Eu.PO.10, Eu.PO.12, RO.PO.1, Os.PO.1, YW.PO.1, and ReV.PO.1

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g., storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

EI.S3. Avoid large-scale habitat changes where risks to species of ecological interest are uncertain.

Physical Objectives Addressed: Eu.PO.1, Eu.PO.5, Eu.PO.7, Eu.PO.10, Eu.PO.12, RO.PO.1, Os.PO.1, YW.PO.1, and ReV.PO.1

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that habitat conditions don't continue to get worse.

EI.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: Eu.PO.1, Eu.PO.5, Eu.PO.7, Eu.PO.10, Eu.PO.12, RO.PO.1, Os.PO.1, YW.PO.1, and ReV.PO.1

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

EI.S5. Limit the effects of toxic contaminants in the Columbia River estuary, lower mainstem, and nearshore ocean.

Physical Objectives Addressed: Eu.PO.3 and Os.PO.2

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on fish or wildlife species is unclear. In general, contaminants affect survival by increasing stress, predisposing organisms to disease, and interrupting physiological processes.

Introduced Species

EI.S6. Do not intentionally introduce new species and take aggressive measures to avoid inadvertent introductions of new species or expansions of existing introduced species.

Physical Objectives Addressed: Eu.PO.11, AS.PO.1, AS.PO.2, AS.PO.3 and AS.PO.4

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced or invasive species can radically alter this balance with severe consequences for native communities. A variety of non-native plant and animal species have already colonized lower Columbia aquatic and terrestrial ecosystems. Other species have been intentionally introduced, to provide sport fisheries for instance. Introduced species are particularly adept at capitalizing on altered habitats. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced or invasive species are unpredictable. Once established, introduced or invasive species are extremely difficult to control or eliminate.

Predators

EI.S7. Evaluate the level of predation mortality to determine significance to prey population viability.

Physical Objectives Addressed: NP.PO.1, Eu.PO.2, Eu.PO.6, Eu.PO.9, CT.PO.1, AS.PO.1, and AS.PO.3

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

EI.S8. Investigate and refine selective harvest methods or other predator control actions to limit predation mortality on ESA-listed salmonids.

Physical Objectives Addressed: NP.PO.1, CT.PO.1, AS.PO.1, and AS.PO.3

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural systems have been substantially altered by human activities or other disturbances, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator eradication; a variety of predator management alternatives exist.

Other Mortality Factors

EI.S9. Avoid incidental mortality of eulachon eggs during dredging operations.

Physical Objectives Addressed: Eu.PO.4

Explanation: Developing eulachon eggs may be present among coarse sand substrates throughout the lower Columbia River. Suction dredging in these areas results in direct mortality; additionally, dredging in the vicinity of eulachon spawning areas can make substrates too unstable for egg incubation. Dredge operations should avoid areas of known eulachon presence.

EI.S10. Manage Columbia River eulachon fisheries at sustainable levels.

Physical Objectives Addressed: Eu.PO.8

Explanation: Columbia River eulachon fisheries should continue to be managed in such a way as to ensure population viability while meeting the needs of commercial, tribal, and recreational fisheries.

EI.S11. Evaluate and improve passage conditions at mainstem dams, insuring no negative effects on salmonid passage.

Physical Objectives Addressed: Eu.PO.10 and AS.PO.3

Explanation: Adult eulachon have difficulty in dam passage; thus, access to historical spawning areas above Bonneville Dam has been restricted. Additionally, the timing and abundance of American shad creates crowding at fish ladders during salmonid return migrations, which can cause delays in salmonid upstream migration. Salmonid arrival timing at spawning grounds is often coordinated with environmental conditions, thus, migration delays can affect spawning success and egg survival.

EI.S12. Investigate and minimize competition among American shad and ESA-listed salmonids.

Physical Objectives Addressed: AS.PO.1, AS.PO.2, AS.PO.3, and AS.PO.4

Explanation: Evidence indicates there is habitat use and diet overlap of juvenile shad and juvenile salmonids, suggesting potential competition effects. It is not clear whether perceived competition between shad and salmonids is limiting salmonid recovery efforts. Additionally, the timing and abundance of American shad creates crowding at fish ladders during salmonid return migration timing, which can create competition for space and cause delays in salmonid upstream migration.

Research

EI.S13. Our understanding of the relationships between species of ecological interest and the lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems needs to be improved.

Physical Objectives Addressed: NP.PO.1, Eu.PO.1, Eu.PO.5, Eu.PO.7, Eu.PO.10, Eu.PO.11, Eu.PO.12, RO.PO.1, CT.PO.1, Os.PO.1, YW.PO.1, ReV.PO.1, AS.PO.1, AS.PO.2, AS.PO.3 and AS.PO.4

Explanation: Each species in this category was chosen because they play an important role in the Columbia River mainstem, estuary, or plume ecosystem. Future research is needed to develop an understanding about how physical processes affect habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume as they relate to the species of ecological interest. Also needed are additional understanding about how species of ecological interest use the existing and changing habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume.

EI.S14. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: ALL

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection and restoration are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

5.3.1.7 Measures to achieve strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary. Finally, the measures have been developed for wide applicability to this diverse group of species; where applicable, we have noted where strategies are species-specific.

Habitat

EI.M1. Maintain preferred spawning, breeding, or nesting habitat of species of ecological interest in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Spawning substrate used by eulachon is characterized by coarse sand substrate. River otter prefer shallow, tidal influenced backwater, slough, and stream habitats. Caspian terns prefer flat, sandy, non-vegetated mid-channel island habitats. Opsrey prefer mature forest habitat with adequate nest/roost trees. Yellow warbler prefer riparian shrub habitat characterized by a dense deciduous shrub layer 1.5-4 m, with edge and with small patch size. Red-eyed vireo prefer forested riparian habitat characterized by tall, closed canopy deciduous forests, with a deciduous understory, forest stand sizes larger than 50 acres, and riparian corridor widths greater than 50 m. At present, there is limited information as to the available acreage of preferred habitats or as to whether acreage of these habitat types is increasing or decreasing. Because of our present lack of information regarding the lower Columbia populations, an inventory of spawning, breeding, or nesting locations, specific habitat characteristics, and habitat availability would be beneficial.

Variables	Context
Strategies addressed	EI.S1, EI.S2, EI.S3, EI.S4, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years

Variables	Context
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The existing programs and/or projects cannot be expected to attain the physical objective for maintenance of preferred habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Maintaining preferred spawning, breeding, or nesting habitat will help to maintain current levels of abundance and productivity.
Barriers to success	*Explanation:* Little is known about the trends in preferred habitat acreage or the location of habitats. Inventories are necessary and will require considerable effort.

EI.M2. Establish an allocation of water within the annual water budget for the Columbia River Basin that simulates peak seasonal discharge, increases the variability of flows, and restores tidal channel complexity in the estuary.

Explanation: Flow affects from upstream dam construction and operation, irrigation withdrawals, shoreline anchoring, channel dredging, and channelization have significantly modified estuary and mainstem habitats and have resulted in changes to circulation, sediment transport, and biological processes. Establishing flows in the Columbia River estuary and lower mainstem that emulate a more natural regime will help improve habitat conditions for fish and wildlife species.

Variables	Context
Strategies addressed	EI.S1, EI.S2, EI.S3, EI.S4, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for allocating water to restore the historical hydrograph. The primary reason is conflicts between other water uses, such as power generation, irrigation withdrawal, and flood control.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of the historical hydrograph would have a high benefit, based on the positive effects to natural habitat forming processes.
Barriers to success	*Explanation:* An annual allocation of water will be possible through the modification of current water uses, which at present seems questionable. Further, some degree of flow reductions have occurred as a result of climate change, which cannot be controlled.

EI.M3. Restore connectivity between river and floodplain.

Explanation: Restoring connection of the river and floodplain begins to restore the historical macrodetritus-based food web, which is expected to be more productive than the present day microdetritus-based food web. Additionally, floodplain connectivity will begin to restore the habitat-forming processes that create wetland and riparian habitat; natural creation of these habitats may directly benefit river otters, yellow warblers, and red-eyed vireos.

Variables	Context
Strategies addressed	EI.S1, EI.S2, EI.S3, EI.S4, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit because of the addition of wetland habitats and increased productivity of the food web.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

EI.M4. Restore impaired sediment transport processes affecting the Columbia River estuary and lower mainstem.

Explanation: Sediment dynamics are a critical component of estuary and lower mainstem habitat forming processes. These dynamics have been altered by changes in sediment transport because of upstream hydrosystem construction and operation, flow regulation, and channel dredging. Sediment transport dynamics have also been altered by land and water use practices in tributary watersheds, as well as flow reductions resulting from climate change.

Variables	Context
Strategies addressed	EI.S1, EI.S2, EI.S3, EI.S4, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective

Variables	Context
	for restoration of sediment transport processes. The primary reason is continued plans for dredging throughout the lower Columbia River and estuary, as well as challenges in restoring the historical hydrograph.
Potential to contribute to biological objectives	High. *Explanation*: Restoration of sediment transport processes would have a high benefit because of the positive effects on natural habitat formation.
Barriers to success	*Explanation:* Sediment transport processes can be restored through the restoration of historical flow regimes and minimized net sediment removal from the system. Success of this measure is unlikely because of conflicts with current water uses, as well as future planned dredging activities.

EI.M5. Limit the effects of toxic contaminants on fitness and survival in the Columbia River estuary, lower mainstem, and nearshore ocean.

Explanation: Industrial and urban development and agricultural practices in the lower Columbia River and estuary has resulted in pollutants accumulating in lower mainstem and estuary habitats, but the extent of detrimental effects of contaminants on most species of ecological interest is not clear. Survival of eulachon eggs may be affected by contaminants present in sediments near spawning areas. Contaminants, particularly DDE, have been detected at high concentrations in lower Columbia River osprey eggs, which has contributed to eggshell thinning which in turn lower reproductive success.

Variables	Context
Strategies addressed	EI.S5
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for limiting contaminant effects. The primary reason is lack of knowledge of contaminant location and concentration throughout the lower mainstem and estuary, as well as uncertainty in exposure risks.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and estuary are uncertain because the current exposure risks are not completely understood. Contaminants are known to be high in lower Columbia River osprey and appear to be limiting reproductive success.
Barriers to success	*Explanation:* Establishing the location and concentration of contaminants throughout the lower mainstem and estuary would require extensive coordinated sampling efforts. Success of this measure is unlikely given the current lack of focus on this issue.

Introduced Species

EI.M6. Implement regulatory, control, and education measures to prevent additional species invasions.

Explanation: Hundreds of aquatic nonindigenous species have been introduced to the lower Columbia River and estuary. Once established, it can be virtually impossible to control or eliminate invasive species. By far, the most cost effective approach is to prevent invasions before they occur. Further, intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	EI.S6, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing species invasions. Baseline survey work was just recently completed and there is currently a lack of focus on how species introductions occur.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Introduction of nonindigenous species can be minimized through stringent regulatory measures, but complete prevention is extremely difficult. Success of this measure is unlikely because of lack of enforcement of regulatory controls as well as considerable uncertainty regarding pathways of invasive species introductions.

EI.M7. Establish a moratorium on intentional introductions of aquatic species and importation of high risk species.

Explanation: Intention species introductions typically do not achieve intended benefits and often produce unforeseen effects.

Variables	Context
Strategies addressed	EI.S6, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to attain the physical objective of preventing intentional species introductions. State and Federal fish and wildlife agencies currently have the authority to prevent intentional species introductions.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing of nonindigenous species introductions are expected to be high because of negative interaction between native and nonnative species and the effects of nonnative species on the ecosystem; however, there is considerable uncertainty in these relationships.
Barriers to success	*Explanation:* Intentional introductions of nonindigenous species can be prevented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

EI.M8. Consider the potential opposite impacts of American shad on the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume ecosystems; evaluate possible shad management programs.

Explanation: Shad have capitalized on the creation of favorable reservoir habitats and improved passage conditions that have allowed widespread access into the upper Columbia and lower Snake rivers. Shad are underutilized as a fishery and attempts to harvest commercially-viable shad numbers have been unable to avoid significant salmon bycatch. The impacts of shad on the lower Columbia River mainstem and estuary ecosystem are unclear but the large shad population biomass has the potential for significant impacts. Juvenile shad may consume similar food items as juvenile salmonids or other fish, thus introducing some potential level of competition. Conversely, returning adult shad may be a substantial food source for numerous mainstem, estuary, and plume species. A pattern is slowly emerging that suggests the presence of shad is changing trophic relationships within the Columbia River. Reduction of shad abundance will likely improve success of salmonid recovery efforts.

Variables	Context
Strategies addressed	EI.S6, EI.S7, EI.S8, EI.S12, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to explain shad ecosystem effects, primarily because the relationships are complex and more focused effort is needed.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing shad management measures are expected to be high, although considerable uncertainty exists regarding the interaction between shad and the Columbia River ecosystem.
Barriers to success	*Explanation:* Shad management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency.

EI.M9. Evaluate gamefish predation or competition risks to eulachon; avoid management or enhancement of introduced gamefish populations that pose significant threats to eulachon.

Explanation: The effects of gamefish (such as walleye, smallmouth bass, or channel catfish) on eulachon are unknown and need to be evaluated. Juvenile and adult gamefish may prey on juvenile or adult eulachon. These, and other eulachon/gamefish relationships, need to be clarified.

Variables	Context
Strategies addressed	EI.S6, EI.S7, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating gamefish effects on eulachon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of implementing gamefish management measures are expected to be high, although considerable uncertainty exists regarding the interaction between gamefish and the Columbia River ecosystem.
Barriers to success	*Explanation:* Gamefish management measures can be implemented through coordinated efforts of State and Federal fish and wildlife agencies. Success of this measure is challenged by different goals of each agency. Gamefish/eulachon interactions are unknown and considerable research is needed to define any relationships.

Predators

EI.M10. Identify predators of eulachon eggs and juveniles; reduce predation mortality.

Explanation: Small white sturgeon (i.e. <725mm) are a substantial predator of eulachon eggs. Other predators of eulachon eggs and juveniles in the lower Columbia River are unknown and need to be identified. Juvenile eulachon have poor swimming ability and are expected to be highly susceptible to predation.

Variables	Context
Strategies addressed	EI.S7, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years

Variables	Context
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or projects focused on evaluating predator effects on eulachon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating predator effects on eulachon are high based on the limited knowledge of current relationships.
Barriers to success	*Explanation:* Predator effects on eulachon are unknown and considerable research is needed to define any relationships.

EI.M11. Continue to manage the Northern pikeminnow fishery to help offset increased salmonid predation that resulted from habitat alteration.

Explanation: Northern pikeminnow are currently managed with a sport reward fishery in an attempt to reduce predation on juvenile salmon. Pikeminnow are significant salmon predators in many Columbia River habitats but particularly near dams. Because pikeminnow are relatively long-lived and only large, old pikeminnow eat salmonids, annual exploitation rates of 10-20% can reduce predation mortality by 50%. The existing program has demonstrated the ability to meet and maintain desired fishing rates.

Variables	Context
Strategies addressed	EI.S7, EI.S8, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing pikeminnow predation on juvenile salmonids. Currently, there are no plans to discontinue the pikeminnow management program.
Potential to contribute to biological objectives	High. *Explanation*: Minimizing pikeminnow predation will have a high benefit, based on increased survival of juvenile salmonids.
Barriers to success	*Explanation:* The current pikeminnow management program has been successful at removing the large, predaceous pikeminnow from the population, thereby reducing predation on juvenile salmonids. Success of this program is expected to continue.

EI.M12. Continue to manage predation by Caspian terns to avoid increases in salmon predation while also protecting the viability of the tern population.

Explanation: Transplanting of the tern colony from Rice Island to East Sand Island has successfully reduced predation on salmon. Ongoing measures will be necessary to ensure that the existing habitat remains suitable for terns, new habitats become available to distribute the tern breeding colony, and no new habitats are created in areas where salmon predation might pose added risks.

Variables	Context
Strategies addressed	EI.S7, EI.S8, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the physical objective for managing Caspian tern predation on juvenile salmonids. Currently, there are no plans to discontinue the Caspian tern relocation program.
Potential to contribute to biological objectives	High. *Explanation*: Minimizing Caspian tern predation will have a high benefit, based on increased survival of juvenile salmonids.
Barriers to success	*Explanation:* The current Caspian tern relocation program has been successful at relocating the tern colony from Rice to East Sand Island, thereby reducing predation on juvenile salmonids. Additional breeding sites are needed to increase the breeding colony's resilience to disturbance. Success of this program is expected to continue.

EI.M13. Evaluate shad predation on juvenile salmonids; minimize salmonid predation mortality.

Explanation: Recent shad returns have reached record high abundance levels near 4 million fish. Shad can live to be 11 years old and are capable of spawning multiple times. Adult shad in the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume may be a substantial predator of juvenile salmonids; this relationship needs to be evaluated and quantified.

Variables	Context
Strategies addressed	EI.S7, EI.S8, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to explain shad predation effects, primarily because the relationships are complex and more focused effort is needed.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating shad predation effects are high; there is currently limited knowledge of shad effects.
Barriers to success	*Explanation:* Shad predation effects are largely unknown and considerable research is needed to define any relationships.

Other Mortality Factors

EI.M14. Mitigate channel dredging activities in the Columbia River estuary and lower mainstem that alter habitat forming processes and result in direct eulachon mortality.

Explanation: Channel dredge activities affect the quality of the various estuary and lower mainstem habitats through disturbance, sediment delivery, alteration of sediment transport mechanisms, and contaminant releases (buried in the substrate). Suction dredging activities in the presence of eulachon eggs results in direct mortality. Measures to mitigate impacts resulting from dredging activities should be identified and implemented.

Variables	Context
Strategies addressed	EI.S9, EI.S13, and EI.S14
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are not expected to attain the physical objective for mitigating dredging activity effects. The Channel Deepening Biological Assessment and resulting BiOp focus on ESA-listed species; dredging effects on eulachon have not been adequately addressed.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of mitigation of channel dredging effects is high based on the positive effect on natural habitat formation.
Barriers to success	*Explanation:* The USACE is required to mitigate dredging effects on ESA-listed species throughout the channel deepening process and beyond. However, there remains uncertainty as how these mitigation efforts will benefit eulachon.

EI.M15. Closely monitor Columbia River eulachon fisheries harvest levels to maintain population viability.

Explanation: Current fishery regulations and harvest effort have maintained harvest at sustainable levels. Harvest levels and fishery regulations should be closely monitored to ensure that population viability is maintained.

Variables	Context
Strategies addressed	EI.S10
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects are expected to attain the objective for managing eulachon fisheries. Current fishery management has been successful and there is currently no reason to believe this will not continue in the future.
Potential to contribute to biological objectives	High. *Explanation*: Fishery management actions have help maintained population viability in conjunction with sustainable levels of harvest; continued fishery management can help maintain current levels of population viability and abundance.
Barriers to success	*Explanation:* Fishery management regulations have resulted in sustainable eulachon harvest while maintaining population viability. Success of fishery management actions is expected to continue.

EI.M16. Modify passage structures at dams to improve adult eulachon passage efficiency.

Explanation: Eulachon access to historical spawning and rearing habitats has been limited because of their inability to navigate fish ladders designed for salmonid passage. Passage modifications need to proceed with caution; negative effects on salmonid passage need to be prevented.

Variables	Context
Strategies addressed	EI.S11
Short vs. long term implementation (<25 years or >25 years)	<25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no known programs and/or projects focused on improving dam passage for eulachon.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of improving eulachon passage are high, based on their inability to access historical spawning areas.
Barriers to success	*Explanation:* Because of differing swimming abilities of eulachon and salmonids, it may be difficult to improve eulachon passage without affecting salmonids.

Research

EI.M17. Improve understanding of interrelationships among fish, wildlife, and habitat conditions in the lower mainstem, Western Oregon tributaries, estuary, and plume.

Explanation: Our current understanding of biological relationships among species in the lower Columbia River and estuary is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	EI.S2, EI.S7, EI.S8, EI.S12, and EI.S13
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships, although the level of focused research on ecological interest species is unknown. In the near-term, this research will allow for more educated management decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships. At present, future research effort levels are uncertain.

EI.M18. Increase monitoring studies to determine the mainstem, estuary, and plume habitat use, survival, and migration patterns of species of ecological interest.

Explanation: Use of the Columbia River lower mainstem, Western Oregon tributaries, estuary, and plume by species of ecological interest is poorly understood. The use of monitoring studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	EI.S13
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of species of ecological interest habitat use in the lower mainstem, Western Oregon tributaries, estuary, and plume in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding habitat use will have a high benefit based on our current level of understanding, although the level of focused research on ecological interest species is unknown.
Barriers to cussess	Unknown. *Explanation:* Ongoing research is investigating habitat use by ecological interest species. In the near-term, this research will allow for more educated management decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships. At present, future research effort levels are uncertain.

Table 5-61. Existing programs and their connection to measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	1, 3
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps.	1, 2, 3, 4, 5, 14, 17
Lower Columbia River Estuary Partnership; Habitat Restoration Program	In Action 160 of the Reasonable and Prudent Alternative of the FCRPS BiOp, NMFS stated, "The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats…Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts..." This program is funding and implementing diverse restoration programs in the estuarine ecosystem as mandated in RPA Action 160. An effort to develop an ecosystem based approach to protecting existing habitat and restoring altered habitat has been initiated by the Estuary Partnership in association with the Columbia River Estuary Study Task Force (CREST). The outcome of this project will be a coordinated, ecosystem based habitat restoration program focused on increasing the survival of juvenile salmonids and monitoring habitat project success over time. The specific objectives of this project are to: (1) establish a habitat restoration program for the lower Columbia River and estuary (Bonneville Dam to mouth of river), and (2) develop monitoring and evaluation protocols for the lower river and estuarine habitats.	3, 17
Lower Columbia River Estuary Partnership; Habitat Monitoring Program	Action 161 of the FCRPS BiOp says, "Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion." This project would logically become part of the monitoring program called for in Action 161. Other closely related monitoring projects in the Columbia River Estuary (CRE) include "Estuarine Habitat and Juvenile Salmon – Current and Historical Linkages" by NOAA Fisheries, "Habitat Monitoring in the Lower Columbia River and Estuary" by the Lower Columbia River Estuary Partnership (BPA 2003-007-00), and "Research, Monitoring, and Evaluation Plan for the Columbia River Estuary and Plume" by the Action Agencies and others. The LCREP's habitat monitoring program involves "status monitoring" as outlined in the Action Agencies RME Plan. Status monitoring is the "measurement of environmental characteristics over an extended period of time to determine status or trends in some aspect of environmental quality." The LCREP's CRE Habitat Monitoring Program is consistent with the RME Plan and, in fact, the CRE may be treated as a pilot monitoring subbasin. The funding from BPA covers a three-year program with annual funding increments. The intent of the funding is to develop and establish a habitat monitoring program that can be initiated in year two, and sustained in year three and after. The three parts with their associated goals are as follows: 1. Population/Habitat Status Monitoring – monitoring for trends in the status of juvenile salmon and conditions in the habitats they use, 2. Ecosystem Status Monitoring – habitat classification using remote sensing, and 3. Invasive	3, 17

Program Name and Affiliation	Program Description	Measures Addressed
	Species Monitoring – monitoring abundance and distribution of non-indigenous plants and animals.	
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 2, 3, 4, 5, 14, 17
NOAA Fisheries; Evaluating Cumulative Ecosystem Response To Restoration Projects in the Columbia River Estuary	The goal of this study is to develop standardized techniques and protocols that will facilitate evaluation of the performance of salmon habitat restoration actions and support the decision-making process for said actions in the CRE aimed at increasing population levels of listed Columbia Basin salmonids. The management implications of this research are two-fold. It will provide techniques to 1. obtain data to compare project results in order to support decisions regarding what projects to pursue for restoration of the ecosystem, and 2. to evaluate the ecological performance of the collective habitat restoration effort in the CRE and its effects on listed salmonids. The objectives of this study are to: 1. Develop standard monitoring protocols and methods to prioritize monitoring activities that can be applied to CRE habitat restoration activities for listed salmonids; 2. Develop the empirical basis for a cumulative assessment methodology, together with a set of metrics and a model depicting the cumulative effects of CRE restoration projects on key major ecosystem functions supporting listed salmonids; 3. Design and implement field evaluations of the cumulative effects of restoration projects using standard methods, and sensors or remotely operated technologies, to measure the effects on listed salmonids through ecosystem response; and 4. Develop an adaptive management system including data management and dissemination to support decisions by the Corps of Engineers and others regarding CRE habitat restoration activities intended to increase population levels of listed salmon.	17
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	1, 3, 4
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	1, 3, 4
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	1, 3
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	1, 3, 4, 5
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	1, 4

Program Name and Affiliation	Program Description	Measures Addressed
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	1, 4
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	1, 3, 4
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	1, 2, 3, 4
Washington State Conservation Commission/ Conservation Districts	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	1, 2, 3, 4
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	1, 3, 4
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 3, 4, 14
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	1, 2, 3, 4, 5
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 2, 3, 4

Program Name and Affiliation	Program Description	Measures Addressed
WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	1, 6, 7, 8, 9, 10, 11, 13, 15, 17, 18
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	1, 3, 4
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 2, 3, 4, 5
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	In addition to protecting and restoring salmon habitat, the SRFB also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat.	1, 3, 4, 17
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 17, 18
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	5
PacFish – The U.S. Forest Service and	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through	3, 4

Program Name and Affiliation	Program Description	Measures Addressed
the Bureau of Land Management	regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	
Partners for Fish and Wildlife Program – USFWS	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	1, 3, 4
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	1, 3, 4, 17
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	4, 5, 14
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	4, 5, 14
Lower	The goal of LCRANS was to produce a baseline of aquatic nonindigenous	6, 7, 17

Program Name and Affiliation	Program Description	Measures Addressed
Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	
Pikeminnow Management Program	The goal of the program is to manage annual pikeminnow predation on juvenile salmonids. The program pays rewards to anglers for harvesting pikeminnow over a prescribed size, thus providing an incentive to remove the large, predaceous pikeminnow from the population.	11, 17
Caspian Tern Relocation Project	The goal of the project was to relocate terns to another location in the estuary where tern predation on juvenile salmonids would be reduced but the viability of the tern population would be maintained.	12
Caspian Tern Working Group	Task force dedicated to establishing the needs of the Columbia River Caspian tern breeding population while minimizing negative effects on ESA-listed species.	12, 17
Caspian Tern Environmental Impact Statement	The purpose of the EIS is to explore options to reduce the level of tern predation on Columbia River salmonids while insuring the protection and conservation of Caspian terns in the Pacific Coast/Western region (California, Oregon, Washington, Idaho, and Nevada).	12, 17

5.4 Species of Management Interest (Dusky Canada Goose, Sandhill Crane)

5.4.1.1 Overview

This category of species is important from a management perspective and are indicative of a habitat type that is not represented elsewhere in the planning process (e.g., agricultural lands). Species include the dusky Canada goose and the sandhill crane (ESA-listed). To the extent possible, species-specific information has been included regarding each species' background, status, threats, value statement, and biological objectives. However, because of the similarity in species' habitat usage within the estuary and mainstem subbasins, strategies and measures have been formulated to apply to the category of species on the whole.

Because of the life history requirements of management interest species, the potential for conflict exists among suggested strategies and measures within this species categories as well as between this category and the focal species group or the other species of interest categories. If conflicts arise, planning and policy decisions will dictate which strategies and measures are implemented, based on species prioritization. However, the strategies and measures suggested within this management plan have been formulated to minimize conflict among species-specific strategies and measures. For example, sandhill crane and the dusky Canada goose utilize floodplain habitats for overwintering. Thus, strategies and measures suggested for management interest species may also benefit focal species. For example, strategies and measures for sandhill crane and the dusky Canada goose promote the acquisition of riparian and wetland habitat within the lower Columbia River floodplain. These strategies and measures are consistent with those suggested for focal species and thus, may benefit many species.

5.4.1.2 Background

Dusky Canada Goose

The dusky Canada goose (*Branta canadensis occidentalis*) is a distinctive race of medium size and dark brown plumage that nests on Alaska's Copper River Delta, migrates through southeastern coastal Alaska and coastal British Columbia, and winters primarily in southwestern Washington and western Oregon. Historically, the wintering population was concentrated in the Willamette Valley; today, duskys continue to overwinter in the Willamette Valley, but also are found along the Columbia River from Portland to Astoria, the Vancouver lowlands, and the Ridgefield National Wildlife Refuge (NWR). The population has been intensively managed since the 1950s with habitat preservation in the form of federal refuge creation and harvest regulations that reduced the harvest of dusky Canada geese. Despite this, the size of the population has fluctuated considerably over the past three decades, with an overall decline since the late 1970s. Events on both the breeding and wintering grounds have affected the status of duskys. In 1964, an earthquake caused their nesting grounds to be uplifted an average of 7ft., initiating decades of ongoing dramatically accelerated plant and animal succession and physiographic change. This succession has resulted in significant habitat changes, with associated effects on activities and populations of goose predators, and subsequent detrimental effects on productivity and numbers of geese. The dusky Canada goose is highly prized by consumptive as well as non-consumptive users, and revenue is generated by hunting and watchable wildlife activities that contribute to local economies.

In the late 1990s, a group of landowners, agency personnel, and others formed the Canada Goose Agricultural Depredation Working Group and developed a management plan to deal with increasing goose numbers and impacts on habitats. The plan outlines strategies to reduce Canada goose numbers, protect the dusky subspecies, improve goose habitat on public lands, outline critical habitats for acquisition, and quantify the dollar value of the crop losses.

Sandhill Crane

Historically, sandhill cranes (*Grus canadensis*) occupied a larger North American range than they do today. Sandhill cranes are represented by three subspecies: greater, Canadian, and lesser. The greater sandhill crane is the only subspecies that nests in Washington. In winter, birds generally concentrate in agricultural regions with extensive areas of small grain crops. However, associated wetlands are still used for some feeding, as well as for nighttime roosting and midday loafing. Generally, the species can be categorized as an opportunistic omnivore, feeding on a variety of food items including roots, bulbs, grains, berries, snails, earthworms, insects, amphibians, lizards, snakes, mice, and greens.

In Washington, sandhill cranes were historically described as "not common summer resident both sides of the Cascades". Evidence of breeding sandhill cranes in Washington was absent from 1941 to 1972, when a paired appeared at Conboy Lake NWR. Sandhill crane breeding habitat in Washington is limited when compared to the large wetland complexes in southern Oregon, northern California, or elsewhere in its range; thus, the potential breeding production in Washington is relatively small compared to other breeding locations. The only known breeding sites in Washington are: Conboy Lake NWR and Panakanic Valley, Klickitat County; Polo Field/Signal Peak on Yakama Indian Nation lands, Yakima County; and Deer Creek on WDNR lands in Yakima County. The only wintering area for sandhill cranes in

Washington is the lower Columbia bottomlands near Vancouver, Ridgefield, and Woodland. All cranes observed wintering at Ridgefield NWR and Sauvie Island Wildlife Area, Oregon, in late November 2001 and February 2002 were Canadian sandhills, and based on observations of marked birds, wintering cranes regularly move back and forth between these areas.

5.4.1.3 Status

Dusky Canada Goose

Beginning in the early 1970s and increasing to the present, tens of thousands of several Canada geese races began wintering sympatrically with duskys. In 1973, about 25,000 Canada geese, the vast majority duskys, wintered in the Willamette Valley; today, over 250,000 Canada geese, less than 10% duskys, winter there. Harvest management that focuses on subspecies other than duskys became more complex and challenging in the face of this massive build-up of other races of geese, particularly given the duskys' declining productivity and relatively high vulnerability to hunting. State agencies that manage harvest and habitat are under increasing pressure to reduce overall goose numbers while stabilizing or increasing dusky numbers.

Estimates of the wintering population of dusky Canada goose in Oregon and Washington (i.e. Willamette Valley and SW Washington) ranged from about 5,000 in the early 1950s to about 25,000 in the late 1970s; the 2002-03 population estimate was 16,724, which is similar to the previous three year's estimates.

Sandhill Crane

Sandhill cranes have been a state listed endangered species in Washington since 1981. The Yakama Indian Nation has listed the sandhill crane as sensitive (BIA 1993); it is also considered a species of cultural importance. In Oregon, the greater sandhill crane is categorized as vulnerable on the sensitive species list and in California, the greater sandhill crane is listed as threatened.

The 2001 total population estimate of greater sandhill cranes in Washington (primarily from Conboy NWR) was 50, consisting of 40 breeding adults and 10 subadults. This estimate is up from the single digit population estimates in the early 1990s. Though not known to be a historical wintering area, an average of few hundred, but up to 1,000 cranes have wintered in the lower Columbia bottomlands near Vancouver, Ridgefield, and Woodland during the last seven or eight years. WDFW estimates that about 3,000-4,000 sandhill cranes currently use the lower Columbia bottomlands during migration or for overwintering.

5.4.1.4 Value statement

Dusky Canada Goose

The dusky Canada goose has ecological, management, and potentially negative economic (crop depredation) significance. The dusky Canada goose is classed as a migratory bird by federal regulation and thus protected by the Migratory Bird Treaty Act. It is considered a game bird by Washington rule. The Pacific Flyway and Washington Fish and Wildlife Commission regulate harvest. The goal for dusky Canada goose is to reverse the declining abundance trend and maintain a wintering population of duskys in the Lower Columbia River, while limiting crop depredation.

Sandhill Crane

Sandhill cranes have ecological, management, and potentially negative economic (crop depredation) significance. They are a Washington state listed species, based partially on concern for the wintering population within the subbasins. Because of their migratory life history, sandhill cranes are protected by the Migratory Bird Treaty Act. The goal for sandhill cranes is to support and maintain a wintering population of sandhill cranes in the Lower Columbia River, while limiting crop depredation.

5.4.1.5 Limiting factor

Dusky Canada geese and sandhill cranes in the lower Columbia River mainstem and estuary have threats to overwintering habitat in the combined subbasins, but the significance of these threats is unclear. Habitat losses are now a critical threat to the long-term viability of the dusky Canada goose and sandhill crane populations. Increasing urbanization and crop depredations by geese and cranes that encourage farmers to plant alternative, less desirable forage crops threaten goose and crane habitat in these wintering areas. Additionally, conversion of agricultural or developed lands to floodplain habitat has been suggested in other chapters of this Management Plan; effects on dusky Canada geese and sandhill crane are uncertain. Some agricultural lands attract geese and cranes, providing overwintering habitat; thus, loss of these habitats may be detrimental. On the other hand, conversion of developed lands to floodplain habitat may benefit geese and cranes if the floodplain habitat provides adequate forage and cover.

Table Dusky Canada goose and sandhill crane limiting factors.

Life Stage	Limiting Factors	Impact/Certainty
Winter Population	**MI.LF.1** Availability of overwintering habitat. Urbanization and conversion of agricultural crops to non-preferred forage crops is reducing the acreage of goose and crane overwintering habitat. Continued habitat loss will decrease the number of overwintering birds the subbasins can support. Wildlife refuges within the subbasins provide a vital baseline of winter habitat.	High/High

5.4.1.6 Biological objectives & working hypotheses

Biological objectives for the species of management interest, including both biological performance and the corresponding environmental conditions, are formulated to support the value statements identified above. It is understood that indices of historical and current population numbers are uncertain, given the assumptions in data collection and the variability that governs population dynamics. As a result, the numeric biological objective goals for the lower mainstem and estuary should be viewed as “order of magnitude” estimates and interim in nature until more certainty can be achieved in abundance estimates and more specific goals can be quantified.

Table 5-62. Species of management interest biological performance levels.

Metric	Performance Level
Dusky Canada Goose	
Winter Population Abundance	~ 25,000, which represents the upper bound of abundance estimates of duskys in Washington and Oregon since 1950
Sandhill Crane	
Winter Population Abundance	~ 3000-4000, which is the present WDFW estimate of cranes using the lower Columbia River and associated uplands for overwintering or as a migratory stopover

Table 5-63. Dusky Canada goose and sandhill crane desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
Winter Population	**MI.PO.1** Protect existing overwintering habitat to ensure no future net degradation. *Hypothesis Statement:* If current winter habitat is protected, then population abundance in the estuary and mainstem can be maintained. *Justification:* Protection and maintenance of existing foraging and roosting habitat will maintain the current level of winter survival. Protection of existing habitat is often more cost effective than restoration of former habitat.	Medium	High/High
	MI.PO.2 Encourage use of public lands over private lands. *Hypothesis Statement:* If geese and cranes primarily use public lands such as wildlife refuges, then overwinter survival in the estuary and mainstem can be maintained or increased. *Justification:* Regulations governing land use practices on public lands are often more restrictive than private lands. Thus, cranes and geese on public lands will be exposed to less disturbance, potentially resulting in better winter survival. Additionally, use of public over private lands will minimize crop depredation.	High	High/Medium
	MI.PO.3 Increase the availability of overwintering habitat on public lands. *Hypothesis Statement:* If winter habitat availability is increased, then population abundance in the estuary and mainstem can be maintained or increased. *Justification:* Acquisition of additional foraging and roosting habitat will maintain or increase the current population abundance. New winter habitats would ideally be local, state, or federal wildlife refuges.	High	High/High
	MI.PO.4 Limit crop depredation. *Hypothesis Statement:* If foraging of agricultural crops continues, then economic losses from crop depredation will be substantial. *Justification:* Crop depredation is a serious concern among local landowners and local, state, and federal biologists. Geese and cranes are attracted to agricultural lands because of the high quality forage. In the face of urban development throughout the region, these agricultural lands become even more important to overwintering geese and crane populations.	High	High/High

5.4.1.7 Strategies

Healthy populations depend on favorable habitats for reproduction and viability. High quality habitat increases population productivity which helps maintain adequate abundance. Populations can typically withstand some combination of mainstem and estuary habitat degradation and other impacts. Current habitat conditions in the lower mainstem and estuary

appear to have improved compared to historical conditions for species of management interest, based on the current acreage of agricultural lands which have attracted geese and crane populations to overwinter in the region. However, continued urban development may decrease the acreage of agricultural lands, thereby decreasing winter habitat availability.

Land use practices vary substantially between regulatory jurisdictions on the Lower Columbia River. Recent changes in land and water use practices in many areas are improving habitat conditions for species of ecological interest. Many land and water use practices have improved considerably from the past because of an improved understanding of the effects on wildlife populations and increased commitment to protect these resources. More environmental-friendly practices have been implemented for many activities.

Habitat forming processes are driven by the cumulative effect of conditions throughout a watershed which typically encompasses a broad area. Restoration of functional habitat-forming processes is a large-scale undertaking. Additionally, it took a long time to alter conditions to their current state and so can require a long time to implement widespread changes. Even where changes are implemented immediately, it may take a long period for benefits to accrue.

Widespread habitat improvements can be extremely costly and disruptive to established uses. It is often more cost effective to protect properly functioning habitat than to attempt restoration. Protection can often be accomplished with regulation which precludes future changes in use but does not require additional activities to reverse previous activities. Natural systems may often be resilient enough to heal themselves where protected from additional insults. Restoring natural, habitat forming processes can also be less costly, especially in the long term, since these types of projects require less maintenance, fewer repairs, provide better habitat quality, and are self-sustaining. It should also be noted that natural processes include disturbances such as floods and channel migration that are important for long-term habitat creation and maintenance.

Factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by species of management interest to any given suite of actions. Additionally, because of the similarity in winter habitat needs of the two species of management interest, the strategies have been developed for applicability to both species.

Habitat

MI.S1. Protect functioning habitats while also restoring impaired habitats.

Physical Objectives Addressed: MI.PO.1, MI.PO.2, and MI.PO.3

Explanation: Important habitats in the Columbia River estuary and lower mainstem that are currently functioning for species of management interest should be protected, where feasible. Important habitats that are isolated or impaired should be restored, when it can be demonstrated that the activities will provide benefits to species of management interest while habitat-forming processes are improving.

MI.S2. Strive to understand, protect, and restore habitat-forming processes in the Columbia River estuary and lower mainstem.

Physical Objectives Addressed: MI.PO.1, MI.PO.2, and MI.PO.3

Explanation: Habitat conditions important to fish and wildlife species are governed by opposing hydrologic forces, including ocean processes (tides) and river processes (discharge). Changes to habitat forming processes have resulted from natural events and human actions (e.g.,

storm events and changes to the hydrograph as a result of the Columbia River hydro system, etc.).

MI.S3. Avoid large-scale habitat changes where risks to species of management interest are uncertain.

Physical Objectives Addressed: MI.PO.1, MI.PO.2, and MI.PO.3

Explanation: This is similar to the physician's credo of first do no harm. Large-scale restoration of estuary habitats may prove difficult but at a minimum we can ensure that habitat conditions don't continue to get worse.

MI.S4. Mitigate small-scale local habitat impacts such that no net loss occurs.

Physical Objectives Addressed: MI.PO.1, MI.PO.2, and MI.PO.3

Explanation: The cumulative effect of local small-scale changes can be significant over time. These effects are more easily mitigated with on site rather than off site efforts.

Economics

MI.S5. Minimize physical crop losses and economic effects from lost agricultural production.

Physical Objectives Addressed: MI.PO.2 and MI.PO.4

Explanation: Crop depredation by geese and cranes can be substantial, creating economic losses to many local farmers and affecting the region's agricultural industry. Alternate overwintering habitat in the region should be sought to decrease the abundance of geese and cranes on private lands.

Research

MI.S6. Our understanding of the relationships between species of management interest and the estuary and lower mainstem ecosystem needs to be improved.

Physical Objectives Addressed: MI.PO.1, MI.PO.2, MI.PO.3, and MI.PO.4

Explanation: This species category was developed because of the significant management interest in the Columbia River mainstem and estuary ecosystem. Future research is needed to develop an understanding about how physical processes affect habitat conditions in the estuary and mainstem as they relate to the species of management interest. Also needed are additional understanding about how species of management interest use the existing and changing habitats in the estuary and lower mainstem.

MI.S7. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: MI.PO.1, MI.PO.2, MI.PO.3, and MI.PO.4

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection and restoration are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

5.4.1.8 Measures to achieve strategies

Habitat related measures can be framed in any number of perspectives, for instance based on habitat effects (forage availability and quality, roost sites, etc.), threat factors (urban,

agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Habitat actions vary substantially from location to location and more specific direction needed to develop implementation plans is necessary. Additionally, because of the similarity in winter habitat needs of the two species of management interest, the measures have been developed for applicability to both species.

Habitat

MI.M1. Maintain preferred overwintering habitat of species of management interest in the estuary and tidal freshwater portion of the lower Columbia River.

Explanation: Geese and cranes are attracted to open lands with high quality forage and adequate roost sites that provide early detection of predators. Agricultural lands provide these functions and are often preferred by geese and cranes. Habitat assessments indicate that acreage of agricultural lands have substantially increased in the subbasins from historical (1850) to current (1999) conditions. However, there is limited information as to whether this trend in agricultural land availability has continued to the present day. In recent years, the establishment of national wildlife refuges within the subbasins has secured a base level of winter habitat for geese and cranes, however, considerably more winter habitat is needed to increase winter population abundance, particularly in the face of potential losses of agricultural lands to urban development.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The existing programs and/or projects cannot be expected to attain the physical objective for maintenance of preferred habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Protection and maintenance of winter habitat is vital to continued overwintering of geese and cranes.
Barriers to success	*Explanation:* Floodplain habitat with quality forage and adequate roost sites is limited; availability of floodplain habitat to convert to geese and crane winter habitat is also limited.

MI.M2. Acquire preferred winter habitat of species of management interest in the estuary and tidal freshwater portion of the lower Columbia River, where the primary land use is to provide a wildlife sanctuary.

Explanation: Geese and cranes are attracted to open lands with high quality forage and adequate roost sites that provide early detection of predators. In recent years, the establishment of national wildlife refuges within the subbasins has secured a base level of winter habitat for geese and cranes, however, considerably more winter habitat is needed to increase winter population abundance, particularly in the face of potential losses of agricultural lands to urban development. Geese and crane winter habitats on public lands are preferred over private lands because the likelihood of disturbance is reduced.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The existing programs and/or projects cannot be expected to attain the physical objective for acquisition of preferred habitats. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Acquisition of quality winter habitat is vital to continued overwintering of geese and cranes.
Barriers to success	*Explanation:* Floodplain habitat with quality forage and adequate roost sites is limited; availability of floodplain habitat to convert to geese and crane winter habitat is also limited.

MI.M3. Restore connectivity between river and floodplain.

Explanation: Restoring connection of the river and floodplain will begin to restore the habitat-forming processes that create wetland and riparian habitat; natural creation of wetland marsh habitats may directly benefit dusky Canada geese and sandhill cranes.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective for connectivity between the river and floodplain. The primary reason is lack of adequate funds to acquire lands, as well as land availability.
Potential to contribute to biological objectives	High. *Explanation*: Floodplain connectivity would have a high benefit, based on the formation of wetland marsh habitat.
Barriers to success	*Explanation:* Floodplain connectivity can be reclaimed through land acquisition and dike breaching, however, success of this measure is unlikely because of a current lack of funds to acquire lands and conflicts with current floodplain land uses.

MI.M4. Minimize geese and crane use of private lands in the estuary and tidal freshwater portion of the lower Columbia River, with no net loss of winter population abundance.

Explanation: This measure is inherently linked with measures 1 through 3 and is likely only possible with some success of these previous measures. Geese and cranes are attracted to agricultural lands; this can cause conflicts in land use. Discouragement of geese and crane use of these private lands can eliminate land use conflicts, however, geese and cranes using these private lands need alternate habitats or population abundance may decline. In recent years, the establishment of national wildlife refuges within the subbasins has secured a base level of winter habitat for geese and cranes, however, considerably more winter habitat on public lands is needed to accommodate geese and cranes that formerly used private lands.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S5, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The existing programs and/or projects cannot be expected to attain the physical objective for transferring geese and cranes from private to public lands. The primary reason is that winter habitats on private lands outweighs that of public lands and there is limited land availability to acquire sufficient public land.
Potential to contribute to biological objectives	High. *Explanation*: Minimizing private land use will minimize crop depredation and geese/crane conflicts with private landowners.
Barriers to success	*Explanation:* Floodplain habitat with quality forage and adequate roost sites is limited; availability of floodplain habitat to convert to geese and crane winter habitat is also limited.

Economics

MI.M5. Investigate options to limit crop depredation.

Explanation: Geese and cranes are attracted to agricultural lands because of the high quality forage and presence of roost sites. Land use conflicts may result, often with substantial economic impacts to local landowners or the region's agricultural industry. Short of excluding geese and cranes from these agricultural lands, practices need to be developed that allow geese and crane use of agricultural lands while minimizing crop depredation and economic losses.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S5, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of limiting crop depredation.
Potential to contribute to biological objectives	High. *Explanation*: Minimizing private land use will minimize crop depredation and geese/crane conflicts with private landowners.

Variables	Context
Barriers to success	*Explanation:* At present, it is easier to discourage geese and crane use of private lands when land use conflicts arise than it is to find solutions that allow multiple land uses with minimal conflicts. Considerable effort is needed to manage for both agriculture and geese and crane winter habitat.

Research

MI.M6. Improve understanding of interrelationships among fish, wildlife, and habitat conditions in the estuary and lower mainstem.

Explanation: Our current understanding of biological relationships among species in the lower Columbia River and estuary is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S3, MI.S4, MI.S5, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem and estuary in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships, although the level of focused research on management interest species is uncertain. In the near-term, this research will allow for more educated management decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships.. At present, future levels of research are uncertain.

MI.M7. Increase monitoring studies to determine the mainstem and estuary habitat use, survival, and migration patterns of species of management interest.

Explanation: Knowledge of the use of the Columbia River estuary and lower mainstem habitats by species of management interest can be improved. The use of monitoring studies can significantly improve our understanding of habitat use and better direct future management actions. Continued abundance estimates will maintain the historic record of geese and crane abundance trends in the region.

Variables	Context
Strategies addressed	MI.S1, MI.S2, MI.S6, and MI.S7
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of species of management interest habitat use in the lower mainstem and estuary in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding habitat use will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Ongoing research is investigating habitat use by management interest species. In the near-term, this research will allow for more educated management decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships, although the level of focused research on management interest species is uncertain.

5.4.1.9 Programs to implement strategies and measures

Table 5-64. Existing programs and their connection to measures.

Program Name and Affiliation	Program Description	Measures Addressed
Pacific Flyway Council, Guidelines for dusky Canada goose management	The management plan for the Dusky Canada goose was developed by USFWS, ODFW, WDFW, OSU, and Pacific Flyway representatives. This group developed harvest, nest survey, management and research tasks with the goal of improving the declining dusky population. If these tasks are funded, then the population of dusky geese will reach a level where special protection is not needed. Funding has been limited recently and many projects are not being implemented as planned.	1, 2, 3, 4, 6, 7
Pacific Flyway Council, NW Oregon/SW Washington Canada goose agricultural depredation control plan	This plan is a list of strategies and tasks to reduce the agricultural depredation committed by geese on private property. The plan was developed by WDFW, ODFW, USFWS, APHIS-WS, OSU, and the Oregon and Washington Farm Bureaus. The funding for this plan is inconsistent and recent reductions have caused landowners to potentially suffer more crop damage. Assistance from agencies to landowners has also declined by lack of funding.	1, 2, 3, 4, 5, 6, 7
Wildlife Area Plan for Vancouver Shillapoo Lake Wildlife Areas	This plan outlines land management practices that will enhance goose habitat and provide a secure resting area for wintering geese. The plan was written by the Wildlife Area manager for WDFW with involvement of a Citizens Advisory Group and review by other biologists. Funding has limited implementation of all the appropriate land practices that could enhance goose habitat and improve population status.	1, 2, 3, 4, 6, 7
USFS , Nest Searches on Copper River Delta	Nest searches are conducted every other year on the Copper River Delta to monitor population trends in the breeding grounds. The effort is coordinated by the USFS at Cordova, Alaska, and assistance is provided by ODFW, WDFW, ADFG, DU and other interested volunteers. Data is used to evaluate harvest quotas and harvest management.	6, 7
ADFG, Banding Operations on dusky Canada geese	Dusky Canada Geese are leg banded and neck collared on a biannual basis. The project is designed to provide data for estimates of the wintering population in Oregon and Washington. The project is coordinated by ADFG and participants include WDFW, USFS, and ODFW. Funding is needed to purchase collars and charter a helicopter to conduct the capture.	6, 7
Agricultural Waterfowl Incentive Program	The program is designed to enhance waterfowl habitat by providing seeds, tubers, graze and invertebrates. In 1998, 49 landowners participated to create 38,949 ac (15,769 ha) of waterfowl habitat, a 75% increase from the proceeding year. Enrolled landowners were predominantly rice producers in the northern Central Valley, with only one elsewhere. Much of this flooding is in addition to the 60,021 ac (24,300 ha) already being flooded before the program was initiated.	6, 7
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	1, 2, 3
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps.	1, 2, 3
Lower Columbia River	In Action 160 of the Reasonable and Prudent Alternative of the FCRPS BiOp, NMFS stated, “The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and	1, 2, 3, 6, 7

Program Name and Affiliation	Program Description	Measures Addressed
Estuary Partnership; Habitat Restoration Program	enhancing 10,000 acres of tidal wetlands and other key habitats…Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts..." This program is funding and implementing diverse restoration programs in the estuarine ecosystem as mandated in RPA Action 160. An effort to develop an ecosystem based approach to protecting existing habitat and restoring altered habitat has been initiated by the Estuary Partnership in association with the Columbia River Estuary Study Task Force (CREST). The outcome of this project will be a coordinated, ecosystem based habitat restoration program focused on increasing the survival of juvenile salmonids and monitoring habitat project success over time. The specific objectives of this project are to: (1) establish a habitat restoration program for the lower Columbia River and estuary (Bonneville Dam to mouth of river), and (2) develop monitoring and evaluation protocols for the lower river and estuarine habitats.	
Lower Columbia River Estuary Partnership; Habitat Monitoring Program	Action 161 of the FCRPS BiOp says, "Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion." This project would logically become part of the monitoring program called for in Action 161. Other closely related monitoring projects in the Columbia River Estuary (CRE) include "Estuarine Habitat and Juvenile Salmon – Current and Historical Linkages" by NOAA Fisheries, "Habitat Monitoring in the Lower Columbia River and Estuary" by the Lower Columbia River Estuary Partnership (BPA 2003-007-00), and "Research, Monitoring, and Evaluation Plan for the Columbia River Estuary and Plume" by the Action Agencies and others. The LCREP's habitat monitoring program involves "status monitoring" as outlined in the Action Agencies RME Plan. Status monitoring is the "measurement of environmental characteristics over an extended period of time to determine status or trends in some aspect of environmental quality." The LCREP's CRE Habitat Monitoring Program is consistent with the RME Plan and, in fact, the CRE may be treated as a pilot monitoring subbasin. The funding from BPA covers a three-year program with annual funding increments. The intent of the funding is to develop and establish a habitat monitoring program that can be initiated in year two, and sustained in year three and after. The three parts with their associated goals are as follows: 1. Population/Habitat Status Monitoring – monitoring for trends in the status of juvenile salmon and conditions in the habitats they use, 2. Ecosystem Status Monitoring – habitat classification using remote sensing, and 3. Invasive Species Monitoring – monitoring abundance and distribution of non-indigenous plants and animals.	1, 2, 3, 6, 7
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	1, 2, 3, 6, 7
NOAA Fisheries;	The goal of this study is to develop standardized techniques and protocols that will facilitate evaluation of the performance of salmon habitat restoration	6

Program Name and Affiliation	Program Description	Measures Addressed
Evaluating Cumulative Ecosystem Response To Restoration Projects in the Columbia River Estuary	actions and support the decision-making process for said actions in the CRE aimed at increasing population levels of listed Columbia Basin salmonids. The management implications of this research are two-fold. It will provide techniques to 1. obtain data to compare project results in order to support decisions regarding what projects to pursue for restoration of the ecosystem, and 2. to evaluate the ecological performance of the collective habitat restoration effort in the CRE and its effects on listed salmonids. The objectives of this study are to: 1. Develop standard monitoring protocols and methods to prioritize monitoring activities that can be applied to CRE habitat restoration activities for listed salmonids; 2. Develop the empirical basis for a cumulative assessment methodology, together with a set of metrics and a model depicting the cumulative effects of CRE restoration projects on key major ecosystem functions supporting listed salmonids; 3. Design and implement field evaluations of the cumulative effects of restoration projects using standard methods, and sensors or remotely operated technologies, to measure the effects on listed salmonids through ecosystem response; and 4. Develop an adaptive management system including data management and dissemination to support decisions by the Corps of Engineers and others regarding CRE habitat restoration activities intended to increase population levels of listed salmon.	
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	1, 2, 3, 6, 7
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	1, 2, 3
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	1, 2, 3
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	1, 2, 3, 6, 7
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion control measures.	1, 2, 3
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	1, 2, 3
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	1, 2, 3
Water Resource Inventory Areas (WRIAs; HB	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	1, 2, 3, 5

Program Name and Affiliation	Program Description	Measures Addressed
2514)		
Washington State Conservation Commission/ Conservation Districts	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	1, 2, 3, 6, 7
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	1, 2, 3
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	1, 2, 3
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	1, 2, 3
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water quality and erosion control, and air quality.	1, 2, 3
WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	1, 2, 3, 4, 5, 6, 7
State Lands Management Program –	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian	1, 2, 3

Program Name and Affiliation	Program Description	Measures Addressed
DNR	Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	1, 2, 3, 4, 5, 6, 7
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	In addition to protecting and restoring salmon habitat, the SRFB also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat.	1, 2, 3
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	
PacFish – The U.S. Forest Service and the Bureau of Land Management	PacFish is an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	1, 2, 3
Partners for Fish and Wildlife Program – USFWS	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal	1, 2, 3

Program Name and Affiliation	Program Description	Measures Addressed
	trust species on private lands.	
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	1, 2, 3, 4
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	1, 2, 3, 4, 5, 6, 7
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	1, 2, 3
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any other work involving the discharge of fill or dredged material.	1, 2, 3
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	6

5.5 Species of Recreational Interest (Walleye, Smallmouth Bass, Channel Catfish)

5.5.1.1 Overview

This category of non-native species has some recreational importance in the estuary and mainstem subbasins, although their abundance and recreational interest in the Columbia River above Bonneville Dam is typically higher. Each of these introduced species has poorly understood ecological interactions with salmonids that are presumed to be negative. The species of recreational interest include walleye, smallmouth bass, and channel catfish. To the extent possible, species-specific information has been included regarding each species' background and status. Conversely, because of the similarity among the species and their perceived role in the lower mainstem and estuary ecosystem, the threats, value statement, biological objectives, strategies, and measures have been formulated to apply to this category of species on the whole.

Because of the life history requirements of recreational interest species, the potential for conflict exists among suggested strategies and measures within this species categories as well as between this category and the focal species group or the other species of interest categories. If conflicts arise, planning and policy decisions will dictate which strategies and measures are implemented, based on species prioritization. However, the strategies and measures suggested within this management plan have been formulated to minimize conflict among species-specific strategies and measures. For example, walleye, smallmouth bass, and channel catfish are perceived to have substantial predation impacts on ESA-listed salmonids. The significance of this predation is believed to be higher above Bonneville Dam where these recreational species have thrived in the impounded Columbia River habitats; however, predation impacts may also be substantial in the lower Columbia River. Thus, the strategies and measures for recreational interest species have been formulated to promote future research to define relationships between recreational interest species and the lower Columbia River mainstem ecosystem while preventing any increased abundance of these introduced recreational interest species in the lower Columbia River and estuary subbasins.

5.5.1.2 Background

Walleye

Walleye *(Stizostedium vitreum)* are native to the Great Lakes and the upper Mississippi River basin. They have been introduced along the East Coast and to most states west of their natural range. Walleye are found only in fresh water. Although the details of the first walleye introductions into Washington are uncertain, since 1960, walleye have become widely dispersed throughout the Columbia River basin, including all of the major reservoirs of the Columbia basin irrigation project. Over the past 40+ years, the walleye has become one of Washington's most popular and valued game fish species.

Hydropower development affected the walleye population in the Columbia River basin positively. The numbers of walleye in the free-flowing portion of the lower Columbia River are lower than those in the impoundment areas. By creating pools and reducing water flow, the dams have actually created habitat that is more suitable for walleye.

As walleye populations expanded into the lower Columbia River reservoirs where treaty tribes traditionally operated net fisheries for salmon and steelhead (i.e. Bonneville Pool), walleye were caught and sold by tribal fishermen. The harvest and sale of walleye taken in tribal fisheries

first became a concern for both state and tribal fish managers in the mid-1980s. The issue was addressed in 1988 as part of the ongoing negotiations under US v Oregon. At that time, the court approved a settlement among Oregon, Washington, and Columbia River treaty tribes known as the Columbia River Salmon Management Plan. As part of this agreement, the right of treaty tribes to sell walleye caught incidental to legally-authorized fisheries for salmon and steelhead was affirmed.

Smallmouth Bass

The original North American distribution of smallmouth bass *(Micropterus dolomeiui)* extended from Minnesota and southern Quebec, south to the Tennessee River drainage, and as far west as eastern Oklahoma. Because of their popularity with anglers, smallmouth bass have been extensively transplanted throughout the continental United States, and are now found in virtually every corner of the mainland US, with the single exception of the extreme southeast. They inhabit slow-moving streams and the shallow areas of warm, rocky, and vegetated lakes.

The first documented introduction of smallmouth bass in Washington occurred in 1924, when a shipment of smallmouth arrived from the "east" and was released by a private individual into a small lake on Blakely Island in the San Juans; other early plants were made into Lake Washington in 1925 and into the Yakima River in 1926. Since then, smallmouth have become widely distributed across Washington, and significant populations are now found in a fairly large number of Washington streams and lakes, including the Columbia. WDFW has expanded the range of smallmouth bass in Washington through a program of selective transplantation aimed at increasing fishing opportunity and success rates for this highly-prized sport fish.

There is concern that smallmouth bass may negatively impact other native species, specifically salmonids. Smallmouth bass and salmonids have overlapping habitats. In 1985, WDFW completed an evaluation of the interaction between smallmouth bass and native salmonid populations in the Northwest and found no clear evidence of reduced salmonid survival as a result of smallmouth bass interaction. However, much has changed in the Columbia River basin since 1985 and smallmouth bass may negatively impact salmonids or other native fish species; research is needed to establish these potential relationships.

Channel Catfish

The original North American distribution of channel catfish *(Ictalurus punctatus)* appeared to be from the St. Lawrence River and its tributaries in Quebec, south along the western Appalachian Mountains to southern Georgia and Florida (Lake Okeechobee), west through the Gulf states to eastern Texas and northern Mexico, and northwest throughout eastern New Mexico to Montana (Missouri River drainage), east to the Red River system in Manitoba, southwestern Ontario, southern Minnesota, Wisconsin, and Michigan through Ontario and Quebec at the level of Lake Nipissing. Channel catfish have been widely introduced outside this native range and now can be found almost everywhere in the United States. Channel catfish are restricted to fresh waters and some brackish waters.

Channel catfish reportedly were first introduced into Washington in 1892 at Clear Lake; Skagit County stocked catfish into an unnamed privately owned farm pond near Vancouver and into Deer Lake in Spokane County. Additional releases of channel catfish were made in various lakes and streams across the state in the ensuing years, as all forms of catfish (predominately bullheads) became abundant and popular in the region with sport and commercial anglers alike.

While bullhead catfish thrived in many of Washington's lakes and streams following these early introductions, channel catfish abundance and distribution was limited by their very specific spawning habitat requirements and the region's generally low water temperatures. Today, naturally reproducing populations of channel catfish are found only in the Snake, Columbia, and lower reaches of the Yakima (Prosser Dam to the mouth), Tucannon, and Walla Walla Rivers. In the last decade, WDW has introduced channel catfish into a number of Washington lakes, attempting to increase predation on overabundant forage fish populations and/or add diversity to mixed-species fisheries. Plans to expand this program are currently under consideration.

5.5.1.3 Status

Walleye

Walleye abundance for Bonneville Pool and below Bonneville Dam has not been estimated. However, extrapolations from research conducted on the John Day Pool give insight to the abundance of walleye in the Bonneville Pool. Walleye abundance in the Bonneville Pool is probably similar to that of the John Day Pool, which was estimated during 1983–86 at 15,000 fish. Abundance below Bonneville Dam is unknown, but is expected to be lower than locations above Bonneville.

The lower Columbia River walleye population is self-sustaining and the carrying capacity of the lower Columbia River walleye habitat is unknown. The condition of lower Columbia River walleye was evaluated by calculating relative weights; the mean relative weight was 99%. An analysis of 113 walleye populations in 27 states and Canadian provinces revealed that 1/20 of these populations had a mean relative weight greater than 99%, indicating the Columbia River population is quite healthy. Successful recruitment coincides with years of lower than average flows, while poor recruitment coincides with years of higher than average flows.

The current sport fishery harvest regulations for walleye in the lower Columbia River (Bonneville and below Bonneville Dam) is a 10 fish limit with no more than 5 fish over 18 inches and no more than one fish over 24 inches. Exploitation rates for the walleye sport fishery are low. The mean harvest per unit effort (fish per hour) for walleye below Bonneville Dam (from the dam to 35 miles downstream) from 1982 to 1993 was 0.322 and for Bonneville Pool, 0.085. Creel survey data collected by WDFW at Bonneville Pool from 1993–2001 also suggests the low exploitation rate is continuing.

Since walleye have become established in Washington, fishing tournaments have become popular. The first recorded walleye tournament was held in 1994 and the first walleye tournament held on the lower Columbia River below Bonneville Dam was in 1999.

Smallmouth Bass

Similar densities of smallmouth bass have been observed in the forebay, mid-reservoir, and tailraces in lower Columbia River impoundments. Densities of smallmouth bass were lower in the free-flowing portion of the Columbia River; they were found as far downstream as river kilometer 71. In recent creel surveys conducted by ODFW, anglers reported catching smallmouth bass on the downstream side of Puget Island. Because of saltwater intrusion, smallmouth bass are probably not found much farther downstream than Puget Island.

The carrying capacity of the lower Columbia River smallmouth bass habitat is unknown; the factors affecting smallmouth bass proliferation in the Columbia and Snake Rivers have not been studied. Since smallmouth bass are not stocked in the lower Columbia River and they continue to be caught and harvested recreationally, there must be some natural reproduction occurring.

There is no targeted commercial harvest of smallmouth bass. Current sport fishery harvest regulations for smallmouth bass in the lower Columbia River (Bonneville Pool and below Bonneville Dam) include a limit of five fish with no more than three fish over 15 inches in length. Exploitation rates for the smallmouth bass fishery are very low. Data from WDFW's Volunteer Angler Diary Program revealed that from 1993-2002, three smallmouth bass fishing trips were taken in the lower Columbia River; a combined total of three fish (data was only available for fish ∃10") were caught in a combined effort of 14 hours for a catch per unit effort (CPUE) of 0.21. The state average for CPUE for smallmouth bass for the 11-year period from 1990-2001 was 0.59.

In Washington, the level of competitive bass fishing tournaments is relatively subdued compared to competition at the national level. Most Washington bass clubs sponsoring tournaments believe fishing contests are for enjoyment and to promote the sport and conservation ethic. The results of bass fishing contests held in Washington since 1978 show a low of 38 contests in 1983 and a high of 178 in 2002. As the number of bass fishing contests began to increase, fish managers and some anglers began to be concerned about their potential impacts. In 1984, WDW undertook a study and concluded that bass fishing contests—at the current or projected level of future activity—did not have a significant impact on Washington's bass resources.

Since 1987, 41 fishing contests have been held in the lower Columbia River—all but one below Bonneville Dam—and 31 reported catching smallmouth bass. The yearly number of contests ranged from 0-9. Although these tournaments are catch and release fishing, some mortality occurs (99.8% of the fish released alive). Compared to other fishing contents around the state, the CPUE for the lower Columbia River is very low. For 1990-2001, the CPUE for the lower Columbia River was 0.10, while for the rest of the state it was 0.59.

Channel Catfish

Although channel catfish have inhabited Washington waters for more than a century, their abundance and distribution remain very limited. Early transplantation efforts succeeded in establishing self-sustaining populations in only a few areas, and recent attempts to expand their distribution and increase their abundance have only slightly increased their range or numbers. This species does, however, have the potential to provide additional fishing opportunity in Washington through the use of artificial production.

The low abundance and limited distribution of channel catfish in Washington is primarily attributable to relatively low water temperature and lack of suitable spawning habitat. There are only a few waters in Washington that have both suitable habitat and sustained water temperatures of 23.9°-26.7°C or higher.

In the early 1990s, sampling efforts did not capture any channel catfish below Bonneville Dam, but there have been reports of fish being present in the Multnomah Channel and as far downstream as Puget Island. During the same sampling efforts, channel catfish were captured in the Bonneville Pool; the number of fish captured was very low, and most were found in the tailrace below The Dalles Dam.

Because Washington waters do not provide the minimal spawning habitat requirements for successful channel catfish reproduction, population levels are generally low and statewide distribution is limited. Washington's streams are typically steep, cold, fast moving, and generally devoid of good cavity nesting habitat. Channel catfish are present but are not stocked in the lower Columbia River, so their presence indicates that some natural reproduction is occurring.

5.5.1.4 Value statement

Walleye, smallmouth bass, and channel catfish are introduced species with fishery management and economic importance; WDFW recognizes the beneficial value of commercial and recreational fisheries of each species. Each species of recreational interest are top-level predators within the aquatic community; each is perceived to have some predation impact on emigrating juvenile salmonids. The goal for the species of recreational interest is to adaptively manage each population to maintain or reduce current abundance levels and minimize adverse impacts on salmonids and other species of interest.

5.5.1.5 Limiting factor (Threats)

Walleye, smallmouth bass, and channel catfish are considered opportunistic generalists that inhabit slow to moderately flowing streams and lakes. Each of these species of recreational interest has benefited from hydrosystem development and they have successfully colonized reservoir habitats throughout the basin. Abundance in the free-flowing portion of the Columbia River below Bonneville Dam is generally recognized to be lower than elsewhere in the Columbia River basin. There are no known threats to any species of recreational interest in the lower Columbia River estuary and mainstem. However, walleye and smallmouth bass are considered predators of emigrating juvenile salmonids. Habitat restoration efforts for salmonids, as suggested in other chapters of this Management Plan, may have negative effects on these species of recreational interest in the lower mainstem and estuary subbasins.

5.5.1.6 Biological objectives & working hypotheses

Biological objectives for the species of recreational interest, consisting of desired environmental conditions, are formulated to support the value statement identified above. Biological performance levels for species of recreational interest have not been formulated because no reliable metric of species abundance or productivity has been estimated for the populations below Bonneville Dam.

Table 5-65. Species of recreational interest desired environmental conditions.

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
Population Abundance and Structure	**RI.PO.1** Manage populations to maintain or decrease current level of abundance. *Hypothesis Statement:* If populations are maintained at present low abundance levels, then negative impacts to salmonids and other focal species can be minimized. *Justification:* The impacts of introduced species are unpredictable. Intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects. The recreational species populations in the lower mainstem should be mutually compatible with objectives for focal species. Each population should be adaptively managed (primarily through harvest) as populations fluctuate.	Medium	High/Medium
	RI.PO.2 Document the interaction between introduced recreational species and native species; minimize negative interactions. *Hypothesis Statement:* If introduced species abundance increases, then native species survival in the estuary and mainstem may be negatively affected. *Justification:* Introduced species, both purposeful and unintentional, have altered the lower mainstem and estuary ecosystem. Effects on native species are generally unknown, may be significant, and need to be quantified.	High	High/Low
	RI.PO.3 Develop an understanding of species of recreational interest habitat use in the lower mainstem and estuary. *Hypothesis Statement:* If our understanding of recreational species integration with the ecosystem increases, then management actions will proceed with greater certainty. *Justification:* Our current understanding of the role of species of recreational interest in the lower mainstem and estuary ecosystem is limited; research is needed to increase our knowledge and reduce uncertainty.	High	High/Low

5.5.1.7 Strategies

The species of recreational interest have all been introduced to the Columbia River basin and thus were not part of the historical ecosystem, although records indicate that each species has been present in the basin for quite some time. Strategies for the species of recreational interest have been formulated differently than other species addressed in this Management Plan; the strategies are intended to limit expansion of the species of recreational interest and minimize negative effects on native species. Additionally, factors and activities affecting habitat and related watershed processes are generally understood but substantial uncertainties exist in our ability to quantify the expected response by species of recreational interest to any given suite of actions.

Effects on Native Species

RI.S1. Take aggressive measures to limit expansion of the species of recreational interest.

Physical Objectives Addressed: RI.PO.1, RI.PO.2, and RI.PO.3

Explanation: Native species have coevolved and typically enjoy some level of balance with each other. They are often coadapted and depend on each other. Introduced species can radically alter this balance with severe consequences for native communities. Species of recreational interest have been intentionally introduced to provide sport fisheries. Introduced species are particularly adept at capitalizing on altered habitats; these recreational species have benefited from development of the hydrosystem. The combined effects of habitat alteration and introduced or invasive species have been widely documented to have depleted or eliminated native species in other systems. The impacts of introduced species are unpredictable; introductions typically do not achieve intended benefits and often produce unforeseen effects. Once established, introduced or invasive species are extremely difficult to control or eliminate.

RI.S2. Evaluate the level of predation mortality by recreational species to determine the significance to viability of native fish populations.

Physical Objectives Addressed: RI.PO.2 and RI.PO.3

Explanation: In an unaltered natural system, predator and prey populations generally establish an equilibrium that does not pose a long-term threat to the viability of either. Where natural habitats have been substantially altered by human activities or non-native species have been intentionally introduced, this equilibrium can be disturbed to the detriment of one species or another. Increased predation and risks are typically a symptom of some more pervasive cause. Predator-prey interactions are also complex and difficult to understand or manage. However, in selected cases it is possible to temporarily limit risks through management of predators or predation. Predator management need not rely on predator control; a variety of predator management alternatives exist.

RI.S3. Investigate and minimize competition among species of recreational interest and native species.

Physical Objectives Addressed: RI.PO.1, RI.PO.2, and RI.PO.3

Explanation: There is little evidence available to determine if there is habitat use or diet overlap between species of recreational interest and native species. If such overlap exists, there are potential competition effects that could limit native species population viability and salmonid recovery efforts.

Research

RI.S4. Our understanding of the relationships between species of recreational interest and the estuary and lower mainstem ecosystem needs to be improved.

Physical Objectives Addressed: RI.PO.1, RI.PO.2, and RI.PO.3

Explanation: Current abundance levels of each species of recreational interest is relatively low below Bonneville Dam, however, there is considerable uncertainty as to the role they play in the Columbia River mainstem or estuary ecosystem. Future research is needed to develop an understanding about how physical processes affect habitat conditions in the estuary and mainstem as they relate to the species of recreational interest. Also needed are additional understanding about how species of recreational interest use the existing and changing habitats in the estuary and lower mainstem.

RI.S5. Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.

Physical Objectives Addressed: RI.PO.1, RI.PO.2, and RI.PO.3

Explanation: A wide variety of regulatory and non-regulatory processes and programs that can contribute to habitat protection and restoration are currently in place across the overlapping jurisdictions in the Washington lower Columbia region.

5.5.1.8 Measures to achieve strategies

Measures can be framed in any number of perspectives, for instance based on habitat effects (temperature, flow, channel diversity, riparian condition, etc.), threat factors (urban, agricultural, forestry, or hydropower activities), or programmatic remedies (regulations, incentives, restoration). Clean sorting into categories is complicated because alternatives exist at several scales and often produce interacting effects. We have used a combined approach to describing the suite of potential measures to facilitate the exercise of relating measures to threats and programs to address those threats.

The measures identified in this chapter represent a list of potential actions or categories of actions. Actions vary substantially from location to location and more specific direction is needed to develop implementation plans.

Effects on Native Species

RI.M1. Implement regulatory, control, and education measures to prevent expansion of species of recreational interest.

Explanation: The impacts of introduced species are unpredictable. Intentional species introductions typically do not achieve intended benefits and often produce unforeseen effects. Once established, introduced species are extremely difficult to control or eliminate.

Variables	Context
Strategies addressed	RI.S1
Short vs. long term implementation (<25 years or >25 years)	<25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to attain the physical objective of preventing recreational species expansion, although these species do not appear to be well adapted for the free-flowing environment below Bonneville Dam.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of preventing recreational species expansion are high because of suspected negative interaction with native species. However, under present habitat conditions, there is limited threat of expansion of these species.
Barriers to success	*Explanation:* With harvest as the only current method to prevent recreational species expansion, success of this measure is unlikely because of lack of current harvest effort. However, there is currently no threat of population expansion of these species of recreational interest.

RI.M2. Evaluate the potential impacts of species of recreational interest on the Columbia River lower mainstem and estuary ecosystem.

Explanation: Species of recreational interest have capitalized on the creation of favorable reservoir habitats but their abundance remains limited in the free-flowing section of the river below Bonneville Dam. The impacts of species of recreational interest on the lower Columbia River mainstem and estuary ecosystem are unclear and need to be evaluated.

Variables	Context
Strategies addressed	RI.S1, RI.S2, RI.S3, and RI.S4
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to explain species of recreational interest ecosystem effects, primarily because the relationships are complex and more focused effort is needed.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating species of recreational interest ecosystem effects are high because of our current limited knowledge.
Barriers to success	*Explanation:* Species of recreational interest ecosystem effects are largely unknown and considerable research is needed to define any relationships, although the level of future focused research on recreational interest species is unknown.

RI.M3. Evaluate predation or competition risks to native species; minimize predation- or competition-related mortality of native species.

Explanation: Competition or predation effects of species of recreational interest on native fish are unknown and need to be evaluated.

Variables	Context
Strategies addressed	RI.S1, RI.S2, RI.S3, and RI.S4
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects cannot be expected to explain species of recreational interest predation or competition effects, primarily because the relationships are complex and more focused effort is needed.
Potential to contribute to biological objectives	High. *Explanation*: Benefits of evaluating species of recreational interest interaction with native species are high because of limited knowledge of current interaction levels.
Barriers to success	*Explanation:* Species of recreational interest interaction with native species are unknown and considerable research is needed to define any relationships, although the level of future focused research on recreational interest species is unknown.

Research

RI.M4. Improve understanding of interrelationships among fish, wildlife, and habitat conditions in the estuary and lower mainstem.

Explanation: Our current understanding of biological relationships among species in the lower Columbia River and estuary is not robust. Recent research activities are beginning to increase our understanding, but our ability to identify and prioritize measures is difficult because of this uncertainty.

Variables	Context
Strategies addressed	RI.S2, RI.S3, RI.S4, and RI.S5
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of the relationships between fish, wildlife, and habitats in the lower mainstem and estuary in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding ecosystem interactions will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Ongoing research is intended to clarify these ecosystem relationships. In the near-term, this research will allow for more educated management decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships, although the level of focused research on recreational interest species is unknown.

RI.M5. Increase monitoring studies to determine the mainstem and estuary habitat use, survival, and migration patterns of species of recreational interest.

Explanation: Use of the Columbia River estuary and lower mainstem by species of recreational interest is poorly understood. The use of monitoring studies can significantly improve our limited understanding of habitat use.

Variables	Context
Strategies addressed	RI.S2, RI.S3, RI.S4, and RI.S5
Short vs. long term implementation (<25 years or >25 years)	Both <25 years and >25 years
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs and/or projects can be expected to slowly increase our understanding of species of recreational interest habitat use in the lower mainstem and estuary in the short term. However, these relationships are complex and dynamic, and considerable time and research effort is necessary to clearly define the relationships.
Potential to contribute to biological objectives	High. *Explanation*: Understanding habitat use will have a high benefit, given our current level of understanding.
Barriers to success	*Explanation:* Ongoing research is investigating habitat use in the lower mainstem and estuary. In the near-term, this research will allow for more educated management decisions. Continued, long-term focus will be necessary to establish clear ecosystem relationships, although the level of focused research on species of recreational interest is unknown.

5.5.1.9 Programs to implement strategies and measures

Table 5-66. Existing programs and their connection to measures.

Program Name and Affiliation	Program Description	Measures Addressed
Columbia Land Trust	The Columbia Land Trust program is actively working in the lower Columbia and estuary subbasins to acquire tidal and marsh habitats. Currently, they have acquired xx acres of land.	
US Army Corps of Engineers	Numerous restoration actions have been proposed through the FCRPS and Channel Deepening BiOps.	4, 5
Lower Columbia River Estuary Partnership; Habitat Restoration Program	In Action 160 of the Reasonable and Prudent Alternative of the FCRPS BiOp, NMFS stated, "The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats…Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts..." This program is funding and implementing diverse restoration programs in the estuarine ecosystem as mandated in RPA Action 160. An effort to develop an ecosystem based approach to protecting existing habitat and restoring altered habitat has been initiated by the Estuary Partnership in association with the Columbia River Estuary Study Task Force (CREST). The outcome of this project will be a coordinated, ecosystem based habitat restoration program focused on increasing the survival of juvenile salmonids and monitoring habitat project success over time. The specific objectives of this project are to: (1) establish a habitat restoration program for the lower Columbia River and estuary (Bonneville Dam to mouth of river), and (2) develop monitoring and evaluation protocols for the lower river and estuarine habitats.	
Lower Columbia River Estuary Partnership; Habitat Monitoring Program	Action 161 of the FCRPS BiOp says, "Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion." This project would logically become part of the monitoring program called for in Action 161. Other closely related monitoring projects in the Columbia River Estuary (CRE) include "Estuarine Habitat and Juvenile Salmon – Current and Historical Linkages" by NOAA Fisheries, "Habitat Monitoring in the Lower Columbia River and Estuary" by the Lower Columbia River Estuary Partnership (BPA 2003-007-00), and "Research, Monitoring, and Evaluation Plan for the Columbia River Estuary and Plume" by the Action Agencies and others. The LCREP's habitat monitoring program involves "status monitoring" as outlined in the Action Agencies RME Plan. Status monitoring is the "measurement of environmental characteristics over an extended period of time to determine status or trends in some aspect of environmental quality." The LCREP's CRE Habitat Monitoring Program is consistent with the RME Plan and, in fact, the CRE may be treated as a pilot monitoring subbasin. The funding from BPA covers a three-year program with annual funding increments. The intent of the funding is to develop and establish a habitat monitoring program that can be initiated in year two, and sustained in year three and after. The three parts with their associated goals are as follows: 1. Population/Habitat Status Monitoring – monitoring for trends in the status of juvenile salmon and conditions in the habitats they use, 2. Ecosystem Status	

Program Name and Affiliation	Program Description	Measures Addressed
	Monitoring – habitat classification using remote sensing, and 3. Invasive Species Monitoring – monitoring abundance and distribution of non-indigenous plants and animals.	
Columbia River Estuary Study Taskforce (CREST)	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments and implements restoration and protection of the Columbia River estuary from river mile 0 to 46. The program provides resource protection, restoration, and management for anadromous and resident fish. CREST assists local jurisdictions with permitting issues, zoning ordinances, comprehensive plan and shoreline master plan amendments, estuarine impact analysis, and wetland, dredging, and water quality issues.	4, 5
NOAA Fisheries; Evaluating Cumulative Ecosystem Response To Restoration Projects in the Columbia River Estuary	The goal of this study is to develop standardized techniques and protocols that will facilitate evaluation of the performance of salmon habitat restoration actions and support the decision-making process for said actions in the CRE aimed at increasing population levels of listed Columbia Basin salmonids. The management implications of this research are two-fold. It will provide techniques to 1. obtain data to compare project results in order to support decisions regarding what projects to pursue for restoration of the ecosystem, and 2. to evaluate the ecological performance of the collective habitat restoration effort in the CRE and its effects on listed salmonids. The objectives of this study are to: 1. Develop standard monitoring protocols and methods to prioritize monitoring activities that can be applied to CRE habitat restoration activities for listed salmonids; 2. Develop the empirical basis for a cumulative assessment methodology, together with a set of metrics and a model depicting the cumulative effects of CRE restoration projects on key major ecosystem functions supporting listed salmonids; 3. Design and implement field evaluations of the cumulative effects of restoration projects using standard methods, and sensors or remotely operated technologies, to measure the effects on listed salmonids through ecosystem response; and 4. Develop an adaptive management system including data management and dissemination to support decisions by the Corps of Engineers and others regarding CRE habitat restoration activities intended to increase population levels of listed salmon.	4
Growth Management Act (GMA)	Requires cities and counties to plan for growth and development through a comprehensive, coordinated, and proactive land use planning approach. The GMA is adopted and implemented at the local government level.	4
Critical Area Ordinances	As part of the GMA, cities and counties are required to adopt policies and regulations that protect critical areas, such as fish and wildlife habitat conservation areas, wetlands, frequently flooded areas, aquifer recharge areas, geologically hazardous areas.	4
Shoreline Management Act (SMA)	The SMA governs proposed land uses within 200 ft. of shoreline areas and their associated wetlands and/or 100-year floodplain, including shorelines along saltwater, streams >20cfs, and lakes >20 acres.	4
State Environmental Policy Act (SEPA)	SEPA aims to maintain and improve environmental quality through requiring government agencies to properly consider environmental matters during decision making, including the identification and evaluation of probable impacts to all elements of the built and natural environment.	4
Clark County Erosion Control Ordinance	County code requires: all development contractors to be trained in erosion and sediment control; all public utilities work within the right-of-way follow erosion control requirements; county road project contractors conform to local and state codes governing the construction of stormwater facilities and erosion	4

Program Name and Affiliation	Program Description	Measures Addressed
	control measures.	
Stormwater Control Ordinance	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their stormwater control ordinances.	4
Skamania National Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	4
Water Resource Inventory Areas (WRIAs; HB 2514)	The goals of HB 2514 are to manage water resources, protect existing water rights vital to state and local interests, protect instream flows for fish, and provide for the economic well-being of the state's citizenry and communities.	4
Washington State Conservation Commission/ Conservation Districts	The goal of the Commission is to protect, conserve, and enhance the natural resources of the state by providing leadership, partnerships, and resources to support locally-governed conservation districts. Conservation districts conduct surveys, investigations, and research relating to the conservation of renewable natural resources, outline preventative and control measures, identify improvements needed, and publish and disseminate the information.	4
Forest Practices Act (FPA)	The FPA defines a plan to protect public resources while assuring that Washington State continues to be a productive timber growing area. The Act regulates activities related to growing, harvesting or processing timber on all local government, state and private forestlands. The FPA provides for a riparian open space program that includes acquisition and conservation easement on lands within unconfined avulsing channel migration zones.	4
Aquatic Land Management	The Department of Natural Resources (DNR) manages state owned aquatic lands for various resource uses. These uses include preservation, mineral extraction, commercial and industrial development, dredged material disposal, and recreational development. The goal of the program is to restore and maintain riparian habitat on non-federal forestland, while meeting the requirements of the CWA, and supporting a harvestable supply of fish.	4
Washington State Department of Agriculture (WSDA) Water Quality Protection Program	The goal of this program is to work together with the agricultural community and regulators to protect water resources. The program addresses a variety of surface and ground water issues that involve fertilizers and pesticides. The WSDA is also evaluating current pesticide use practices in conjunction with pesticide residue data in surface waters that provide habitat for ESA- listed species.	4
Environmental Services - Washington State Department of Transportation (WSDOT)	The Environmental Services Department of WSDOT is responsible for implementation of the department's transportation services with consideration of environmental resources. The goal of the program is to ensure that fish have access to available functional habitat for spawning, rearing, and migration. The Biology Branch addresses issues involved with the Endangered Species Act, Fish Passage, Wetland Mitigation, and Wetland Monitoring. The Compliance Branch addresses regulatory compliance with the National Environmental Policy Act (NEPA) and administers the Advance Environmental Mitigation Revolving Account for watershed management. Compliance also addresses flood management and hydrogeology, stormwater management, and NPDES. The Resource Branch addresses cultural resources, hazardous materials, water	4

Program Name and Affiliation	Program Description	Measures Addressed
	quality and erosion control, and air quality.	
WDFW	WDFW manages land for fish, wildlife, and recreation needs. The Department is mandated to preserve, protect, and perpetuate fish and wildlife and their habitat. A goal of WDFW is to encourage and assist local governments in adopting policies and regulations to protect fish and wildlife habitat. The Priority Habitats and Species Program is the principal means by which WDFW provides important fish, wildlife, and habitat information to local governments, state and federal agencies, private landowners and consultants, and tribal biologists for land use planning purposes. The Department also provides a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington.	1, 2, 3, 4, 5
State Lands Management Program – DNR	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and maintenance of existing habitat. The DNR manages the Riparian Management Zone (RMZ) under the HCP for all Washington State lands. DNR oversees 2.2 million acres of forested trust lands, which include requirements for the RMZ on certain water types affected by timber harvest activities.	4
Conservation Reserve Enhancement Program (CREP)	The CREP is a joint state and federal conservation partnership program targeted to address specific state and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture use. The goals of the CREP are to protect and restore natural watershed processes, to promote channel and floodplain complexity, and to mitigate habitat loss and improve water quality in streams that have been impacted by agricultural practices. The CREP intends to restore riparian forest buffers on agricultural lands by paying agricultural producers to plant and maintain a riparian forest buffer along salmonid producing streams for a 10 to 15 year period.	4
Regional Recovery Plan – Salmon Recovery Funding Board (SRFB)	In addition to protecting and restoring salmon habitat, the SRFB also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat.	4
Habitat Conservation Program (ESA Sections 4, 7, 10) - NOAA Fisheries	NOAA Fisheries is responsible for habitat conservation through application of ESA Sections 4, 7, and 10). NOAA Fisheries regulates water quality, quantity, habitat, and wetlands for the management of anadromous fish. Conserving the habitat of ESA listed pacific salmon is the Habitat Conservation Division's largest program area.	1, 2, 3, 4, 5
Environmental Contaminants Program – US Fish and Wildife Service (USFWS)	The USFWS implements the Environmental Contaminants Program, which applies to all watersheds within the Columbia River Basin. The Environmental Contaminants program conducts studies that help to reveal the health of terrestrial and aquatic ecosystems. Wildlife and fish populations are assessed for the health of their habitats, populations and individual organisms. The purpose is to identify and prevent the harmful effects of contaminants on fish and wildlife, and to restore resources degraded by contamination. The Service provides technical assistance on a variety of issues including: pesticide use, mining, agriculture, industrial discharges, forestry practices, range management, urbanization, wastewater treatment system discharges, and non-point source discharges, crop production for waterfowl, and control of fish diseases at hatcheries.	4
PacFish – The	PacFish is an ecosystem-based, aquatic habitat and riparian-area management	4

Program Name and Affiliation	Program Description	Measures Addressed
U.S. Forest Service and the Bureau of Land Management	strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat. The goal of PacFish is to improve fish survival and habitat conditions through regulatory actions. PacFish is an interim program agreed to by all federal regulatory and land management agencies and applies to only those lands outside the 1994 President's Forest Plan. PacFish is an agreement to follow certain standards and guidelines for roads, timber harvest, grazing, mining and recreation that may impact anadromous fish habitat. PacFish regulates activities in ocean waters up to 200 miles from the pacific coastline.	
Partners for Fish and Wildlife Program – USFWS	The program is the USFWS's primary mechanism for delivering voluntary on-the-ground habitat improvement projects on private lands for the benefit of Federal trust species. The purpose of the program is to promote watershed based restoration of wetland, riparian, prairie, and other habitats essential to fish and wildlife resources. Restoration projects are intended to provide direct benefit to fish and wildlife resources. The program provides technical and financial assistance to landowners to help meet the habitat needs of Federal trust species on private lands.	4
Washington State Ecosystem Conservation Program – USFWS	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout, spotted owls, and marbled murrelets. The USFWS issues incidental take permits under section 10(a)(1)(B) of the Endangered Species Act (ESA).	4
Fish and Wildlife Program - Northwest Power and Conservation Council (NPCC)	The NPCC develops and maintains a regional power plan and a Fish and Wildlife Program to balance the Northwest's environment and energy needs. NPCC is responsible for developing a 20-year electric power plan that guarantees adequate and reliable energy at the lowest economic and environmental cost to the Northwest, developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin, and educating and involving the public in the Council's decision-making process. The NPPC works to protect, mitigate, and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the Fish and Wildlife program.	1, 2, 3, 4, 5
Rivers and Harbors Act – US Army Corps of Engineers (USACE)	The USACE presides over permitting, mitigation, and enforcement of waters of the U.S. primarily in matters pertaining to Section 404 of the Clean Water Act and Sections 10 and 13 of the Rivers and Harbors Act. The Corps evaluates permit applications and enforcement work including wetlands and other special aquatic sites. Section 10 of the Rivers and Harbors Act requires authorization for the construction of any structure in or over any navigable water of the United States. This law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of navigable water of the United States, and applies to all structures.	4
Clean Water Act (Section 404) – USACE	Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States, including wetlands, both adjacent and isolated. Discharges of fill material generally include, without limitation: placement of fill that is necessary for the construction of any structure or impoundment requiring rock, sand, dirt, or other material for its construction; site-development fills for recreational, industrial, commercial, residential, and other uses; causeways or road fills; dams and dikes; artificial islands; property protection or reclamation devices such as riprap, groins, seawalls, breakwaters, and revetments; beach nourishment; levees; fill for intake and outfall pipes and subaqueous utility lines; fill associated with the creation of ponds; and any	4

Program Name and Affiliation	Program Description	Measures Addressed
	other work involving the discharge of fill or dredged material.	
Lower Columbia River Aquatic Nonindigenous Species Survey (LCRANS)	The goal of LCRANS was to produce a baseline of aquatic nonindigenous species in the lower Columbia River that could be used to measure the usefulness of ballast water regulations and management efforts to reduce aquatic nonindigenous species introductions. The intent of the survey was to document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	1, 4