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.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3

1. INTRODUCTION AND OVERVIEW 1-1
2. ASSESSMENT 2-1
   2.1 Columbia River Estuary and Lower Mainstem 2-1
      2.1.1 Subbasin Description 2-5
         2.1.1.1 Purpose 2-5
         2.1.1.2 History 2-6
         2.1.1.3 Physical Setting 2-7
         2.1.1.4 Fish and Wildlife Resources 2-9
         2.1.1.5 Habitat Classification 2-22
         2.1.1.6 Estuary and Lower Mainstem Zones 2-33
         2.1.1.7 Major Land Uses 2-35
         2.1.1.8 Areas of Biological Significance 2-36
      2.1.2 Focal Species 2-37
         2.1.2.1 Selection Process 2-37
         2.1.2.2 Ocean-type Salmonids 2-39
         2.1.2.3 Stream-Type Salmonids 2-46
         2.1.2.4 Pacific Lamprey 2-55
         2.1.2.5 Sturgeon 2-56
         2.1.2.6 Northern Pikeminnow 2-58
         2.1.2.7 Eulachon 2-59
         River Otter 2-61
         2.1.2.8 Columbian White-tailed Deer 2-61
         2.1.2.9 Caspian Tern 2-62
         2.1.2.10 Bald Eagle 2-63
         2.1.2.11 Osprey 2-65
         2.1.2.12 Sandhill Crane 2-66
         2.1.2.13 Yellow Warbler 2-67
         2.1.2.14 Red-eyed Vireo 2-67
      2.1.3 Habitat 2-68
         2.1.3.1 Habitat-Forming Processes 2-68
         2.1.3.2 Habitat Change 2-84
         2.1.3.3 Historical vs. Current Habitat Condition 2-92
      2.1.4 Species/Habitat Interactions 2-108
         2.1.4.1 Focal Species Habitat Associations 2-108
         2.1.4.2 Salmonids 2-116
         2.1.4.3 Pacific Lamprey 2-133
         2.1.4.4 Sturgeon 2-133
         2.1.4.5 Northern Pikeminnow 2-135
         2.1.4.6 Eulachon 2-135
         2.1.4.7 River Otter 2-135
         2.1.4.8 Columbian White-tailed Deer 2-136
         2.1.4.9 Caspian Tern 2-136
         2.1.4.10 Bald Eagle 2-136
         2.1.4.11 Osprey 2-137
         2.1.4.12 Sandhill Crane 2-137
         2.1.4.13 Yellow Warbler and Red-eyed Vireo 2-137
      2.1.5 Ecological Relationships 2-137
         2.1.5.1 Native Species Interactions 2-138
         2.1.5.2 Non-Indigenous Species Interactions 2-141

2.1.6 Knowledge Gaps 2-147
2.1.6.1 Uncertainty 2-147
2.1.6.2 Physical Process Models 2-148
2.1.6.3 Current Research Needs 2-150
2.1.7 Hypothesis Statements 2-153
2.1.8 Literature Cited 2-171
2.2 Western Oregon Tributaries 2-203
2.2.1 Overview and General Purpose 2-203
2.2.2 General Description of the Western Oregon Tributaries Subarea 2-204
2.2.3 Summary of Existing Watershed Assessments 2-204
2.2.3.1 Lower Columbia-Clatskanie 2-205
2.2.3.2 Scappoose Bay 2-206
2.2.3.3 Youngs Bay, Nicolai-Wickiup River and Skipanon River Watershed 2-209
2.2.3.4 Assessment Methodology 2-213
2.2.4 Aquatic Focal Species 2-215
2.2.4.1 Selection 2-215
2.2.4.2 The Coast Range Ecological Zone 2-216
2.2.4.3 TRT Population and ESU Risk Characterization in the Coastal Strata 2-217
2.2.4.4 Status and Charactorization of Listed Species 2-220
2.2.4.5 Chum 2-223
2.2.4.6 Steelhead 2-230
2.2.4.7 Coho 2-236
2.2.4.8 Fall Chinook 2-243
2.2.5 Assessment 2-251
2.2.5.1 Qualitative Habitat Assessment 2-251
2.2.5.2 Reach Rankings 2-268
2.2.5.3 Limiting Factors and Working Hypothesis 2-276
2.2.5.4 Integration with Mainstem Lower Columbia River and Columbia River Estuary Assessment 2-280
2.2.6 References 2-282
3. INVENTORY 3-1
3.1 Overview 3-1
3.2 Agencies and Authorities 3-1
3.2 Plans, Programs, projects 3-86
4. MANAGEMENT PLAN 4-1
4.1 Introduction 4-1
4.1.1 Approach 4-1
4.2 Vision 4-8
4.2.1 Subbasin Vision 4-8
4.2.2 Supporting Statements 4-8
4.2.3 Species value statements 4-11
4.2.3.1 Chum 4-11
4.2.3.2 Fall Chinook 4-11
4.2.3.3 Coho 4-12
4.2.3.4 Winter Steelhead 4-12
4.2.3.5 Spring Chinook 4-12
4.2.3.6 Summer Steelhead 4-13
4.2.3.7 White Sturgeon 4-13
4.2.3.8 Green Sturgeon 4-13
4.2.3.9 Pacific Lamprey 4-13
4.2.3.10 Bald Eagle 4-13
4.2.3.11 Columbian White-tailed Deer 4-14

4.2.3.12 Species of Ecological Interest 4-14
4.2.3.13 Species of Management Interest 4-15
4.2.3.14 Species of Recreational Interest 4-15
4.3 Limiting factors summary 4-16
4.3.1 Focal Aquatic Species 4-17
4.3.1.1 Limiting Factors, Aquatic Focal, Salmonids 4-17
4.3.1.2 Limiting Factors, Aquatic Focal, non-Salmonids 4-24
4.3.1.3 Limiting Factors, Non-focal Species. 4-28
4.3.2 Terrestrial Species-Focal (Bald Eagle and Columbian White-tailed Deer and others) 4-31
4.3.3 Biological and Physical Objectives Summary 4-33
4.4 Management Strategies and Priorities Summary 4-44
4.4.1 Strategies Overview 4-44
4.4.2 Prioritized Focal Strategies 4-46
4.4.3 Western Oregon tributaries specific strategies 4-100
4.5 Measures summary 4-105
4.5.1 Description of Measures 4-105
4.5.2 Existing Programs as they relate to measures 4-139
4.6 Endangered Species Act and Clean Water Act Considerations 4-148
4.6.1 Endangered Species Act 4-148
4.6.2 Clean Water Act 4-150
4.6.2.1 Western Oregon tributaries 4-150
4.6.2.2 Mainstem Lower Columbia River and Columbia River Estuary 4-154
4.7 Artificial Production 4-159
Research, Monitoring, and Evaluation 4-164
4.7.1 Estuary workshop 4-165
4.7.2 Draft Research, Monitoring, and Evaluation Plan, Federal Columbia River Power System (FCRPS) 4-166
4.8 References 4-1
5. MANAGEMENT PLAN SUPPLEMENTARY MATERIAL 5-1
5.1 Overview 5-1
5.1.1 A Brief Review of Organization 5-5
5.1.1.1 Limiting factors 5-5
5.1.1.2 Biological and Physical Objectives 5-5
5.2 Focals 5-7
5.2.1 Aquatic Focal 5-7
5.2.2 Terrestrial Focal 5-286
5.2.2.1 CWT Deer 5-286
5.2.2.2 Bald eagle 5-294
5.3 Species of Ecological Interest (N. Pikeminnow, Shad, Eulachon, Caspian Tern, Osprey, Yellow Warbler, Red-eyed Vireo) 5-299
5.3.1.1 Overview 5-299
5.3.1.2 Status 5-303
5.3.1.3 Value statement 5-305
5.3.1.4 Limiting factor (Threats) 5-306
5.3.1.5 Biological objectives & working hypotheses 5-309
5.3.1.6 Strategies 5-317
5.3.1.7 Measures to achieve strategies 5-321
5.4 Species of Management Interest (Dusky Canada Goose, Sandhill Crane) 5-344
5.4.1.1 Overview 5-344
5.4.1.2 Background 5-345

5.4.1.3 Status 5-346
5.4.1.4 Value statement 5-346
5.4.1.5 Limiting factor 5-348
5.4.1.6 Biological objectives & working hypotheses 5-348
5.4.1.7 Strategies 5-349
5.4.1.8 Measures to achieve strategies 5-351
5.4.1.9 Programs to implement strategies and measures 5-358
5.5 Species of Recreational Interest (Walleye, Smallmouth Bass, Channel Catfish) 5-364
5.5.1.1 Overview 5-364
5.5.1.2 Background 5-364
5.5.1.3 Status 5-366
5.5.1.4 Value statement 5-368
5.5.1.5 Limiting factor (Threats) 5-368
5.5.1.6 Biological objectives & working hypotheses 5-368
5.5.1.7 Strategies 5-370
5.5.1.8 Measures to achieve strategies 5-371
5.5.1.9 Programs to implement strategies and measures 377

APPENDIX A: SPECIES TECHNICAL FOUNDATION

APPENDIX B: TRT/WLC POPULATION IDENTIFICATION MATERIAL

APPENDIX C: LOWER COLUMBIA FISH RECOVERY BOARD PROGRAMS INVENTORY (See LCFRB Salmon & Steelhead Subbasin Plan, Technical Foundation, Volume IV: Programs and Project Directory)

TABLES & FIGURES

Tables

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

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

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

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) 6

Assessment

Table 2-1. List of fish and wildlife species known to occur in the Columbia Estuary and Columbia Lower Subbasins. 2-10

Table 2-2: Wildlife habitat types in Washington and Oregon determined by Johnson and O'Neil (2001). 2-25

Table 2-3. Potential relationship of specific habitat types among the different habitat classification systems. 2-32

Table 2-4. Species Selection and Planning Context. 2-38

Table 2-5. Estimated change in estuary habitats by region within the Columbia River estuary from rm 0 to rm 46 (Thomas 1983). 2-94

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). 2-95

Table 2-7. Historical (circa 1850) and current (1999) wildlife habitat types and acreage in the Columbia Estuary Subbasin (IBIS 2003). 2-102

Table 2-8. Historical (circa 1850) and current (1999) wildlife habitat types and acreage in the lower Columbia Lower Subbasin (IBIS 2003). 2-104

Table 2-9. Estimated change in Columbia River estuary habitat cover types from 1992 to 2000 (Garono et al. 2003a). 2-106

Table 2-10. Estimated change in non-estuarine habitats by region within the Columbia River estuary from rm 0 to rm 46 (Thomas 1983). 2-107

Table 2-11. Likelihood of focal species utilization within various lower Columbia River mainstem and estuary habitat types. 2-110

Table 2-12. Wildlife focal species habitat associations in the Columbia Estuary and Columbia Lower Subbasins (IBIS 2003). 2-113

Table 2-13. Focal species relationship to salmonids (IBIS 2003). 2-116

Table 2-14. Conceptual model pathways and components for juvenile salmonid production in the Columbia River estuary (USACE 2001). 2-118

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). 2-125

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). 2-132

Table 2-17. Projected abundance of northern pikeminnow, salmonid consumption rates, and estimated losses of juvenile salmonids to predation (NMFS 2000b). 2-139

Table 2-19: Population persistence categories for use in recovery planning 2-217

Table 2-20: TRT and ODFW evaluation of population persistence for Oregon salmonid populations wihtin the coastal stratum of the WLC Domain (TRT, 2004) 2-218

Table 2-21: Status of Salmonid Species and Their Critical Habitat 2-222

Table 2-22 Estimated number of populations in different strata in the Willamette/Lower Columbia domain (TRT, 2003, Meyers et. al. 2002) 2-223

Table 2-23: Coho spawning in Western Oregon tibutaries (ODFW, 2004) 2-238

Table 2-24: WOTS QHA workshop participants, January 14-16, 2004 2-252

Table 2-25: Reach labels and descriptions evaluated in QHA workshop 2-253

Table 2-26: Chum Species Hypothesis 2-255

Table 2-27: Steelhead Species Hypothesis 2-256

Table 2-28: Chinook Species Hypothesis 2-257

Table 2-29: Coho Species Hypothesis: 2-258

Table 2-30: Current conditions evaluation of key habitat attributes by reach in the WOTs subbarea 2-261

Table 2-31: Reference conditions evaluation of key habitat attributes by reach in the WOTs subbarea 2-262

Table 2-35: Fall Chinook Restoration and Protection Priorities 2-267

Table 2-36: Restoration and protection priorities, limiting factors by watershed 2-269

Table 2-37: Sensitivity analysis of QHA restoration and 2-278

Table 2-38. Estuary and lower mainstem subbasins working hypotheses..... 2-281

Inventory

Table 3-1: Reference table for agencies and authorities 3-2

Table 3-2: Condensed list of plans, programs, project, or other RME activies (E=Estuary; M=Mainstem; B=Both) 3-87

Management Plan

Table 4-1. Species Selection and Planning Context. 4-3

Table 4-2: Mainstem And Estuary Working Hypotheses 4-5

Table 4-3: Western Oregon tributaries working hypotheses 4-5

Table 4-4: Limiting Factors for Focal Salmonids (WOTs-specific factors identified by a "-w" notation)..... 4-17

Table 4-5: Biological objectives summary 4-34

Table 4-6: Existing programs and their connection to recovery measures..... 4-139

Table 4-7 Estimated number of populations in different strata in the Willamette/Lower Columbia domain (TRT, 2003, Meyers et. al. 2002) 4-150

Table 4-8: EPA approved 2002 Oregon §303d list for Western Oregon tributaries 4-152

Table 4-9: 2002 updates to 1998 Oregon §303d list for Mainstem Lower Columbia River and Columbia River Estuary 4-155

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 4-161

Table 4-11: Summary of draft objectives from federal RME effort (Johnson, G.E. et al 2004). 4-167

Management Plan Supplement

Table 5-1. Species Selection and Planning Context. 5-3

Table 5-2. Chum salmon abundance estimates by life stage. 5-8

Table 5-3. Chum salmon limiting factors by life stage..... 5-9

Table 5-4. Chum salmon biological performance levels. 5-11

Table 5-5. Chum salmon desired environmental conditions (within and out-of-basin populations). 5-12

Table 5-6. Existing programs and their connection to recovery measures. 5-38

Table 5-7. Fall chinook salmon abundance estimates by life stage. 5-44

Table 5-8. Fall chinook salmon limiting factors by life stage. 5-45

Table 5-9. Fall chinook biological performance levels. 5-47

Table 5-10. Fall chinook desired environmental conditions (within and out-of-basin populations). 5-48

Table 5-11. Existing programs and their connection to recovery measures. 5-79

Table 5-12. Coho salmon abundance estimates by life stage. 5-83

Table 5-13. Coho salmon limiting factors by life stage. 5-86

Table 5-14. Coho desired environmental conditions. 5-88

Table 5-15. Existing programs and their connection to recovery measures. 5-117

Table 5-16. Winter steelhead abundance estimates by life stage. 5-121

Table 5-17. Winter steelhead limiting factors by life stage. 5-123

Table 5-18. Winter steelhead biological performance levels. 5-125

Table 5-19. Winter steelhead desired environmental conditions. 5-126

Table 5-20. Existing programs and their connection to recovery measures. 5-154

Table 5-21. Spring chinook salmon abundance estimates by life stage. 5-158

able 5-22. Spring chinook salmon limiting factors by life stage. 5-160

Table 5-23. Spring chinook biological performance levels. 5-161

Table 5-24. Spring chinook desired environmental conditions. 5-161

Table 5-25. Existing programs and their connection to recovery measures. 5-190

Table 5-26. Summer steelhead abundance estimates by life stage. 5-195

Table 5-27. Summer steelhead limiting factors by life stage. 5-196

Table 5-28. Summer steelhead biological performance levels. 5-198

Table 5-29. Summer steelhead desired environmental conditions. 5-198

Table 5-30. Existing programs and their connection to recovery measures. 5-228

Table 5-31. White sturgeon abundance estimates by life stage. 5-233

Table 5-32. Green sturgeon abundance estimates. 5-234

Table 5-33. White sturgeon limiting factors by life stage. 5-235

Table 5-34. Green sturgeon limiting factors. 5-236

Table 5-35. White sturgeon biological performance levels. 5-237

Table 5-36. White sturgeona desired environmental conditions. 5-238

Table 5-37. Existing programs and their connection to measures. 5-259

Table 5-38. Pacific lamprey abundance estimates by life stage. 5-263

Table 5-39. Pacific lamprey limiting factors by life stage. 5-264

Table 5-40. Pacific lamprey biological performance levels. 5-265

Table 5-41. Pacific lamprey desired environmental conditions. 5-265

Table 5-42. Existing programs and their connection to recovery measures. 5-281

Table 5-43: Columbia White-tailed Deer limiting factors 5-288

Table 5-44: Columbia White-tailed Deer biological performance levels 5-289

Table 5-45: Columbia White-tailed Deer desired environmental conditions 5-289

Table 5-46:Bald Eagle in the Lower Columbia 5-294

Table 5-47: Bald Eagle limiting factors 5-295

Table 5-48: Bald eagle desired environmental conditions 5-296

Table 5-49: Programs relevant to bald eagle measures 5-298

Table 5-50. Suspected eulachon limiting factors by life stage. 5-306

Table 5-51. Suspected limiting factors to osprey reproductive success. 5-309

Table 5-52. Species of ecological interest[a] biological performance levels. 5-310

Table 5-53. Northern pikeminnow desired environmental conditions. 5-310

Table 5-54. Eulachon desired environmental conditions 5-311

Table 5-55. River otter desired environmental conditions. 5-314

Table 5-56. Caspian tern desired environmental conditions[a]. 5-314

Table 5-57. Osprey desired environmental conditions. 5-314

Table 5-58. Yellow warbler desired environmental conditions..... 5-315

Table 5-59. Red-eyed vireo desired environmental conditions. 5-315

Table 5-60. American shad desired environmental conditions..... 5-315

Table 5-61. Existing programs and their connection to measures. 5-339

Table 5-62. Species of management interest biological performance levels..... 5-348

Table 5-63. Dusky Canada goose and sandhill crane desired environmental conditions..... 5-349

Table 5-64. Existing programs and their connection to measures. 5-358

Table 5-65. Species of recreational interest desired environmental conditions. 5-369

Table 5-66. Existing programs and their connection to measures. 377

Figures

Assessment

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

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

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

Figure 2-4. Cross-sectional depiction of general estuary habitat types (USACE 2001). 2-23

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. 2-35

Figure 2-6. Adult fall Chinook distribution in the Columbia Estuary and Columbia Lower Subbasins. 2-42

Figure 2-7. Adult chum salmon distribution in the Columbia Estuary and Columbia Lower Subbasins. 2-45

Figure 2-8. Adult spring chinook distribution in the Columbia Estuary and Lower Columbia Subbasins. 2-48

Figure 2-9. Adult winter steelhead distribution in the Columbia Estuary and Lower Columbia Subbasins. 2-50

Figure 2-10. Adult summer steelhead distribution in the Columbia Estuary and Lower Columbia Subbasins. 2-52

Figure 2-11. Adult coho salmon distribution in the Columbia Estuary and Lower Columbia Subbasins. 2-54

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. 2-69

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. 2-71

Figure 2-14. Current regulated mean monthly flow compared to historical unregulated mean monthly flow at Bonneville Dam (USACE 2001). 2-71

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). 2-72

Figure 2-16. Frequency of mainstem Columbia River flow above historical bankfull (18,000 cms) and current bankfull (24,000 cms) flow levels. 2-73

Figure 2-17. Volume of material dredged over time from the Columbia River between rm 3 and 40 (USACE 2002). 2-75

Figure 2-18. Volume of material dredged over time from the Columbia River between rm 40 and 106 (USACE 2002). 2-76

Figure 2-19. Volume of material dredged from the mouth of the Columbia River over time (USACE 2002). 2-78

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). 2-78

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). 2-80

Figure 2-22. Diagram of an ETM “event” as tidal forces push salinity upriver beneath the outflowing river water (NSF 2003). 2-81

Figure 2-23. Diagram of biological activity within the ETM, illustrating the productivity of this area (NSF 2003). 2-82

Figure 2-24. Variations in the estuary turbidity maximum (ETM) under different river flow and tide cycle conditions (USACE 2001). 2-83

Figure 2-25. Historical (circa 1850) and current (1999) wildlife habitat types in the Columbia Estuary Subbasin (IBIS 2003). 2-103

Figure 2-26. Historical (circa 1850) and current (1999) wildlife habitat types in the Columbia Lower Subbasin (IBIS 2003). 2-105

Figure 2-27. Conceptual model of the major components affecting juvenile salmonid production in the Columbia River estuary (USACE 2001). 2-117

Figure 2-28. Conceptual model for juvenile salmon growth and survival in the Columbia River estuary (from Bottom et al. 2001). 2-122

Figure 2-29. Conceptual model of the Columbia River estuary food web (adapted from USACE 2001). 2-122

Figure 2-30. Conceptual model of juvenile salmonid growth in the Columbia River estuary (adapted from USACE 2001). 2-123

Figure 2-31. Conceptual model of juvenile salmonid production from the Columbia River estuary (adapted from USACE 2001)..... 2-124

Figure 2-33 Steelhead Distribtution in the Western Oregon tributaries (Streamnet, 2004). .. 2-233

Management Plan

Figure 4-1: Large-scale map of the lower Columbia River mainstem and estuary, depicting major tributaries and population centers (R2 2003). 4-1

Figure 4-2: Process model workflow for development of the Mainstem Lower Columbia River and Columbia River Estuary subbasin plan 4-2

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