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
	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

Life Stage	Limiting Factors	Impact/Certainty
	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
	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
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* The current programs are expected to

Variables	Context
	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
Programs and projects currently addressing measure	See Table 5-6

Variables	Context
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 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

Variables	Context
	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 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 River Estuary Study Taskforce	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	1, 4, 5, 6, 7, 8

Program Name and Affiliation	Program Description	Measures Addressed
(CREST)	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.	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
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

Program Name and Affiliation	Program Description	Measures Addressed
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 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, 4, 5
Washington State	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout,	16

Program Name and Affiliation	Program Description	Measures Addressed
Ecosystem Conservation Program – USFWS	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.	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

5.2.1.1.2 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
	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

Life Stage	Limiting Factors	Impact/Certainty
	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
	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

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	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
	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		

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	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
	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 biological objectives	Medium. *Explanation*: Benefits of limiting contaminant exposure to species in the lower mainstem and

Variables	Context
	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/ 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 River Estuary	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments	1, 4, 5, 6,

Program Name and Affiliation	Program Description	Measures Addressed
Study Taskforce (CREST)	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 (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
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	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
	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 (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 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, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
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 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

5.2.1.1.3 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 populations, Western Oregon tributaries)	Historical productivity of coho 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]).	Current productivity of coho is 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	Historical total Columbia River	The 2000 total Columbia River run

populations, Western Oregon tributries)	run size ranged from about 50,000 to 1.6 million (primarily hatchery fish)	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-subbasin populations, Western Oregon tributaries)	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
	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

Life Stage	Limiting Factors	Impact/Certainty
	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 estuary, as well as uncertainty in exposure risks to salmonids.

Variables	Context
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 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:* 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 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 River Estuary	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments	1, 4, 5, 6,

Program Name and Affiliation	Program Description	Measures Addressed
Study Taskforce (CREST)	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 (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
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	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
	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 (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 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, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
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 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 River abundance index of 100,000).	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 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

Life Stage	Historical Abundance	Current Abundance
		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

Life Stage	Limiting Factors	Impact/Certainty
	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	
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
	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

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	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
	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

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	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
	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
Programs and projects currently addressing measure	See Table 5-6

Variables	Context
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 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

Variables	Context
	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 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 River Estuary	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments	1, 4, 5, 6,

Program Name and Affiliation	Program Description	Measures Addressed
Study Taskforce (CREST)	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 (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
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	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
	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 (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 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, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
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 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

5.2.1.1.6 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
	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.		

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	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 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.

Variables	Context
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 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.

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 estuary, as well as uncertainty in exposure risks to salmonids.

Variables	Context
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/ 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

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, 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
State Lands Management	DNR has a Habitat Conservation Plan (HCP) in place with the United States Fish and Wildife Service (USFWS) that incorporates restoration, protection, and	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
Program – DNR	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.	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 Wildlife 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 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	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
	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 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	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	14

Program Name and Affiliation	Program Description	Measures Addressed
Project	of the tern population would be maintained.	

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
	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.		

Life Stage	Physical Objective	Difficulty	Benefit/Certainty
	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 River Estuary	CREST is a council of local governments serving as a forum for collaboration and regional planning that provides technical assistance to local governments	1, 4, 5, 6, 7, 8

Program Name and Affiliation	Program Description	Measures Addressed
Study Taskforce (CREST)	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.	
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	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 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	1, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
	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 species on private lands.	1, 4, 5
Washington State	The program is responsible for developing and implementing Habitat Conservation Plans (HCPs) for listed and unlisted species including bull trout,	16

Program Name and Affiliation	Program Description	Measures Addressed
Ecosystem Conservation Program – USFSS	spotted owls, and marbled murrelets. The USFSS 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.	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
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

Life Stage	Limiting Factors	Impact/Certainty
	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
	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

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
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
	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

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	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
	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 historical hydrograph with existing programs.

Variables	Context
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 native and nonnative species and the effects of nonnative species on the ecosystem; however, there

Variables	Context
	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 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 Dam operations effects on sturgeon.
Potential to contribute to	High.

Variables	Context
biological objectives	*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 Taskforce	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	1, 2, 3, 4, 5, 11, 14

Program Name and Affiliation	Program Description	Measures Addressed
(CREST)	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 for the RMZ on certain water types affected by timber harvest activities.	3, 4
Conservation	The CREP is a joint state and federal conservation partnership program targeted	2, 3, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
Reserve Enhancement Program (CREP)	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.	
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 State Ecosystem Conservation	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).	3, 4, 14

Program Name and Affiliation	Program Description	Measures Addressed
Program – USFWS		
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
	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

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	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
	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

Life Stage	Physical Objective	Difficulty	Benefit/ Certainty
	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 be high because of negative interaction between native and nonnative species and the effects of

Variables	Context
	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 biological objectives	High. *Explanation*: Mitigation of dredging effects would have a high benefit because of the effects on natural

Variables	Context
	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, estuary, and plume in the short term. However, these relationships are complex and dynamic, and

Variables	Context
	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 estimation challenge, however, this project is not currently active? Other sampling efforts have

Variables	Context
	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 Scenic Areas Ordinance	The program addresses any land disturbing activity within the national scenic area and regulates development along wetlands and other water bodies.	
Water Resource	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	1

Program Name and Affiliation	Program Description	Measures Addressed
Inventory Areas (WRIAs; HB 2514)	provide for the economic well-being of the state's citizenry and communities.	
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. 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	1, 3, 4, 5, 6, 8, 10, 11, 12, 13

Program Name and Affiliation	Program Description	Measures Addressed
	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.	
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 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.	

Program Name and Affiliation	Program Description	Measures Addressed
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 other work involving the discharge of fill or dredged material.	2, 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.	3, 4, 5, 10
Pacific Lamprey Research and	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	10, 11, 12, 13

Program Name and Affiliation	Program Description	Measures Addressed
Restoration Project	the status and biology of Pacific lamprey in the Columbia River basin.	
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

Limiting Factors	Impact
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
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

Physical Objective	Difficulty	Benefit
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 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 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
	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
	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
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 for restoration of sediment transport processes. The primary reason is continued plans for dredging

Variables	Context
	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
Programs and projects currently addressing measure	See Table 5-6
Program Gap Analysis	*Analysis:* There are currently no programs and/or

Variables	Context
	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 Species Monitoring – monitoring abundance and distribution of non-indigenous plants and animals.	3, 17

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, 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
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

Program Name and Affiliation	Program Description	Measures Addressed
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
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	1, 6, 7, 8, 9, 10, 11, 13, 15, 17, 18

Program Name and Affiliation	Program Description	Measures Addressed
	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.	
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 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

Program Name and Affiliation	Program Description	Measures Addressed
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 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, 17
Pikeminnow	The goal of the program is to manage annual pikeminnow predation on juvenile	11, 17

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.	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.
Barriers to success	*Explanation:* At present, it is easier to discourage geese and crane use of private lands when land use

Variables	Context
	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 Estuary Partnership;	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	1, 2, 3, 6, 7

Program Name and Affiliation	Program Description	Measures Addressed
Habitat Restoration Program	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; Evaluating Cumulative Ecosystem Response To Restoration	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	6

Program Name and Affiliation	Program Description	Measures Addressed
Projects in the Columbia River Estuary	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 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, 5
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, 2, 3, 6, 7

Program Name and Affiliation	Program Description	Measures Addressed
Districts	improvements needed, and publish and disseminate the information.	
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	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, 2, 3
Conservation Reserve Enhancement Program	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	1, 2, 3, 4, 5, 6, 7

Program Name and Affiliation	Program Description	Measures Addressed
(CREP)	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.	
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 trust species on private lands.	1, 2, 3
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	The NPCC develops and maintains a regional power plan and a Fish and	1, 2, 3, 4,

Program Name and Affiliation	Program Description	Measures Addressed
Wildlife Program - Northwest Power and Conservation Council (NPCC)	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.	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 Monitoring – habitat classification using remote sensing, and 3. Invasive Species Monitoring –	

Program Name and Affiliation	Program Description	Measures Addressed
	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 control measures.	4
Stormwater Control	The Department of Ecology (DOE) is updating its Stormwater Management Manual; the manual is utilized by local governments as the basis of their	4

Program Name and Affiliation	Program Description	Measures Addressed
Ordinance	stormwater control ordinances.	
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 quality and erosion control, and air quality.	4
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	1, 2, 3, 4, 5

Program Name and Affiliation	Program Description	Measures Addressed
	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.	
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 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	4

Program Name and Affiliation	Program Description	Measures Addressed
	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 other work involving the discharge of fill or dredged material.	4
Lower Columbia River Aquatic Nonindigenou	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	1, 4

Program Name and Affiliation	Program Description	Measures Addressed
s Species Survey (LCRANS)	document which species are introduced, where they are located, where they are from, how they got here, and when they arrived.	