

**Pacific Lamprey (*Entosphenus tridentatus*)
Assessment and Template for Conservation Measures**



**Region 1
U.S. Fish and Wildlife Service
Portland, Oregon**

(October 2011)

DISCLAIMER

The Pacific Lamprey Assessment and Template for Conservation Measures was written with the most current information available at the time, gathered at regional meetings hosted throughout the United States range of Pacific Lamprey in 2009 and 2010. Any new information will be incorporated into subsequent revisions of the Assessment and into the Regional Implementation Plans.

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ACRONYM AND SYMBOL LIST

ADFG	Alaska Department of Fish and Game
BIA	Bureau of Indian Affairs
BKD	Bacterial Kidney Disease
BLM	Bureau of Land Management
BON	Bonneville Dam
BPA	Bonneville Power Administration
CBFWA	Columbia Basin Fish and Wildlife Authority
CBWTP	Columbia Basin Water Transactions Program
CDFG	California Department of Fish and Game
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRB	Columbia River Basin
CRBLTWG	Columbia River Basin Lamprey Technical Workgroup
CRITFC	Columbia River Inter-Tribal Fish Commission
CTBYN	Confederated Tribes and Bands of the Yakama Nation
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CTWSRO	Confederated Tribes of the Warm Springs Reservation of Oregon
EPA	Environmental Protection Agency
ESA	U.S. Endangered Species Act
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FPC	Fish Passage Center
FPOM	Fish Passage Operations and Maintenance Coordination Team
FY	Fiscal Year
GIS	Geographic Information System
GMA	Growth Management Act
HCP	Habitat Conservation Plans
HUC	Hydrologic Unit Code
ID	Identification
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
ISAB	Independent Scientific Advisory Board
IUCN	International Union for Conservation of Nature
LCFRB	Lower Columbia Fish Recovery Board (Washington)
LCREP	Lower Columbia River Estuary Partnership
LWD	Large woody debris
MOA	Memorandum of Agreement
mtDNA	Mitochondrial DNA
<i>N_e</i>	Effective population size
NF	North Fork
NMFS	National Marine Fisheries Service (NOAA)
NOAA	National Oceanographic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPT	Nez Perce Tribe

ACRONYM AND SYMBOL LIST (Continued)

ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OSU	Oregon State University
PHS	Priority Habitats and Species Program
PLCI	Pacific Lamprey Conservation Initiative
PSP	Puget Sound Partnership
PUD	Public Utility District
RKM	River Kilometer
RM	River Mile
RM&E	Research Monitoring and Evaluation
SEPA	State Environmental Policy Act (Washington)
SIP	Steelhead Intrinsic Potential
SMA	Shoreline Management Act
SRSRP	Snake River Salmon Recovery Plan
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
USACE	United States Army Corp of Engineers
USBR	United States Bureau of Reclamation
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey
WCSSP	Washington Coast Sustainable Salmon Partnership
WDE	Washington Department of Ecology
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

Overview

Although Pacific Lamprey were historically widespread along the west coast of the United States there is an observed decline in abundance and distribution throughout California, Oregon, Washington, and Idaho. Threats to Pacific Lamprey occur in much of the range of the species. The U.S. Fish and Wildlife Service (USFWS) recognizes the need for a comprehensive plan to conserve and restore Pacific Lamprey in collaboration with Native American tribes and other federal, state, and local agencies; and to further lamprey research and conservation actions throughout their native range. The Pacific Lamprey Conservation Initiative is the USFWS's strategy to improve the status of Pacific Lamprey throughout their range in the United States.

The approach of the Pacific Lamprey Conservation Initiative is a three part process: assessment and template for conservation measures; conservation agreement; and regional implementation plans. This Assessment identifies critical uncertainties regarding their life history and improves the scientific understanding of the importance of Pacific Lamprey in the ecosystems of the United States. In addition, the Assessment tracks the current knowledge of Pacific Lamprey habitat requirements; abundance; historic and current distribution; describes threats and factors for decline; and identifies conservation actions and research, monitoring and evaluation needs.

The development of this document relied on voluntary involvement of various federal, state, and local governmental agencies, Native American Tribes, scientific institutions, consultants, non-profit groups, utility companies, private landowners, and others. The Assessment incorporates other plans and authorities applicable to Pacific Lamprey, and acknowledges that conservation cannot happen without all stake holders.

To characterize the risk to Pacific Lamprey populations, we conducted an assessment using a modified NatureServe ranking approach. Our objective in using this assessment tool was to conduct a structured evaluation of existing data with the capability to incorporate and integrate both population data and threat information. This systematic analysis was conducted for discrete geographic groupings in Idaho, Oregon, Washington and California to rank the risk to Pacific Lamprey relative to their vulnerability of extirpation. Data used to rank geographic units included information on population abundance, distribution, population trend, and threats to lamprey. In several geographic areas, little information was available to identify population abundance and trend. In these cases, best professional judgment was used. These relative ranks of risk calculated for each geographic grouping were summarized by regional area. We analyzed discrete geographic groupings to rank the relative risk to extirpation, and summarized this risk by regions. The risk results were used to identify and prioritize threats to Pacific Lamprey. We collected additional information to identify ongoing and needed conservation actions and research monitoring and evaluation. The integration of this regional information and the resulting risk analysis will be used to inform the priorities for recommended conservation actions.

Key Conclusions

Rangewide—There is a decline in abundance and distribution of Pacific Lamprey throughout California, Oregon, Washington, and Idaho. Threats such as barriers to mainstem and tributary passage, streamflow management, stream and floodplain degradation, and reduced water quality are impacting all freshwater life stages. The low viability of populations further elevates the threats. Conservation actions being implemented include modifying fish ladders and entranceways at mainstem dams, constructing lamprey passage structures at tributary barriers, restoring lamprey habitat, and consideration of lamprey presence during in-stream work. In addition, we believe that additional research, monitoring and evaluation including lamprey specific surveys and lamprey identification are needed. We recommend additional actions and research to address the threats that are not addressed by ongoing plans. These include targeted lamprey restoration projects, passage improvements and evaluation, development and implementation of water diversion screen criteria, additional lamprey distribution surveys, and population structure studies.

We evaluated Pacific Lamprey populations in specific geographic areas of the Pacific Coast. This report discusses each of these areas in detail.

Puget Sound/Strait of Juan de Fuca/Coastal Washington—Due to the lack of information on populations and threat factors, the watersheds in the Puget Sound/Strait of Juan de Fuca/Coastal Washington geographic area were not assessed with the NatureServe ranking approach. However, several of these watersheds were analyzed with the available information on short-term trends and general threats. The abundance of the Pacific Lamprey geographic population groupings in these watersheds were characterized as ‘rapidly declining’. Threats included barriers to adult and juvenile passage, stream and floodplain degradation, and streamflow management. Additional data on distribution, population factors and threats are needed in this geographic area. Ongoing conservation actions include restoration for other anadromous fish, fishing regulations that protect lamprey, lamprey surveys, and the development of an identification guide for lamprey species. Recommended conservation actions include restoration of stream and floodplain habitat and water quality, improved flow management and tributary passage, and more targeted lamprey distribution surveys.

Columbia River—The NatureServe rank indicates that Pacific Lamprey geographic population groupings are at ‘high risk’ throughout much of the Columbia River Basin, particularly in the Snake River, the Mid-Columbia and the Upper Columbia Regions. Threats affecting these populations include barriers to mainstem and tributary passage, stream and floodplain degradation and “small population” effects. Lower Columbia and Willamette river Pacific Lamprey populations are at relatively lower risk; however, tributary passage, water quality and stream and floodplain degradation are on-going threats in these regions. Ongoing actions such as distribution and habitat surveys, barrier removals, fish screening, and habitat restoration projects are assisting Pacific Lamprey restoration in these regions. Recommended actions and research throughout the Columbia River Basin include passage improvements at mainstem and tributary dams, adult and juvenile lamprey surveys, water quality improvements, stream and floodplain restoration, species identification workshops, and education and outreach.

Coastal Oregon—The NatureServe rank indicates that Pacific Lamprey geographic population groupings in this region are at relatively lower risk than those of the Columbia River Basin. The most serious threat in this region is stream and floodplain degradation, which was classified as a moderate threat. Ongoing actions in the Oregon Coast Region that could benefit lamprey include implementation of salmonid recovery plans and restoration projects. Recommended actions and research include lamprey distribution surveys, water quality improvements, passage improvements and development of passage criteria for culvert replacements, explicit screening criteria for water diversions, in-stream work salvage operation guidance, species identification and research to better understand the lamprey life stage during the ocean phase of residency.

California—Conservation planning has been initiated in California using similar methods employed in Washington, Oregon and Idaho; however, the information has been completed at 3rd field HUC (Hydrologic Unit Code). Future work will focus on completing this regional analysis at a finer geographic scale. The preliminary NatureServe rank results indicate that most Pacific Lamprey geographic population groupings are at relatively high risk in the California Region. The threats identified most often in the California Region include stream and floodplain degradation, reduced water quality, dewatering and flow management, and barriers to tributary passage. Needed actions in California include restoration from urbanization and agricultural impacts, tributary passage improvements, and more lamprey-specific distribution surveys.

Alaska— A risk assessment and query of ongoing and needed actions and research was not conducted for Pacific Lamprey in Alaska. The State of Alaska has six species of lampreys but little research has been done on them so their distribution and status are unknown. The Alaska State Comprehensive Wildlife Strategy outlines the species, suspected distribution, general concerns, habitat concerns, conservation goals and objectives, and plan for monitoring the species and habitats.

Next Steps

While analysis in some areas still needs to be completed, many watersheds are complete with the most current data available. In these areas, the threats have been prioritized, and needed actions and research have been identified in conjunction with the other Pacific Lamprey plans (e.g., Draft Columbia River Inter-Tribal Fish Commission (CRITFC) Tribal Restoration Plan, United States Army Corp of Engineers (USACE) 10-Year Lamprey Plan, Public Utility District (PUD) lamprey management plans). The next steps in this process are: 1) complete the compilation of currently available data; 2) schedule meetings with regional policy and decision makers to present the Assessment and determine best strategies for regional implementation; 3) develop a Conservation Agreement and 4) develop step-down regional action plans for implementation.

1. INTRODUCTION

Historically Pacific Lamprey, *Entosphenus tridentatus*, formerly *Lampetra tridentata*, were widely distributed from Mexico north along the Pacific Rim to Japan. They are culturally important to indigenous people throughout their range, and play a vital role in the ecosystem as food for mammals, fish and birds, nutrient cycling and storage, and as a prey buffer for other species.

Recent observations in the reduction of abundance and range of Pacific Lamprey have spurred conservation interest in them, with increasing attention from tribes, agencies, and others. It is the U.S. Fish and Wildlife Service's (USFWS) strategy to improve the status of lampreys by proactively engaging in a concerted conservation effort. This collaborative conservation effort, through the development and implementation of the Pacific Lamprey Conservation Initiative, will facilitate opportunities to address threats, restore habitat, increase our knowledge of Pacific Lamprey, and improve their distribution and abundance in the United States portion of their range.

Problem: Rangewide Status of Pacific Lamprey

Pacific Lamprey were historically widespread along the west coast of the United States (Scott and Crossman 1973; Ruiz-Campos and Gonzalez-Guzman 1996) and as they overlap with several Endangered Species Act (ESA) – listed salmonids they may be vulnerable to many of the same threats. In particular, they appear to be declining in numbers due to: reduced quantity and quality of spawning and rearing habitats, associated hydropower and irrigation diversion passage issues such as entrainment and mortality, a propensity for high predation risks, and a vulnerability to contaminants due to their life history (Beamish 1980; Beamish and Northcote 1989; Matter et al. 2000; Close et al. 2002; Swift and Howard 2009). Although accurate abundance data for Pacific Lamprey are difficult to obtain, observational trends suggest that the current populations are declining from historical numbers in the Columbia River Basin and Pacific Coast streams from Washington to South of Point Conception in California (Close 2001; Moser and Close 2003; Luzier et al. 2009; Moyle et al. 2009; Swift and Howard 2009). In addition, Pacific Lamprey have been extirpated from many river basins (USFWS 2004a).

In the Columbia River Basin, mainstem dam counts give minimum estimates of adult Pacific Lamprey that have passed since counts began in 1938. Visual counts are considered to represent a minimum abundance, as historic sampling protocols missed movement at night, and adult Pacific Lamprey moved upstream in the fish ladders in areas not visible from the counting windows. Current use of 24 hour video technology at several sites is considered more accurate than direct visual counts during a portion of a 24 hour time period, so caution should be used when comparing newer adult count data with older count data (Fish Passage Center, http://www.fpc.org/lamprey/lamprey_home.html). Despite these limitations, Pacific Lamprey historically numbered in the hundreds of thousands at Bonneville Dam. The highest recorded count at Bonneville Dam is 379,509 in 1969 (Figure 1-1). There are no lamprey counts available at Bonneville Dam from 1970 through 1997. Recent years indicate a dramatic decline in the number of adult lamprey returning to the Columbia River (Table 1.1).

Information collected in California south of Point Conception also indicate a dramatic decline in the number of juvenile Pacific Lamprey found in historically occupied streams (Swift and Howard 2009). Pacific Lamprey population status in Canada is considered to be apparently secure (Renaud et al. 2009) although the authors note that more needs to be done in terms of surveys and population monitoring. Population status around the Pacific Rim to Japan, including Alaska, is unknown.

Brown et al. (2009) point out that if sufficient information were available, it is likely a majority of lamprey species would be characterized as being in a vulnerable status. Most species of lamprey throughout California (including coastal rivers) are in steady decline, including the once abundant Pacific Lamprey (Moyle et al. 2009). They assessed these populations using a systematic evaluation of available information employing criteria that include aspects of lamprey biology, vulnerability to environmental change, and limiting factors; and they found that all species are either declining, in low numbers, or isolated populations. As a result of these collective observations, conservation of Pacific Lamprey has become an increasingly important priority along the west coast of the United States, given their ecological and cultural importance.

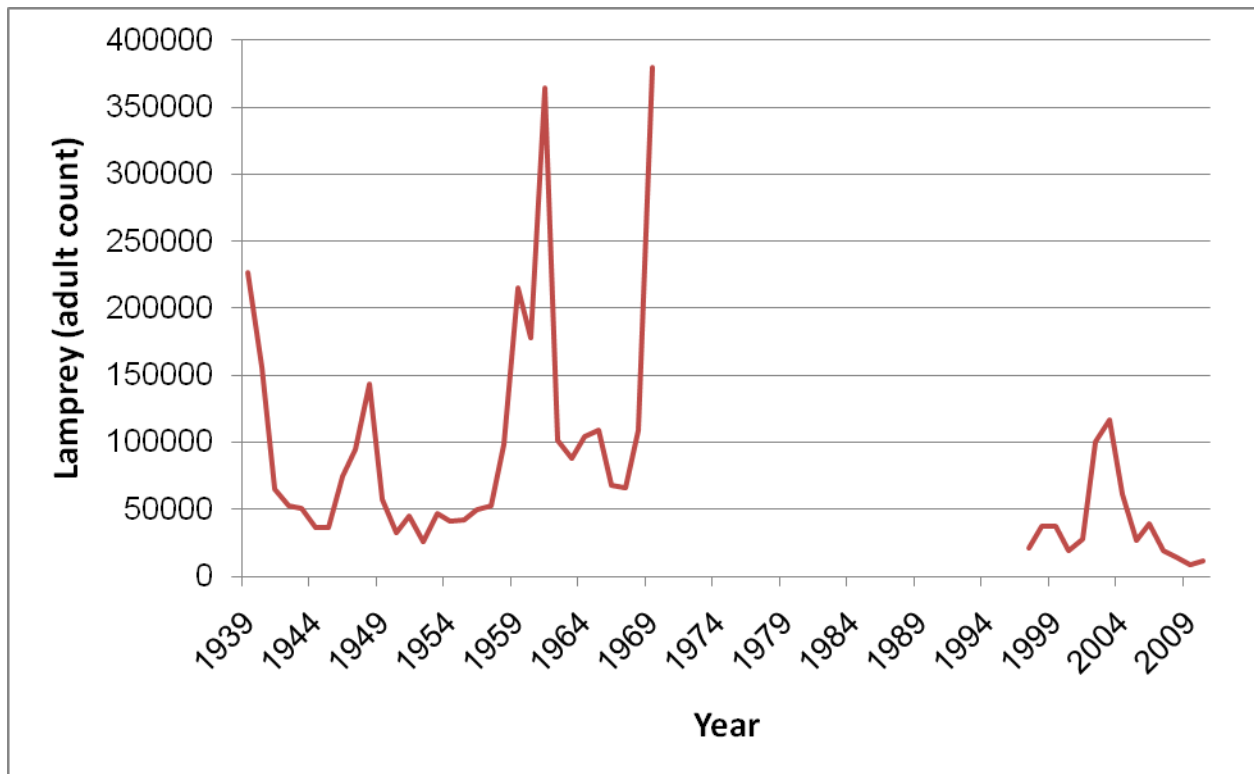


Figure 1-1. Counts of adult Pacific Lamprey at Bonneville Dam, 1939-2009. Counts for 2010 are not corrected for lamprey passage systems.

Table 1-1. Counts of adult Pacific Lamprey at mainstem Columbia and Snake River dams, 2000-2010. (USACE 2011). Priest Rapids counts include Wanapum Dam counts through 2006. Counts for 2010 are not corrected for lamprey passage systems.

Year	Dam												
	Bonneville	The Dalles	John Day	McNary	Priest Rapids	Wanapum	Rock Island	Rocky Reach	Wells	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
2000	19,002	8,050	5,844	1,281			822	767		315	94	71	28
2001	27,947	9,061	4,005	2,539	1,624		1,460	805	261	203	60	104	27
2002	100,476	23,417	26,821	11,282	4,007		4,878	1,842	338	1,127	284	365	138
2003	117,027	28,995	20,922	13,325	4,339		5,000	2,521	1,408	1,702	468	660	282
2004	61,780	14,873	11,663	5,888	2,647		2,362	1,043	403	805	194	243	117
2005	26,664	8,361	8,312	4,158	2,598		2,267	404	212	461	222	211	40
2006	38,938	6,894	9,600	2,456	4,381		1,326	370	21	277	175	125	35
2007	19,313	6,083	5,740	3,454	6,593	4,771	1,299	541	35	290	138	72	34
2008	14,562	4,599	6,625	1,530	5,083	1,519	880	368	7	264	145	104	61
2009	8,622	2,318	2,044	676	2,714	718	375	278	9	57	58	34	12
2010	11,183	1,726	1,662	825	1,114	707	318	268	2	114	44	29	15

Description of the Pacific Lamprey Conservation Initiative

The USFWS has been committed to Pacific Lamprey conservation by engaging in activities including, but not limited to: conducting lamprey research, sponsoring and leading the Columbia River Lamprey Technical Workgroup, participating in Lamprey Tribal Summits, funding lamprey conservation actions and research, and partnering with tribes and other agencies to further lamprey research and conservation actions. Pacific Lamprey is a tribal trust species and as such the USFWS recognizes tribal treaty and other rights, interacts with tribes on a government to government basis, and strives to conduct its programs and actions in a manner that protects tribal trust resources, including fish and wildlife resources and their associated habitat.

The Pacific Lamprey Conservation Initiative (PLCI) is the USFWS's strategy to improve the status of Pacific Lamprey by coordinating conservation efforts among states, tribes, federal agencies, and other involved parties. This collaborative conservation effort will facilitate opportunities to address threats, restore habitat, increase our knowledge of Pacific Lamprey, and improve their distribution and abundance.

Purpose of the Pacific Lamprey Conservation Initiative

Goal.—The purpose of the PLCI is to develop implementation plans and to help coordinate the full suite of actions needed to restore and sustain Pacific Lamprey populations throughout their range in the United States.

Strategy.—The USFWS will act as coordinating agency to engage entities willing to participate, coordinate conservation efforts, facilitate increased knowledge about distribution, abundance, population structure, and threats, and work with partners in the development of regional implementation plans for restoring Pacific Lamprey populations. This will be accomplished through a variety of approaches including voluntary participation.

Partnerships.—The development and implementation of the PLCI will be based upon the involvement of various federal, state, tribal, county and city biologists working with representatives of local watersheds, private landowners, industry, and conservation organizations. The PLCI is intended to be compatible with other Pacific Lamprey management plans throughout the species' range. It is intended to be consistent with other management strategies of federal, state and tribal natural resource management agencies and supportive of efforts aimed at the conservation and enhancement of Pacific Lamprey.

Objectives.—The objectives of the PLCI are to:

1. Develop an assessment rangewide and regionally that includes:
 - An enhanced description and tracking of current knowledge of Pacific Lamprey life history, biology, and habitat requirements.
 - Identification of Pacific Lamprey populations, and their current distribution, abundance, and population structure.
 - A rangewide map of historical and current Pacific Lamprey distribution.
 - Description of known threats and reasons for decline.
 - Identify actions to address known threats.

2. Construct a Conservation Agreement:
 - Develop overarching agreement with signatories.
 - Will link to Assessment document and regional implementation plans.

3. Develop regional implementation plans:
 - Identify partnerships and participants for implementation.
 - Identify regional strategies and prioritize actions to address threats (that were identified in the regional conservation assessment chapters) and promote restoration and conservation of Pacific Lamprey.
 - Prioritize and implement research, monitoring and evaluation to improve status assessments and the efficacy of conservation measures.
 - Develop restoration goals and population outcomes that will be modified as we learn from research, monitoring and evaluation work (adaptive management approach).
 - Identify potential funding sources and partnerships to address priority actions;
 - Identify potential funding sources and partnerships for research, monitoring and evaluation.
 - Identify priority tasks by region and develop implementation schedules.

Inclusion of Ongoing Conservation Measures

The approach described here is to be inclusive of the other federal, state, tribal and county conservation measures and with the objective of yielding coordinated efforts throughout the range of Pacific Lamprey. The approach is to have the PLCI be an umbrella under which the conservation and restoration of Pacific Lamprey and associated habitats can be coordinated. The primary method was to describe the threats to the long-term survival, which, in theory, if addressed, should reverse the decline of the species. It is anticipated that some of the actions, tasks, and threats identified in this document will require further environmental analysis and public review, especially those actions taken by federal agencies. Because a key component of the approach is to be inclusive of ongoing efforts, we have provided a summary of the regulatory history and ongoing conservation measures that directly or indirectly influence Pacific Lamprey.

Endangered Species Act – In 2003 the USFWS was petitioned by 11 conservation groups to list four species of lamprey in Oregon, Washington, Idaho, and California (Pacific Lamprey, Western River Lamprey *Lampetra ayresi*, Western Brook Lamprey *Lampetra richardsoni*, and Kern Brook Lamprey *Lampetra hubbsi*) under the ESA (Nawa et al. 2003). The USFWS review of the petition indicated a likely decline in abundance and distribution in some portions of the Pacific Lamprey range, and the existence of both long-term and proximate threats to this species, but the petition did not provide the information describing how the portion of the species' petitioned range (California, Oregon, Idaho, and Washington) or any smaller portion is appropriate for listing under the ESA. Thus, in December 2004, the USFWS determined that listing the Pacific Lamprey was not warranted (69 FR 77158).

Columbia River Inter-Tribal Fish Commission (CRITFC) acts as a unified body to ensure a voice in the overall management of the fishery resources in the Columbia River Basin, and as managers, to protect reserved treaty rights through the exercise of the inherent sovereign powers

of the tribes that were guaranteed in 1855 treaties with the United States. The Commission is comprised of the Nez Perce Tribe (NPT), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO), and the Confederated Tribes and Bands of the Yakama Nation (CTBYN). On May 15th, 2008 CRITFC released a formal restoration plan titled “A Draft Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin” (CRITFC 2008). This document outlines Tribe-specific sub-basin plans and actions to restore lamprey populations to numbers adequate for ecological and tribal cultural benefits, and harvest utilization of Pacific Lamprey. More specifically, the plan encourages actions and partnerships that will result in the halt of population declines and reestablish lampreys as a fundamental component of the ecosystem by 2018 to sustainable, harvestable levels throughout the historical range and in all tribal usual and accustomed areas (see http://www.critfc.org/text/lamprey/restor_plan.pdf).

The Columbia River Basin Lamprey Technical Workgroup (CRBLTWG) functions under the authority of the Columbia Basin Fish and Wildlife Authority (CBFWA) as a subcommittee of the Anadromous Fish Advisory Committee. It was established in 1995 to serve and guide coordination activities for new and existing lamprey projects or projects proposed for funding, through Bonneville Power Administration (BPA). Specifically the CRBLTWG is to provide technical review, guidance, and recommendations for activities related to lamprey conservation and restoration. Currently, the workgroup includes scientists with lamprey technical expertise from federal, state, and tribal governments, academia, the private sector, and support staff such as contract officers and members of CBFWA (see <http://www.cbfga.org/committees/LTWG/>).

The Northwest Power and Conservation Council (NPCC) Fish and Wildlife Program is an interstate compact agency of Idaho, Montana, Oregon and Washington. It was established under the authority of the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act or Act). The Act directs the NPCC to develop a program to “protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries ... affected by the development, operation, and management of [hydroelectric projects] while assuring the Pacific Northwest an adequate, efficient, economical, and reliable power supply.” The Act also directs the NPCC to ensure widespread public involvement in the formulation of regional power and fish and wildlife policies. The program includes 40 subbasin plans covering 59 subbasins (<http://www.nwcouncil.org/fw/subbasinplanning/Default.htm>). The NPCC uses the subbasin plans to provide the context for reviewing mitigation projects and assessing whether projects support and are consistent with the program (see the NPCC’s *Columbia River Basin Fish and Wildlife Program NPCC2009*). As a planning, policy-making and reviewing body, the NPCC develops the Program, and then monitors its implementation by the BPA, the U.S. Army Corp of Engineers (USACE), the U.S. Bureau of Reclamation (USBR) and the Federal Energy Regulatory Commission (FERC) and its licensees.

Given that Pacific Lamprey traditionally migrated hundreds of miles through both mainstem Columbia and Snake River habitats, effective passage of adult and juvenile lampreys is a major concern addressed in many subbasin plans. Large mainstem hydropower dams that have fishways designed primarily to effectively pass Salmon and Steelhead *Oncorhynchus mykiss* delay and obstruct adult and juvenile lamprey passage. Predation may also be a limiting factor

for mainstem passage of lamprey. Although the NPCC noted lamprey as a species of ecological importance in Section 2.4.5 in its 2004 Lower Columbia Mainstem Subbasin Plan (LCFRB 2004), restoration actions have been generally limited to “obtain the information necessary to begin restoring the characteristics of healthy lamprey populations” (NPCC 2000). The NPCC has set goals for Pacific Lamprey in the Fish and Wildlife program to: restore lamprey passage and habitat in the mainstem and in tributaries that historically supported spawning lamprey populations; attain self-sustaining and harvestable populations of lamprey throughout their historical range; and mitigate for lost lamprey production in areas where restoration of habitat or passage is not feasible.

The Columbia Basin Federal Caucus (Caucus) is a group of ten federal agencies (National Oceanic and Atmospheric Administration (NOAA), USFWS, BPA, USACE, USBR, Environmental Protection Agency (EPA), U.S. Forest Service (USFS), Bureau of Land Management (BLM), U.S. Geological Survey (USGS), and Bureau of Indian Affairs (BIA)) operating in the Columbia River Basin that have natural resource responsibilities related to the ESA. The agencies work together to: better integrate, organize, and coordinate the federal fish recovery and water quality efforts in order to improve the Columbia River Basin aquatic ecosystem, and coordinate execution of federal trust and treaty responsibilities to Columbia River Basin Native American tribes. The Caucus accomplishes these purposes consistent with each member agency’s missions and responsibilities. The Caucus formed a lamprey focus group to coordinate the federal activities designed to conserve lamprey, and to communicate this information to our state and tribal partners. The Caucus has identified past and ongoing projects related to Pacific Lamprey in the Columbia River Basin (Appendix B and D). This information was used in developing the Regional Chapters.

U.S. Army Corps of Engineers Northwestern Division developed the Pacific Lamprey Passage Improvements Implementation Plan: 2008-2018 (USACE 2009) in response to the September 2008 Memorandum of Agreement (MOA) between the Action Agencies and Columbia Basin Fish Accord Tribes. The development and prioritization of the plan and its implementation requires frequent and close collaboration with CRITFC and the Tribes. The document is intended to facilitate and guide improvements in lamprey passage at Columbia River hydropower dams. This includes structural and operational measures to improve adult lamprey passage into and through fish ladders. To date, both structural and operational changes have occurred at various hydropower facilities. Evaluation of the efficacy of these modifications is ongoing to guide development of similar aids to lamprey movement at other passage impediments in accordance with the plan (Moser et al. 2009).

The goal of the Pacific Lamprey passage program is to improve both juvenile and adult lamprey passage and survival through the Federal Columbia River Power System (FCRPS) as a part of a regional effort to immediately arrest the decline of Pacific Lamprey populations within the Columbia Basin and to quickly and substantially contribute towards rebuilding these populations to sustainable, harvestable levels throughout their historic range. USACE in their 10 year passage plan believes deciding where to prioritize efforts to improve lamprey passage should be based on two simple but critical factors: (1) where passage efficiency is the poorest; and (2) where the affected numbers of Pacific Lamprey are the highest. This approach will maximize the improvements for both upper and lower Columbia River Basin Pacific Lamprey. The

USACE has identified several specific actions to improve adult and juvenile passage at mainstem Columbia River and Snake River dams (USACE 2009; also Appendix B and D).

Columbia Basin Fish Accords (Accords) have been signed by BPA, the USACE, USBR, CTUIR, CTWSRO, CTBYN, CRITFC, Confederated Tribes of the Colville Indian Reservation, and the states of Idaho and Montana. The Accords, in part, are intended to ensure habitat restoration and hatchery actions take effect. The Accords assure 10 years of funding for projects that improve the survival of ESA-listed and non-listed native fish. The Accords are intended to supplement the NPCC's Fish and Wildlife Program while simultaneously acknowledging the tribes' and states' substantive role as managers of the fish resource. Projects under the Accords are designed to contribute to hydro, habitat, hatchery and predation management activities contained in the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (citation) as well as meet obligations under the Northwest Power Act.

The Accords include a number of actions designed to assist Pacific Lamprey restoration (see Appendix D). For example, the USACE provide \$50 million to improve lamprey passage at FCRPS dams and reservoirs and create a collaborative 10 year passage plan with CRITFC (funds to implement USACE 10 year passage plan). Although Pacific Lamprey are not a listed species, BPA's commitment to the lamprey effort includes funding of up to \$18.66 million in projects over the term of the Agreement.

Public Utility District (PUD) Management Plans for Pacific Lamprey have been developed by Chelan and Douglas County PUDs in Washington State as part of the relicensing process. Chelan County PUD's management plan was produced to provide safe, timely, and effective passage for adult and juvenile Pacific Lamprey; and where unavoidable project impacts are measured, then provide appropriate and reasonable protection, mitigation, and enhancement measures that achieve an overall no net impact on the population. The goal of Douglas County PUD's plan is to implement measures to monitor and address impacts to Pacific Lamprey as a result of the Project operations

The State of Oregon recognized that lampreys were a conservation concern in the early 1990s when tribal co-managers and some Oregon Department of Fish and Wildlife (ODFW) staff noted that populations of Pacific Lamprey were declining to low numbers (Kostow 2002). As a result the Pacific Lamprey was listed as an Oregon State sensitive species in 1993, and in 1996 lampreys were given legal protection (OAR 635-044-0130) where it is unlawful to fish for them or possess them unless one has obtained a tribal permit authorized by a federally-recognized Indian tribe to which the Oregon Fish and Wildlife Commission has issued a permit.

The State of Washington identifies fish and wildlife resources that are a priority for management and conservation. Pacific Lamprey are listed as a Priority Species in Washington State (WDFW 2008). The Priority Habitat Species program (PHS) is the principal means by which Washington Department of Fish and Wildlife (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. PHS is the agency's primary means of transferring fish and wildlife information from resource experts to those who can protect habitat. PHS information is used to screen 12,000 - 15,000 Forest Practice Applications, 10,000 - 18,000

Hydraulic Project Applications, and over 3,000 Washington State Environmental Policy Act (SEPA) reviews annually; by a majority of cities and counties to meet the requirements of the Growth Management Act; for the development of Habitat Conservation Plans on state, federal, and private lands; by state, federal, and tribal governments for landscape-level planning and ecosystem management; and, for statewide oil spill prevention planning and response. WDFW has placed Pacific Lamprey on the PHS list (<http://wdfw.wa.gov/hab/phspage.htm>). The state's rationale for listing the species is primarily because historically, Pacific Lamprey were important for food and medicinal purposes to Native American tribes in the mid-Columbia River Plateau, and they remain important for traditional tribal cultural practices (BPA 2005; M. Hallock, WDFW, personal communication). Current sport fishing regulations prohibit fishing for or possessing lamprey in Washington State (see regulations at <http://wdfw.wa.gov/publications/00957/wdfw00957.pdf>).

The State of California established a daily bag limit of five Pacific Lamprey within state waters. Pacific Lamprey stocks are depressed throughout much of its west coast range. The California Department of Fish and Game (CDFG) established this bag limit to be similar to other west coast states as a reasonable management measure. (see:http://www.fgc.ca.gov/regulations/new/2009/5_00fsor.pdf). In addition CDFG is revisiting Commercial Bait and Inland Freshwater Take Permits to address conservations issues and compile Pacific Lamprey data and information (R. Bellmer, CDFG, personal communication).

The State of Idaho considers Pacific Lamprey a state endangered species, a native species in danger of extinction throughout all or a significant portion of its Idaho range. The state cites a recent inventory (2002-2007) by Idaho Department of Fish and Game (IDFG) that has documented the absence of Pacific Lamprey in locations throughout the Clearwater and Salmon River drainages where they were known to occur as recently as the 1980s. The IDFG has prepared a Status of Pacific Lamprey in Idaho (IDFG 2011) that contains population goals for each major river basin. The document will guide state interactions with stakeholders in state and downriver mainstem forums to improve passage and habitat in conjunction with salmonid restoration. Population monitoring will occur in tandem with other species sampling. Currently Pacific Lamprey are managed by IDFG as a Protected Nongame Species (Idaho Administrative Procedures Act (IDAPA)).

The State of Alaska has classified Lamprey as a commercial species. It occurs in Wrangell-St. Elias, Glacier Bay, Kenai Fjords and Lake Clark National Parks, Togiak, and Kenai National Wildlife Refuges, and Aniakchak National Monument. (http://aknhp.uaa.alaska.edu/zoology/species_ADFG/ADFG_PDFs/Fishes/Pacific_lamprey_AD FG_web_060105.pdf).

Summary of Approach

The approach described here uses the best scientific and empirical information available to assess the current risk to viability for Pacific Lamprey throughout its range in the western United States. We use scientific and empirical information as a foundation for identifying the environmental and anthropogenic threats to Pacific Lamprey within major regions of California, Idaho, Oregon, and Washington, with additional information presented for Alaska. We then use demographic information and identified threats to qualitatively assess the relative risks of

extirpation of Pacific Lamprey within each geographic grouping (3rd and 4th Field Hydrologic Unit Code watershed) and summarize the risk information for each region. Finally, we use the combined results of the viability and threats assessments, and ongoing conservation measures to propose future conservation efforts that we believe would reduce risks to Pacific Lamprey within each region and thereby increase the conservation of the species rangewide.

Because Pacific Lamprey are widely distributed across a large area, the approach for the Assessment is to organize it into multiple chapters around regional components. The introductory chapters (Chapter 1-4) describes our overall assessment and conservation strategy for the species whereas, the successive chapters (Chapters 5-14) focuses on Pacific Lamprey in specific geographic areas, and describes conditions, defines threats, and identifies specific actions for the conservation of the species; along with research, monitoring and evaluation needs.

2. BIOLOGY, GEOGRAPHY, THREATS, AND CURRENT RESTORATION ACTIONS OF PACIFIC LAMPREY

Phylogenetics

Pacific Lamprey was first described by Gairdner in 1836 (Richardson 1836). The fish are in the Class Petromyzontida, Order Petromyzoniformes, and Family Petromyzontidae. Formerly assigned to the Genus *Lampetra* (Hubbs and Potter 1971), recent genetic and morphological analyses (Docker et al. 1999, Gill et al. 2003) have put them in the Genus *Entosphenus* (Renaud et al. 2009). This name change will be formerly recognized in the newest American Fisheries Society Committee on Names of Fishes which will be published in 2011. Pacific Lamprey, *Entosphenus tridentatus*, is one of at least 21 species within this genus. Pacific Lamprey are jawless fishes and considered part of a large, ancient assemblage (Agnatha) that date back to the Ordovician Period (about 500 million years ago). Near the end of the Devonian Period (about 350 million years ago), most Agnathan taxa were extinct, and only the hagfishes and the lamprey remained. Modern agnathans include members that are filter feeders, scavengers, and ectoparasites. All northern hemisphere lampreys belong to the family Petromyzontinae; Alaska species are members of the tribe Lampetrini and genus *Lampetra*. The Goose Lake population of *E. tridentatus*, presumably derived from sea-run populations from the Klamath drainage, likely deserves recognition as a distinct subspecies (Moyle et al. 1989). Populations in Lake Cowichan and Mesachie Lake, British Columbia, formerly included in *E. tridentatus*, are now regarded as a distinct species, Vancouver Lamprey *E. macrostoma* (Beamish 1987).

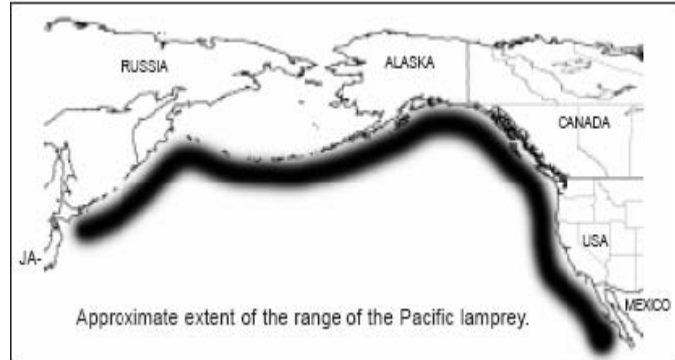
Lamprey species known to currently occur in the range of Pacific Lamprey include: Western Brook Lamprey, Western River Lamprey, Kern Brook Lamprey, Klamath Lamprey *Entosphenus similis*, Miller Lake Lamprey *E. minimus*, Pit-Klamath Brook Lamprey *E. lethophagus*, Vancouver Lamprey, Alaskan Brook Lamprey *Lethenteron alaskense*, Arctic Lamprey *Lethenteron camtschaticu*, Siberian Lamprey *Lethenteron kessleri*, and Fluvial Lamprey *Lethenteron reissner*.

General Morphological Description

Pacific Lamprey are considered a relatively large anadromous and parasitic fish. This species, like all lamprey species, has a round sucker-like mouth (oral disc), no scales, and multiple gill openings instead of an operculum. The fish is characterized by the presence of three large teeth (cusps) on the supraoral bar and three points on each of the central four lateral tooth plates. Their bodies are elongate, eel-like, more or less cylindrical toward the head, and compressed toward the tail resulting in an anguilliform swimming mode (Moyle 2002; Mesa et al. 2003). Two dorsal fins arise far back on its body; and fish exhibit sexual dimorphism during sexual maturity in the pseudo-anal fin. Adults fresh from the sea are blue-black to greenish above, silvery to white below. They do not have swim bladders that allow them to maintain neutral buoyancy and must, therefore, swim constantly or hold fast to objects with their oral disc to maintain their position in the water column (Mesa et al. 2003). Spawning adults become reddish brown (Morrow 1980) but may vary in color.

Geographic Distribution

Historic.—Their range extended from Hokkaido Island, Japan (Yamazaki et al. 2005); and around the Pacific Rim including Alaska (Vogt 1988), Canada, Washington, Oregon, Idaho (Beamish and Northcote 1989; Moyle et al. 1996; USFWS 2004a; Hamilton et al. 2005); and California to Punta Canoas, Baja California, Mexico (Swift et al. 1993; Ruiz-Campos and Gonzalez-Guzman



1996; Ruiz-Campos et al. 2000; Chase 2001; Renaud 2008). In North America, their distribution included major river systems such as the Fraser, Columbia, Klamath-Trinity, Eel, and Sacramento-San Joaquin rivers. Pacific Lamprey are the most widely distributed lamprey species on the west coast of the United States.

Current.— In Japan, Pacific Lamprey have recently been documented in the Naka River on Honshu Island, as well as other river systems on the Hokkaido Island (Yamazaki et al. 2005). Population status in British Columbia is unranked but may be secure (Renaud et al. 2009); and status is unknown in Alaska. Anecdotal and empirical information suggests that Pacific Lamprey populations have declined or been locally extirpated in parts of California, Oregon, Washington, and Idaho (Close 2001; Moser and Close 2003; Luzier et al. 2009; Moyle et al. 2009; Swift and Howard 2009). In these states, Pacific Lamprey have declined in their distribution along all coastal streams and large rivers, including the Columbia River Basin. They are extirpated in parts of Southern California, above dams and other impassable barriers in coastal streams and larger rivers, and in the upper Snake and Columbia rivers. However, like historical distribution information, current distribution information is extremely limited or simply unavailable. The only readily accessible quantitative measurements (both historical and current) of Pacific Lamprey distribution and abundance are from the Columbia River and limited state and federal records and publications from throughout its range. Although fish counts at Columbia River hydropower facilities may show gross trends, they lack precision and certainly do not encapsulate the species' range or current distribution.

Life History Characteristics

Compared to what information has been collected about Pacific salmon, there is not much known about the nature of Pacific Lamprey across its range. Much of what is known about the biology and life history of Pacific Lamprey were from early studies done in Canada (Pletcher 1963; Beamish 1980; Richards 1980) and in the Pacific Northwest (Kan 1975; Hammond 1979). In recent years more emphasis has been placed to gather this information in other parts of their range (Bayer and Seeyle 1999; Chase 2001; Brumo 2006; Gunckel et al. 2006; McGree et al. 2008; Jolley et al. 2010). These studies are useful to characterize its life history in North America. Often what is known about landlocked sea lamprey in the Great Lakes is inferred to apply to anadromous lamprey such as Pacific Lamprey, without justifiable evidence (Clemens et al. 2010). Similarities and differences in the biology as well as key uncertainties between Pacific Lamprey, anadromous Sea Lamprey *Petromyzon marinus* in North America and the landlocked sea lamprey in the Great Lakes were identified in Clemens et al. (2010), suggesting that further

research is needed to more completely describe the biology of each species. A generalized life cycle for Pacific Lamprey is depicted in Figure 2-1, and descriptions of the life stages follow.

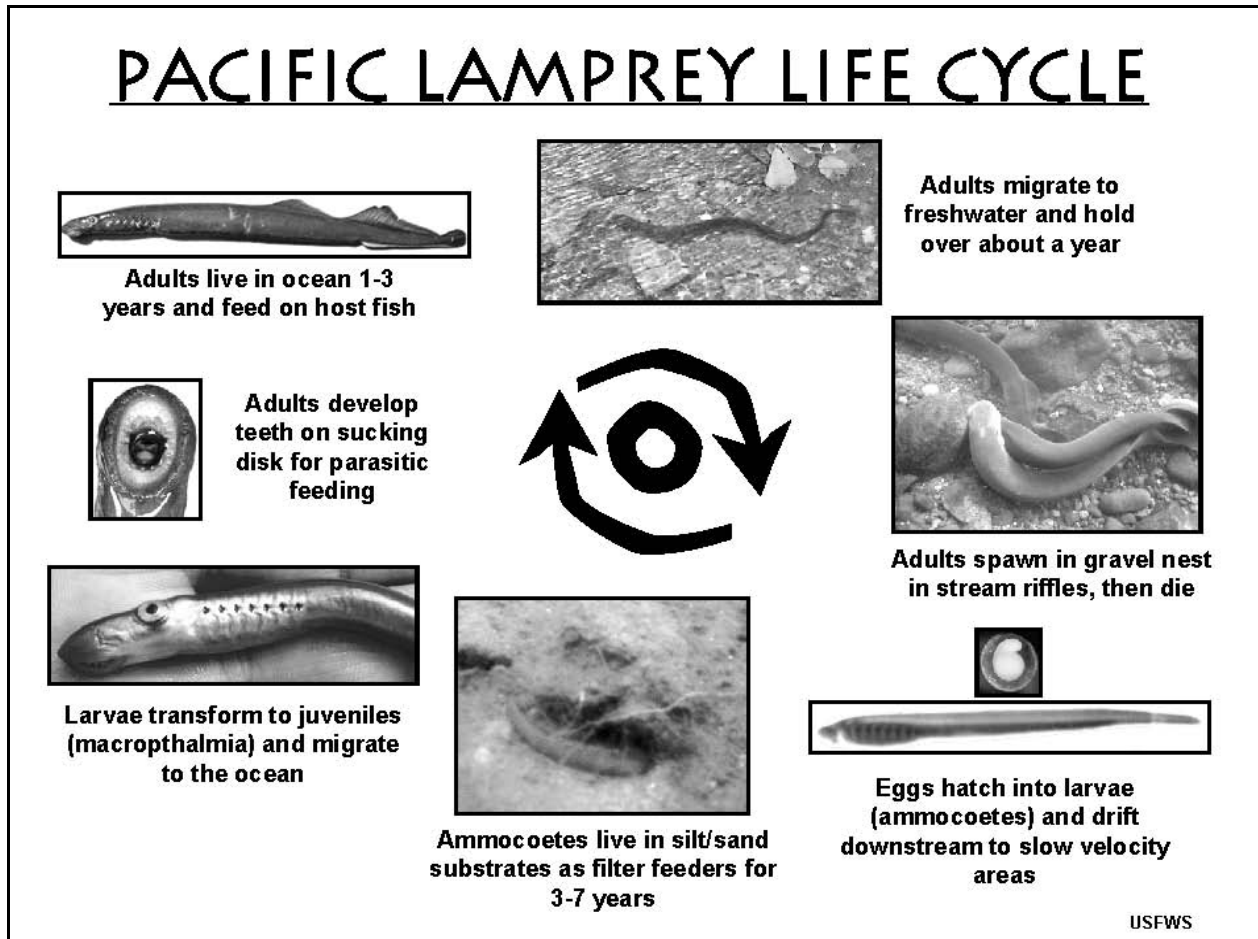


Figure 2-1. General life cycle of Pacific Lamprey, illustrating the duration and morphological characteristics of its life history stages.

Spawning/Adult.—Adult Pacific Lamprey enter freshwater and reside there anywhere from a few months (Bayer and Seelye 1999) to a few years prior to spawning (Whyte et al. 1993; Bayer and Seelye 1999; Fox and Graham 2008; M. Mesa, USGS; S. Gunckel, ODFW; R. Graves, NOAA; Bob Cordie, USACE, personal communication), though spawning generally occurs in the spring following migration into freshwater (Chase 2001). Adults migrate upstream nocturnally (e.g., Potter 1980; Beamish and Levings 1991; Chase 2001) from late spring to fall (e.g., Luzier et al. 2006). Regional and size differences may be present in adult migration timing (Pletcher 1963; Kan 1975; Beamish 1980; Moyle et al. 1995; Chase 2001; Kostow 2002). Spawning generally occurs from April to July (Wydoski and Whitney 2003), but regional differences have been observed (Luzier et al. 2009). For example, in the Santa Clara River of southern California, spawning likely begins in January and may continue through April (Chase 2001).

Adult Pacific Lamprey spawn in low gradient stream reaches, in gravel, at the tailouts of pools and riffles (Mattson 1949; Pletcher 1963; Kan 1975). Velocities over nests generally range from 0.5–1.0 m/s and spawning depths between 30 cm and 4 m (Pletcher 1963; Kan 1975; Gunckel et al. 2006). Nest dimensions are generally between 20–73 cm in diameter and range in depth from 4–8 cm (Kan 1975; Russell et al. 1987; Howard et al. 2005). Spawning habitat has been associated with rearing habitat for ammocoetes (Moser et al. 2007).

Pletcher (1963) described Pacific Lamprey nest construction, summarized here: “A form of low intensity nest construction or “play with stones” was observed first. Both males and females lifted and dropped stones haphazardly without construction of a nest in any one locality. There seemed to be considerable movement within the gravel area before nest construction was started. The male was the instigator of nest construction and contributed to at least 2/3 of the effort. The female helped complete the nest after it was started. Nest construction involved three definite actions on the part of either adult: 1) Rock lifting - most often to downstream edge of nest; 2) Combination of rock lifting and digging; 3) Digging - buccal disk was attached to a rock at the edge of the nest and on its side fish vibrated its tail rapidly to remove sand and small rocks. Digging serves to loosen the bottom and line the bottom of the nest with sand for egg attachment. Nest construction and digging was carried on between spawning acts”. A video of the third action can be seen at <http://www.fws.gov/pacific/Fisheries/sphabcon/Lamprey/index.cfm>.

Deposition, incubation, and emergence life stages have been documented in a few studies for Pacific Lamprey, and extrapolations from other species have also been made. Female fecundity ranges from 30,000–238,400 eggs (Kan 1975; Close et al. 2002; Wydoski and Whitney 2003). Regional differences in fecundity were found in British Columbia and were related to the distance of upstream migration (Beamish 1980). Death in adults has been observed 3–36 days after spawning (Pletcher 1963; Kan 1975; Beamish 1980).

Many factors affect survival of egg to emergence. Survival to hatching ranges from 50–60% (Close et al. 2002) and appears to be correlated with spawning stock size, water flows during spawning (Brumo 2006), and water temperature (Meeuwig et al. 2005). Although egg predation by Speckled Dace, *Rhinichthys osculus*, has been observed, it occurred only above 14°C and appeared to increase in intensity with increasing water temperature (Brumo 2006). Predation of eggs has not been well documented for other potential predators. Brumo (2006) observed that the period of incubation ranged from 18–49 days and was dependent on water temperature. Yamazaki et al. (2003) found that eggs hatched in 11 days when water temperature was 18°C, while Scott and Crossman (1973) reported hatching in 19 days with a water temperature of 15°C. Yamazaki et al. (2003) documented incubation in Pacific Lamprey, and found the stages of embryological development to be similar between three species of lamprey. Egg size may play a role in the rate of embryological development. In laboratory studies, the effects of temperature on the development of larvae showed zero development at 4.85°C and greatest survival at 18.0°C (Meeuwig et al. 2005). Survival of larvae is optimal over a range of 10–18°C with a sharp decline at 22°C that coincides with an increase in morphological abnormalities (Meeuwig et al. 2005).

Much of what is known about natal homing and lamprey migratory behavior originates from studies of Sea Lamprey. Bergstedt and Seelye (1995) investigated spawning site fidelity in a

non-anadromous Sea Lamprey population by mark-recapture studies in Lake Huron. Of the 555 tagged juvenile lamprey, 41 tags were recovered, but none within the stream of origin. This study is presented as evidence for a lack of homing in Sea Lamprey populations. Rather than natal homing, Sea Lamprey may migrate in response to pheromones produced by conspecific larvae. In a study conducted by Robinson et al. (2009), migrating adult Pacific Lamprey were highly sensitive to petromyzonol sulfate (a component of the migratory pheromone) and 3-keto petromyzonol sulfate (a component of the sex pheromone) when first captured. This sensitivity persisted throughout their long migratory and overwinter holding period, before declining to nearly immeasurable levels by the time of spawning. The absolute magnitudes of adult Pacific Lamprey responses to lamprey bile acids were smaller than those of the Sea Lamprey, and unlike the Sea Lamprey, the Pacific Lamprey did not appear to detect tauroolithocholic acid 3-sulfate. No sexual dimorphism was noted in olfactory sensitivity. Thus, it appears that Pacific Lamprey are broadly similar to Sea Lamprey in showing sensitivity to the major lamprey bile acids but apparently differ in having a longer period of sensitivity to those acids. Further investigation in the potential utility of bile acid-like pheromones in the restoration of Pacific Lamprey populations may be warranted (see Li et al. 1995; Bjerselius et al. 2000; Yun et al. 2003; Fine et al. 2004).

Rearing/Ammocoetes.—Eggs hatch in graveled upstream areas and newly emerged ammocoetes (larvae) drift downstream to silt areas (Stone and Barndt 2005). Ammocoetes remain in stream and metamorphose in 4–7 years (Beamish 1987). Ammocoetes are filter feeders, diets consisting of detritus, diatoms and algae (Hammond 1979; Potter 1980). Ammocoetes have been observed in Salmon and Steelhead carcasses (R. Lampman, OSU; T. Whitesel, USFWS; A. Brumo, Stillwater Science; personal communication) which could be part of their diet but more likely the ammocoetes are eating microorganisms growing on the carcasses (A. Brumo, Stillwater Science, personal communication). Downstream movement happens year round. Due to poor swimming ability, movement is probably driven by flow conditions and velocities (Moursund 2002). Movement is mostly nocturnal (Beamish and Levings 1991; Moursand et al. 2000; White and Harvey 2003) and correlated with discharge but not temperature (Hammond 1979; Potter 1980; Beamish and Levings 1991; Close et al. 1995).

At larger scales, larvae are most abundant where the stream channel is relatively deep (0.4–0.5 m), gradient is low (<0.5%), and the riparian canopy is open (Torgerson and Close 2004). Pacific Lamprey ammocoetes have been found residing in sediments under 16 m of water in the mainstem Columbia and Willamette rivers (Jolley et al. 2010; Jolley et al. 2011). Ammocoetes rear in areas located near reaches where spawning occurred (Pletcher 1963). At finer scales, larval occurrence corresponds positively with low water velocity, pool habitats, and the availability of suitable burrowing habitat (Roni 2002; Pirtle et al. 2003; Torgersen and Close 2004; Graham and Brun 2005). Ammocoetes of all sizes are known to use slow depositional areas along streambanks and burrow into fine sediments mixed with organic matter and detritus during rearing periods (Pletcher 1963; Lee et al. 1980; Potter 1980; Richards 1980; Torgersen and Close 2004; Graham and Brun 2005; Cochnauer et al. 2006). Ammocoetes have been collected in beaver dams, reservoirs, mussel beds and the hyporheic zone (T. Whitesel, USFWS, personal communication), but it is unknown whether these are preferred habitats for ammocoetes.

Metamorphosis/Macrophthalmia.—The stages of metamorphosis have been described for Pacific Lamprey (McGree et al. 2008). McGree et al. (2008) followed ammocoetes through transformation from July to December; however, there may be regional differences in the duration of metamorphosis. Triggers for metamorphosis and the ability to predict it remain unknown. Migrating macrophthalmia have been collected in smolt traps and dams year round though more are thought to migrate from late fall to late spring (Close et al. 1995; Kostow 2002). Migration timing has been anecdotally correlated with rain or snow melt, distance from ocean, and elevation.

During metamorphosis, Pacific Lamprey move from fine substrate in low velocity areas to silt covered gravel in moderate current. When fully transformed they are found in gravel or boulder substrate where currents are moderate to strong (Beamish 1980; Potter 1980; Richards and Beamish 1981). During migration, macrophthalmia are thought to occupy the lower proportion of the water column (Close et al. 1995; Moursund et al. 2000; White and Harvey 2003). Other studies such as Moursund et al. (2003) found juvenile lamprey distributed throughout the depths of the water column. This is probably because they lack a swim bladder and cannot regulate their location in the water column (Moursund et al. 2000). There is a regional data gap on the habitat needs of macrophthalmia based on migration distances. Macrophthalmia that migrate greater distances must deal with greater habitat variations. The estuarine and nearshore habitat requirements for macrophthalmia are also unknown.

Ocean Phase/Macrophthalmia to Adult.—Metamorphosed individuals migrate from parent streams to the Pacific Ocean (Orlov et al. 2008). Onset of parasitic feeding is unknown, although macrophthalmia have been observed attached to salmonids in both fresh and varying concentrations of salt water (C. Luzier and G. Silver, USFWS, personal communication), presumably as they were migrating to ocean environments. Adults are parasitic on fishes, attaching and feeding on body fluids and blood. They parasitize a wide variety of ocean fishes, including Pacific salmon, *Oncorhynchus* spp.; flatfish such as, *Pleuronectes* spp. and *Platichthys* spp.; rockfish, *Sebastes* spp.; Pacific Hake *Merluccius productus*; and Walleye Pollock, *Theragra chalcogramma* (USFWS 2004a). It is unknown how hosts are chosen, if there is a preferred host, when they attach, how long they are attached, what stimulates release from a host, or when and where lamprey initiate free swimming migration. The parasitic stage may last 20–40 months (Lee et al. 1980).

Although little is known about ocean distribution rangewide their spatial distribution has been described for the North Pacific (see Orlov et al. 2008). Pacific Lampreys are geographically found in their greatest concentrations in the Bering Sea, Navarin Cape, the Koryak shelf, East Aleutian Islands, and the west coast of the USA (Orlov et al. 2008). Time spent in the marine habitat for adults is thought to be 6 months to 3.5 years (Kan 1975; Beamish 1980; Richards 1980). They have been caught at depths ranging from 90–800 m and at distances greater than 100 km offshore in ocean haul nets (Close et al. 2002; USFWS 2004a; Orlov et al. 2008). Orlov et al. (2008) analyzed trawl surveys and commercial trawling, which were carried out using bottom and variable–depth trawls for regions of the North Pacific for the period 1975–2007. They found that the overwhelming majority of Pacific Lamprey catches occurred on the shelf and continental slope waters. Results of bottom trawl data showed that about 80% of the Pacific Lamprey were caught at depths of less than 500 m and for pelagic trawls about 83% of all the

catches occurred at depths of less than 200 m (Orlov et al. (2008). These results provide evidence that Pacific Lamprey primarily occupy the upper 100 m pelagic zone and were occasionally found at depths of 500 m or greater (Beamish 1980; Orlov et al. 2008). Pacific Lamprey apparently make daily vertical migrations from the ocean bottom into the pelagic zone, presumably to feed (Orlov et al. 2008). The authors' hypothesize that the lamprey vertical movement may be related to the vertical migration of the Alaska Pollock (lamprey's prey), which has characteristic vertical feeding migrations during the day (Orlov et al. 2008). It is unknown what habitat adult lamprey use when between hosts. Adults are preyed upon by sharks, sea lions, and other marine animals during their ocean phase (USFWS 2004a). After feeding and growth, adult lamprey transition from the ocean to fresh water for spawning.

Ecology

Pacific Lamprey are an important part of the ecosystem, contributing to food web dynamics, acting as a buffer for salmon from predators, and contributing important marine nutrients to inherently nutrient-poor watersheds (Close et al. 2002; CRITFC 2008).

Larval Pacific Lamprey can make up a large portion of the biomass in streams where they are abundant, thus making them an important component along with aquatic insects in processing nutrients, nutrient storage, and nutrient cycling (Kan 1975; Close et al. 2002). Larval lampreys process nutrients by filter feeding on detritus, diatoms, and algae suspended above and within the substrate (Hammond 1979; Moore and Mallatt 1980). They are efficient at trapping food; however, they have low food assimilation rates. The material that is undigested by the lamprey is processed into fine particulate matter which is then exported from the system or taken up by other organisms such as filter feeding insects (Merritt et al. 1984). In addition, adult lamprey die after spawning, leaving the marine-derived nutrients in freshwater streams (Beamish 1980).

Pacific Lamprey appear to be a choice food for avian, mammalian, and fish predators, and at times may be preferred over salmon smolts (Close et al. 1995; Stansell 2006 cited in CRITFC 2008). Ammocoetes and macrophalmia migrating downstream may buffer salmonids from predation by birds, mammals, and other fishes (Close et al. 2002). For example, lampreys comprised 71% by volume of the diets in California gulls, ringbill gulls, western gulls, and Fosters tern in the mainstem Columbia River during early May (Merrell 1959). Past predation rates on salmon smolts by avian and aquatic predators in the Columbia River basin may have been reduced by historically large numbers of outmigrating lampreys (Close et al. 2002). Also, ammocoetes and macrophalmia become available to predators, including salmonids, during scour events, emergence, and downstream migration.

Adult lamprey returning upstream are an important food for freshwater fishes, birds, and mammals. They may also be an important buffer for migrating adult salmonids from marine mammal predation. Lamprey are relatively easy for marine mammals to catch, have high caloric value, and they migrate in schools (Close et al. 1995). Caloric values for lamprey range from 5.92 to 6.34 kcal/g wet weight (Whyte et al. 1993); whereas salmon average 1.26 to 2.87 kcal/g wet weight (Stewart et al. 1983). The most abundant dietary item in seals and sea lions in the Rogue River, Oregon was found to be Pacific Lamprey (Roffe and Mate 1984). Declines of Pacific lamprey may increase marine mammal predation on salmonids.

Population Structure

To date, three genetic studies have evaluated the broad scale population structure of Pacific Lamprey. Goodman et al. (2008) investigated population structure of Pacific Lamprey from Central British Columbia to Southern California through restriction fragment length polymorphism (RFLP) and sequence analysis of the mtDNA. In this study, no significant population structure was identified among populations or regions, indicating a high level of historical gene flow. Higher proportions of drainage-specific or “private” haplotypes were identified in southern regions, but were present in a low number of samples and therefore the implications on Pacific Lamprey population structure are equivocal. Likewise, Lin et al. (2008a) investigated the nuclear genome using amplified fragment length polymorphism (AFLP) analyses among populations from Northern California to Alaska and Japan. This data also suggests significant levels of historic gene flow among populations. The results of these two genetic studies on Pacific Lamprey indicate high levels of historic gene flow identified among collection localities, even those separated by large geographic distances (Northern California to Japan). Docker (2011) investigated population structure of Pacific Lampreys at 21 locations between British Columbia and Southern California using microsatellite analyses. Similar to Goodman et al. (2008), levels of genetic differentiation were low among sites. However, refinement in genetic differentiation techniques in the future may alter this paradigm.

When interpreted on an evolutionary timescale these data indicate a shared evolutionary history and a lack of reproductive isolation. Several components of the available data suggest the possibility of some geographic population structure: 1) higher number of private haplotypes in southern regions; and 2) significant differences in AFLP frequencies among collection localities.

Threats and Reasons for Decline

Pacific Lamprey face a variety of threats to its various life history stages, and no single threat can be pinpointed as the primary reason for their apparent decline. Threat include artificial barriers to migration, poor water quality, predation by native and nonnative species, stream and floodplain degradation, loss of estuarine habitat, decline in prey, ocean conditions, dredging, and dewatering (Jackson et al. 1996; Close et al. 1999; BioAnalysts, Inc. 2000; Close 2000; Nawa et al. 2003).

Passage (dams, culverts, water diversions, tide gates, other barriers).—Artificial barriers impact distribution and abundance of Pacific Lamprey by impeding upstream migrations by adult lamprey and downstream movement of ammocoetes and macrophthemia (Close et al. 1995; Vella et al. 1999; Ocker et al. 2001; Lucas et al. 2009). Upstream adult migrations are blocked by dams without suitable passage alternatives or attraction to fish ladder entrances (Moser et al. 2002). Fish ladders and culverts designed to pass salmonids can block lamprey passage, particularly if they have sharp angles that lamprey cannot attach to (Keefer et al. 2010) and high water velocities (Moser et al. 2002; Mesa et al. 2003). Culverts and other low-head structures that have a drop at the outlet are impassable for a variety of reasons including high velocities or distance, insufficient resting areas, and lack of suitable attachment substrate (CRBLTWG 2004). Pacific Lamprey populations persist for only a few years above impassable barriers before becoming locally extirpated (Beamish and Northcote 1989).

Downstream migrating macrophthalmia and drifting ammocoetes are often entrained in water diversions or turbine intakes (Moursund et al. 2001; Dauble et al. 2006). Juvenile lampreys have shown high survival through the juvenile salmonid bypass system at Columbia River mainstem dams (Moursund et al. 2002), but the lamprey are often inadvertently collected and transported downstream in barges or trucks with salmonid smolts. It is unknown whether this is detrimental to lamprey (Moser and Russon 2009). However, observations made by a fish technologist on the transportation barge included rapid dewatering and resulting stranding of ammocoetes and macrophthalmia, potential predation in the hold, and potential injuries similar to descaling of salmon smolts (M. Barrows, USFWS, personal communication). Due to their size and weak swimming ability (Sutphin and Hueth 2010), ammocoetes and macrophthalmia can be impinged on turbine screens (Moursund et al. 2002) and irrigation screens (Ostrand 2004) resulting in injury or death. Irrigation screens can also cause migration delay in macrophthalmia as they attach to the screen infrastructure, avoid contact with the screen and take up long residence times (Ostrand 2004). Outmigrant lamprey travel deeper in the water column (no air bladder) compared to salmonids, therefore, traditional spill gates block passage (Moursund et al. 2003).

Passage barriers affect the amount of marine-derived nutrients available to the basin which influence primary productivity of food sources available to ammocoetes. They also affect other threats to lamprey, such as water quality, predation, toxicity, decreased habitat availability, and stream and floodplain degradation.

Dewatering and StreamFlow Management (reservoirs, water diversions, instream projects).—Rapid fluctuations in reservoir and stream water levels from irrigation diversions, power hydropeaking and instream channel activities strand ammocoetes in the substrate and isolate them from flowing water (J. Brostrom, USFWS; J. Crandall, Wild Fish Conservancy; E. Egbers, WDFW; personal communication; Douglas County PUD 2006 http://relicensing.douglaspud.org/documents/pud_relicensing_documents/downloads/SR/EffectofWaterLevelFluctuations.pdf). Suitable habitat for juvenile lamprey is often at stream margins in areas of low velocity with fine substrate and canopy shading (Claire 2003; Pirtle et al. 2003; Graham and Brun 2005; Torgerson and Close 2004), which are the first areas dewatered when stream flows drop. Juvenile lamprey do not segregate themselves by age (King et al. 2008) so a single event can affect multiple year classes, significantly impacting a local lamprey population. Channel reconstruction or barrier removal projects targeting the restoration of Pacific salmonids can result in rapid and sometimes extensive dewatering of existing channels, stranding juvenile lamprey. Salmonid salvage prior to reconstruction projects has not typically included efforts to rescue ammocoetes which may emerge from the sediment well after salvage/rescue efforts cease and no water remains in the channel.

Nests are often found in low gradient stream reaches, in gravel, and at the tailouts of pools and riffles (Mattson 1949; Pletcher 1963; Kan 1975). These areas are vulnerable when flows drop suddenly, which is common during irrigation season and power hydropeaking. Nests are desiccated when this occurs.

Low flows during summer and fall can impede adult lamprey migration by restricting flow into an exposed, shallow river channel or creating a thermal block. Lamprey movement at all life stages is predominantly nocturnal (Beamish and Levings 1991; Moursund et al. 2000; Chase

2001; White and Harvey 2003); consequently, flow reductions during daylight will inhibit lamprey from moving into more suitable habitat as they will be reluctant to leave a dark, secure area.

Stream and Floodplain Degradation (channelization, loss of side channel habitat, scouring).—Lamprey spawn (Mattson 1949; Pletcher 1963; Kan 1975), and rear (Pletcher 1963; Potter 1980; Richards 1980; Torgeson and Close 2004; Graham and Brun 2005) in low gradient stream reaches with complex channel structure, pools, and riffles, and adjacent stream margins and side channels with finer sediment and detritus. These features are frequently found in lower gradient areas with wider floodplains, which are popular for development. The loss of these habitats reduces areas for spawning and rearing.

Riparian vegetation is an important component of ammocoete rearing areas. Pirtle et al. (2003) found that ammocoetes were collected where canopy cover was 71.8% on average; however, they were observed over a wide range of cover from 7.5% to 100%. In Idaho, the amount of riparian vegetation and shading was positively correlated with ammocoete abundance (Claire 2003) and loss of these features would likely negatively impact lamprey.

Eggs and ammocoetes from many lamprey species that rear in stream substrates have been impacted by activities that remove silt and fine substrate from the stream such as excavation, mining, or dredging activities (Beamish and Yousan 1987; King et al. 2008). Excavation by heavy equipment can remove high numbers and several age classes of juvenile lamprey (King et al. 2008). Suction dredging has been an effective sampling technique (Bergstedt and Genovese 1994; Steeves et al. 2003; G. Silver, USFWS, personal communication) but not enough is known about its effect on lamprey populations. However, any spoils not filtered, and instead removed from the water, will remove any lamprey within them (King et al. 2008). Dredging activities associated with irrigation screen maintenance can also remove ammocoetes (J. Crandall, Wild Fish Conservancy; and E. Egbers, WDFW, personal communication).

Legacy effects from past practices associated with log drives in rivers are still being observed in several streams in the Pacific Northwest (R. Lampman, OSU, personal communication). The legacy effects on fish habitat include lack of slow water refuges and deep pools, lack of sediment deposition and a more flashy hydraulic system where sediment budget retention rates are low (R. Lampman, OSU, personal communication).

Water Quality (Water temperature, chemical poisoning and toxins, accidental spills, chemical treatment, sedimentation, non-point source).—Water temperatures of 22°C have been documented to result in mortality or deformation of eggs and early stage ammocoetes under laboratory conditions (Meeuwig et al. 2005). Water temperature of 22°C or higher is often a common occurrence in degraded streams during the early-to-mid-summer period of lamprey spawning and ammocoete development.

Ammocoetes are relatively immobile in the stream substrates and can concentrate in areas of suitable habitat that include many age classes (King et al. 2008) making them susceptible to chemical spills or chemical treatment (e.g. rotenone) targeting other species. Bettaso and Goodman (2010) investigated mercury concentrations of larval lampreys (ammocoetes;

Entosphenus spp.) and western pearlshell mussels *Margaritifera falcata* in the Trinity River, California to determine whether these two long-lived and sedentary filter feeders show site-specific differences in uptake of this contaminant. Ammocoetes contained levels of mercury 12 to 25 times those of mussels from the same site in Trinity River (Bettaso and Goodman 2010). The Pacific Lamprey ammocoetes were also found to have 70% higher mercury levels in a historically mined area when compared to a non-mined reference reach (Bettaso and Goodman 2008). Their data indicate that ammocoetes may be a preferred organism to sample for mercury contamination and ecological effects compared with mussels in the Trinity River. Other chemicals of concern include PCBs, pesticides and other heavy metals, but the threat of these is not well assessed. Pacific Lamprey adults sampled in the Willamette River had levels of dieldrin, total PCBs and arsenic that were above acceptable tissue concentrations, and as a result consumption guidelines were recommended to Siletz Tribal members (ODHS 2005). More study is needed to determine potential impacts of elevated toxins on Pacific Lamprey.

The effects of low dissolved oxygen levels, eutrophication, or turbidity on Pacific Lamprey are unknown.

Harvest/Overutilization.—Pacific Lamprey harvest for food or commercial purposes may present a threat if these activities are concentrated on rivers with low population numbers. Harvest of lamprey can change population structure and alter distribution, thus reducing population numbers. Legal harvest of adults and ammocoetes occurs in California and Alaska.

Predation.—Native and non-native fish, marine mammals, and birds, prey upon Pacific Lamprey (Close et al. 1995; Moyle 2002) and may pose a threat to lamprey abundance, particularly in altered habitat. As Pacific Lamprey migrate through reservoirs and their associated dams, they may be more susceptible to predation. American mink, birds, raccoons, various fish, and other species feed upon ammocoetes (Semakula and Larkin 1968; Galbreath 1979; Beamish 1980; Wolf and Jones 1989). Adult lamprey are eaten by otters, sea lions, seals, and sturgeon (Roffe and Mate 1984), and northern pike in Alaska (Betsy McCracken, USFWS, personal communication). Concentrations of Stellar sea lions in recent years below Bonneville Dam in the Columbia River have been observed consuming large quantities of Salmon, White Sturgeon *Acipenser transmontanus*, and Pacific Lamprey, although the impact of predation has not been quantified. In the North Umpqua River, blue heron were often observed in areas where tagged adult Pacific Lampreys were holding below the Winchester Dam, and raccoons and mink were observed feeding on larval Pacific Lamprey during the dewatering of the Dam (Ralph Lampman, OSU, personal communication). Native fish species known to prey upon Pacific Lamprey are Northern Pikeminnow *Ptychocheilus oregonensis* and Sacramento Pikeminnow *P. grandis* (Russ Belmer, CDFG, personal communication). Non-native fishes such as bass, *Micropterus* spp.; sunfish, *Lepomis* spp.; Walleye, *Stizostedion vitreum*; Striped Bass, *Morone saxatilis*; and catfish, *Ictalurus* spp. have become established over the last century in some rivers in the western U.S.

Disease.—Information pertaining to Pacific Lamprey disease is limited; however, some adults have been collected and the samples analyzed for a spectrum of potential pathogens by the USFWS Lower Columbia River Fish Health Laboratory in the 1990–2003 period (Cochner et al. 2006). The pathogen that causes furunculosis, *Aeromonas salmonicida*, has been detected in

lamprey in the Columbia River Basin (Cummings et al. 2008) and western Oregon. The causative agent for bacterial kidney disease (BKD), *Renibacterium salmoninarum*, was also found in Pacific Lamprey sampled in the ponds at Entiat National Fish Hatchery in Washington (J. Evered, USFWS, personal communication). The impact of these diseases in lamprey is currently unknown; however, in general, disease may influence lamprey health and reduce their ability to reproduce and survive. Finally, a basic understanding of the pathology of lampreys is lacking. *Aeromonas salmonicida* (the causative agent of furunculosis) and *A. hydrophila* are known to infect adult Pacific Lamprey (Cummings et al. 2008; Clemens et al. 2009; CRBLTWG 2011), and *Renibacterium salmoninarum* has been shown to reside in Sea Lamprey (Faisal et al. 2006) but no infection was found in directly challenged Pacific Lamprey adults (Bell and Traxler 1986). Virtually no information is available on the pathology of larval and juvenile Pacific Lamprey. Future research directed at direct disease challenges of Pacific Lamprey with pathogens of concern (e.g., infectious hematopoietic necrosis virus [IHNV] or BKD) may provide information related to the ability to larval lamprey to serve as vectors of transmission.

Small Effective Population Size.—Effective population size (N_e) is important for assessing conservation and the management of fishes (Rieman and Allendorf 2001). The loss of genetic diversity and the degree of inbreeding within a population is related to the rate of genetic drift that is measured by N_e (Wright 1969). As a result, maintaining populations large enough so that these effects are minimized has become an important goal for ESA-listed species (McElhaney et al. 2000). The potential effects of the various and commonly cited threats to Pacific Lamprey have the potential to lead to reductions in population size (Rieman and McIntyre 1993; Rieman et al. 1997) and therefore in N_e . A significant loss of genetic variation can influence population demographics, dynamics, and ultimately the persistence of populations via inbreeding depression, loss of phenotypic variation and plasticity, and loss of evolutionary potential. Although data on the effective population size is lacking for Pacific Lamprey it is recognized as a critical need (CRBLTWG 2005) for the conservation and enhancement of populations. In this assessment we use adult abundance (N) as a surrogate for N_e , because presently there are no studies that estimate the ratio of $N_e:N$ for Pacific Lamprey.

As Pacific Lamprey adults are attracted to ammocoete pheromones (Fine et al. 2004) as seen in other lamprey species (Li et al. 1995; Bjerselius et al. 2000; Vrieze and Sorensen 2001; Fine et al. 2004), low numbers or a lack of ammocoetes in spawning tributaries may result in reduced attraction of adults and therefore increase the chances of inbreeding.

Lack of Awareness.—A lack of awareness on the distribution of Pacific Lamprey and their preferred habitat use can have negative and unintended impacts to Pacific Lamprey when in-channel activities restoring habitat or passage for other species are implemented. For example, dewatering a stream to replace a culvert may strand ammocoetes, and use of heavy equipment to dig out channels can remove ammocoetes from the channel (Streif 2009; USFWS 2010). To date, Pacific Lamprey have rarely been included in the analysis of impacts of land management activities, such as stream alteration or channel dredging, simply because their presence and distribution is not known. Until recently, Pacific Lamprey were not considered in hydropower operations and relicensing. Identifying and overcoming funding bias and barriers to lamprey-friendly salmon restoration work is needed. Also, the negative impacts of Sea Lamprey from the Great Lakes have given all lamprey species a bad reputation. We are further understanding the

role of Pacific Lamprey as an important component of the ecosystem. To combat negative perceptions that many people have toward lamprey, information on the ecological and cultural benefits of native lamprey needs to be disseminated.

Ocean Conditions.—Given that Pacific Lamprey spend up to several years at sea to increase in weight and length prior to returning to freshwater to reproduce, it follows that direct and indirect actions to this environment may significantly influence the population. Actions that greatly effect lamprey, their prey species, or that alter the pelagic or substrate habitats to depths up to 500 meters may alter population demographics (Orlov et al. 2008). Nevertheless, additional research, evaluation and monitoring will be needed to determine how actions are reflected in the population.

Climate Change.—Climate change may exacerbate many of the threats listed above, especially flow, ocean conditions, water quality, diseases, predation, and stream conditions. Across the 20th century, the mean annual air temperature has risen by between 0.3°C and 0.6°C (IPCC 1996), and predictive models forecast continued increases in mean global temperatures (Kerr 1997; McCarty 2001). These increases in global climate temperatures during the 20th century have been linked to threats to species and populations, and it is theorized that these impacts will be accelerated given the current predictive models of future climate change (McCarty 2001). Ultimately, species adapted to current local conditions will face a set of ecosystem changes that can induce changes in the latitudinal and altitudinal range of populations (Brander 2007), collapses of populations that are unable to adapt to changing conditions (Pörtner and Knust 2007), asynchrony of cues necessary for animal migrations (McCarty 2001), and altered timing of biological events that coincide with seasonal changes in food availability (Wiltshire and Manly 2004). Climate change alone may threaten the conservation status of many populations and species (Daufresne and Boet 2007; Pörtner and Farrell 2009).

Other. —There are other factors that may be threats to Pacific Lamprey. Aquatic invasive species are a relatively new occurrence in the range of Pacific Lamprey (USGS 2010), and include New Zealand mudsnails, quagga mussels, zebra mussels, Asian clams, Eurasian water milfoil, Didymo, water chestnut and others. These species may encroach on available habitat, compete for food sources or affect lamprey in other ways not currently recognized.

Current Restoration Activities

As described in the introduction, there are a number of ongoing conservation and restoration activities that are directed at Pacific Lamprey or for other fish species that indirectly help address the threats to lamprey. The Pacific Lamprey Assessment and Template for Conservation Measures approach is to be inclusive of the other federal, state, tribal and county conservation measures and with the objective of yielding coordinated efforts throughout the range of Pacific Lamprey. We have summarized the ongoing conservation activities that are directly designed to address the threats to Pacific Lamprey or recovery activities for other listed species that indirectly address these threats. The details of ongoing and planned restoration activities are contained in the individual regional chapters.

Passage (dams, culverts, water diversions, tide gates, other barriers).—In the Columbia River Basin a large effort has been undertaken by the federal action agencies to improve passage

conditions for migrating adult lamprey at mainstem dams. Specifically, the NPCC has recommended that BPA and the USACE, in coordination with federal, state, and tribal fish managers: 1) identify specific fish passage structures; 2) identify operations at mainstem hydropower dams that delay, obstruct or kill migrating lamprey; 3) develop and implement lamprey passage aids at known passage obstacles; 4) monitor lamprey passage at mainstem hydropower dams to evaluate passage improvement actions and to identify additional passage problem areas; 5) assess lamprey passage efficiency, direct mortality, and/or other metrics relating to migratory success of lamprey; and 6) determine predation on lamprey during mainstem passage. Actions in place to address mainstem passage are modifications being made to fish ladders and entranceways at dams to improve the upstream passage of adults. Research has identified that modification to turbine screens may resolve impingement of juvenile lampreys on their downstream seaward migration. Lamprey passage structures that bypass the regular fishways, flow reductions, rounding of sharp corners, and screen modifications are examples of actions being taken to improve lamprey passage at mainstem dams. There has been significant activity in initiating actions in many of these areas, however much work remains to design structural or operational solutions to these mainstem dam passage obstacles and expeditiously implement these solutions at each of the dams. These findings and potential solutions may be applied more broadly across the range of Pacific Lamprey.

A large number of small barriers to passage such as culverts and small dams are being addressed through actions identified in National Marine Fisheries Service (NMFS) Salmon and Steelhead recovery plans and the USFWS draft Bull Trout recovery plans. In addition, there are evaluations of improved tide gate designs to address Salmon and Steelhead threats that have the potential to benefit lamprey passage. Other actions in place to address some of these passage threats are the removal of dams (e.g., Marmot Dam on the Sandy River) and culvert modifications or replacement.

There are numerous inventories that have been conducted or are in progress, throughout the western states, to identify fish passage barriers and water diversions. These inventories are used to prioritize work on all human-made fish passage barriers and unscreened or inadequately screened diversions to ensure compliance with state codes. These barrier removals will benefit lamprey. Research has been conducted to evaluate NMFS criteria screen material (for salmon) placed in a vertical configuration in a laboratory setting to test incidence of impingement and mortality of Pacific Lamprey macropthalmia at various velocities (Ostrand 2005). In addition, research is being conducted by USGS to evaluate the effectiveness of common fish screen materials to prevent entrainment of Pacific Lamprey ammocoetes. The findings of the research on screens should assist in the development of design and operational criteria for screened water diversion structures. The development of these criteria and the comprehensive inventories are a positive step for addressing these broad ranging threats to larval lamprey.

Dewatering and Flow Management (reservoirs, water diversions, instream projects.—

There are numerous watershed planning activities in the western states that help prioritize actions to address the threats from water quantity issues for aquatic species by undertaking an assessment of water supply and use within the watershed. A specific example is the Watershed Planning Act in Washington that requires plans to be developed that must balance competing resource demands. The plans are required to address water quantity by undertaking an assessment of water supply and use within the watershed. Elements that may be addressed in the

plans include instream flow, water quality, and habitat. Also, water transaction programs throughout the western states has been a valuable tool to save water in several tributaries by using permanent acquisitions, leases, investments in efficiency and other incentive-based approaches. Leaving water in the stream improves instream flows and temperature, and also provides more in-channel habitat during critical times. These efforts will assist in addressing the threats to Pacific Lamprey from effects of dewatering and flow management.

Water Quality (Water temperature, chemical poisoning and toxins, accidental spills, chemical treatment, sedimentation, non-point source).—The goal of the Clean Water Act (CWA) is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C §1251(a)). Under section 303(d) of the CWA, states, territories, and authorized tribes, collectively referred to in the act as "states," are required to develop lists of impaired waters. These are waters for which technology-based regulations and other required controls are not stringent enough to meet the water quality standards set by states. The law requires that states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDLs), for these waters. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards. Throughout the western states there are completed TMDLs for several Hydrologic Unit Codes¹ (HUCS) to identify measures to provide management direction for addressing TMDLs, specifically temperature and sediment. In addition, many states are invoking water quality standards, and plans to meet aquatic criteria.

EPA has issued a comprehensive plan to reduce toxic pollution in the Columbia River Basin. The plan tilts toward new monitoring and research programs, but also calls for more stringent water quality standards and more restrictions on water discharges, as well as greater attention to toxics in air emissions and contaminated site cleanups. EPA and a working group developed the Columbia River Basin Toxics Reduction Action Plan ("Action Plan"). This action plan builds off the State of the River Report and identifies 5 major initiatives to accomplish toxics reduction in the Columbia River Basin. In the EPA 2009 Strategic Plan, the program established numeric targets for wetland restoration, sediment clean up, and toxics reduction in fish and water to reach over the next 5 years. This plan should help prioritize actions to address some of the threats to rearing lamprey juveniles.

Stream and Floodplain Degradation (channelization, loss of side channel habitat, scouring).—Current protection of fish resources in most western states is achieved in partnership with landowners, cities, counties, tribes, states, other federal agencies, and others through voluntary conservation efforts and under various laws and regulations. Most of the Salmon recovery plans outline activities that have occurred, are currently being implemented, and are planned, to address habitat threats from channelization, loss of side channel habitat, and scouring. While these actions and plans are targeted towards anadromous salmonids, several of the activities will benefit lamprey species. Many of the states are engaged in watershed planning processes, which provide fish, wildlife, and habitat information to local governments, state and

¹ Hydrologic Unit Code is a system assigning bodies of water into a hydrologic unit. Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system (region, subregion, accounting unit and cataloging unit). For example, the Columbia River (17), Snake River (06), Clearwater Basin (03) and Lochsa River (03) 4th field HUC would be 17060303.

federal agencies, private landowners, consultants, and tribal biologists for land use planning purposes. There are also watershed planning processes, salmonid recovery activities (e.g., site specific restoration projects), and other conservation efforts underway throughout the states that focus on: 1) protection of intact ecosystem processes, structures, and functions; 2) restore ecosystem processes, structures, and functions; 3) reduce sources of water pollution; 4) work effectively and efficiently together on priority actions; and 5) build an implementation, monitoring, and accountability management system. While plans and reports focus on salmonids and restoring the stream and floodplain, many of the recommended future restoration activities identified will benefit lamprey species.

A Best Management Practices document for Pacific Lamprey was issued in 2010 by the USFWS and the U.S. Forest Service (USFWS 2010b), so that this advice can be incorporated into any stream disturbing activity (e.g., aquatic habitat restoration, prescribed fire, recreational development, grazing, gravel extraction/mining, water diversions, etc.) on lands managed by the Forest Service and Bureau of Land Management throughout the range of Pacific lamprey. In addition, this information can help other federal, state, tribal and private land managers to implement stream disturbing activities that afford protection for individual lamprey and lamprey populations.

Harvest/Overutilization.—It is currently illegal to sport-fish for or possess lamprey for bait in the states of Oregon, Washington, and Idaho. A bag limit of 5 fish was imposed by CDFG for adult lamprey in 2010. These measures have restricted the harvest of Pacific Lamprey and help reduce this threat.

Translocation.—Translocation can be defined as the movement of wild-caught fishes from one place to another within their known range (George et al. 2009). It is commonly applied when freshwater habitats have been restored but cannot be re-colonized naturally. This management action is an important component of the conservation of imperiled fishes to prevent extinction or population loss and is being conducted more frequently as the number of imperiled fish increase. Translocation of adult Pacific Lamprey is a tool for reintroduction, augmentation, and as an interim measure while primary limiting factors (e.g., mainstem passage) are addressed in the longer term. In the case where long standing impassable barriers are being removed, translocation of adult lamprey may be necessary to start the restoration process in these areas. Translocation is one of the potential tools to be used in the broad geographic restoration of Pacific Lamprey. However, there are potential risks that have been identified with this restoration tool. A number of authors (George et al. 2009; CRBLTWG 2011) have identified risks that should be considered when implementing translocation and these include: disruption of any connection between stock structure and particular watersheds, if one exists; moving fish to areas with substantial limiting factors; introduction of pathogens and diseases and decreases in abundance from donor areas.

The translocation model for lamprey is predicated on the attraction of adult migratory fish to areas where juvenile fish are abundant, probably via a unique pheromone. This migratory mechanism for Pacific Lamprey should be supported by population genetic evidence and results of population genetic studies that are not indicative of multiple within basin stocks (Goodman et al. 2008; Lin et al. 2008a, b). In addition, although Goodman et al. (2008) concluded that there

is high gene flow among Pacific Lamprey along the west coast, they found a high (about 30%) but non-significant frequency of a rare haplotype in the Fraser River; this haplotype was found in less than 1% of the Pacific Lamprey from other locations. This suggests that there may be some degree of reproductive isolation between lampreys spawning in the Fraser River and those spawning in other locations. Recent work by Docker (2010) used nine newly-developed microsatellite markers (Spice et al. in press) to determine if there is broad-scale population structure in Pacific Lamprey populations. The results of this study indicate that Pacific Lamprey at most sites along the west coast of North America are not highly genetically differentiated from each other. Docker (2010) also found that although 56% of the pairwise comparisons for Pacific Lamprey were statistically significant, the majority (91%) show low levels of differentiation, i.e., F_{ST} values less than 0.05. This supports the hypothesis that generally Pacific Lamprey do not home to their natal streams, as homing results in significant reproductive isolation among groups spawning at different sites (Dittman and Quinn 1996). However, these results should be verified with samples from additional locations within large river systems to inform specific translocation projects.

Whether or not adult Pacific Lamprey home to their natal streams or are attracted by larval pheromones is unknown. The lack of this critical information reduces the certainty of translocation as a restoration approach for Pacific Lamprey populations. If there is no homing or pheromone attraction, the translocation of adults from a healthier population to one that is declining or to an area that has been extirpated will likely fail to produce an improvement in recruitment and production. If habitat degradation has occurred or a barrier is blocking the downstream migration of macrophthalmia and/or upstream return of adults, the translocation will likely have a low probability of success. If translocation fails, it could result in a decrease in the donor population.

The CRBLTWG has written a white paper outlining the benefits and risks of translocating lamprey and provide a summary of existing guidelines for Pacific Lamprey translocation (CRBLTWG 2011). The guidelines summarized in CRBLTWG (2011) have been approved by CBFWA and adopted by the Nez Perce, Umatilla, Yakama, and Warm Springs tribes for inclusion into the Draft Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin (CRITFC 2008). The guidelines correspond well with rules for propagation and translocation recently published by the American Fisheries Society (George et al. 2009) and also correspond well with guidelines established for translocation of living organisms by the International Union for Conservation of Nature (IUCN 1998).

A specific objective of the Draft Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin (CRITFC 2008) is to “supplement lamprey by reintroduction and translocation in areas where they are severely depressed or extirpated”. To date, translocation programs have been implemented by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and the Nez Perce Tribe (NPT). The Confederated Tribes of the Yakama Nation is also considering implementation of a pilot adult Pacific Lamprey translocation program from mainstem Columbia River hydropower projects into various subbasins, including an evaluation of methodology and potential biological benefits and risks (Confederated Tribes of the Yakama Nation 2008). The key to success for translocation projects as a restoration tool is to follow established guidelines, closely monitor the response of donor and source populations, and proceed cautiously with future translocations based on these results.

Climate Change.— Consistent with the U.S. Fish and Wildlife Service’s Climate Change Strategic Plan (USFWS 2010a), we have embarked on a process to assess how climate change will influence threats and how to plan science-based management actions that will help reduce the impacts on fish and their habitats (adaptation). The adaptive response to climate change is going to be a long process involving strategic conservation of freshwater and marine habitats for Pacific Lamprey, a future activity.

3. METHODS

General Description of Assessment Development

Western Lamprey Conservation Team (Team) and Steering Committee.—The USFWS formed an internal multi-office team in June 2004 to work on lamprey conservation partly in response to a petition to list four species of lamprey in 2003 and the planning of the first Columbia River Basin Tribal Lamprey Summit. The original mission of the Team was: "Through a variety of internal and external partnerships, we will facilitate the development of an 'on-the-ground' strategy to conserve native lamprey in the Pacific Northwest and California within the next 2 years and beyond. Our strategy will focus on improving our understanding of the life history and distribution of lamprey, restoring and stabilizing lamprey populations, and reducing adverse affects of existing infrastructure on lamprey populations. Our intent is to improve the status of lamprey throughout their range." Eight USFWS biologists from six offices, both Fisheries and Ecological Services, in Oregon, Washington, and Idaho formed the original Team. The current Team is comprised of eight biologists from seven USFWS offices, six Fisheries and one Ecological Services, in Oregon, Washington, Idaho, and California. Contact information for team members can be found on pages iii and iv of this Assessment. The primary responsibility of the team is to develop the Plan with the goal of restoring and sustaining Pacific Lamprey populations throughout their historical range by coordinating conservation efforts among states, tribes, federal agencies, and other involved parties.

The approach of the PLCI is a three part process: assessment and template for conservation measures (Assessment); conservation agreement; and implementation plan. The development of this document is based on voluntary involvement of various federal, state, and local governmental agencies, Pacific Rim countries, tribes, scientific institutions, consultants, non-profit groups, utility companies, private landowners and others. A steering committee made up of representatives from these partner organizations was formed in June 2008 (see iii in the Introduction). Duties of the steering committee include guiding the PLCI development process and review of PLCI products.

Pacific Lamprey Work Session.—The first official product was the proceedings from the PLCI Work Session that was held in October 2008 in Portland, Oregon. The purpose of the Work Session was to bring managers and scientists with various skills and expertise together to facilitate communication on the current status and ongoing efforts to conserve Pacific Lamprey and to begin development of the collaborative PLCI for populations in the United States.

The general objectives of the Work Session were: 1) to develop an outline of existing knowledge, data, and information about Pacific Lamprey; and 2) to identify uncertainties or knowledge gaps related to these topics. The Work Session was organized around four questions: 1) Pacific Lamprey biology; 2) conservation units and Pacific Lamprey population structure; 3) Pacific Lamprey habitat preferences; and 4) threats to Pacific Lamprey. A presentation outlining the information that is currently known about each topic was given to the whole group and participants were given a chance to ask clarifying questions. The large group then broke into smaller sections at which time they were asked to answer specific questions about these topics and provide data and references. Each small group was led by a facilitator who was responsible

for recording the information shared in the break-out sessions. This information was then compiled, checked for accuracy, and sent to the USFWS Team to develop draft proceedings. A draft of the proceedings was produced and sent to the Work Session participants for review. Comments were received and incorporated before the final proceedings document was completed (Luzier et al. 2009). One of the primary outcomes of the Work Session was the recommendation to develop a step-down process for collecting region-specific Pacific Lamprey information on population status and threats.

Regional Meeting Process.—In 2009 and 2010, the Team hosted a number of regional work sessions. The purpose of these meetings was to collect region-specific information on historic and current distribution; estimated abundance; trends in populations; the identification and prioritization of threats to Pacific Lamprey; identification of ongoing conservation actions and needs; and ongoing research, monitoring and evaluation activities and needs.

Following are the dates and locations of the regional meetings:

- July 2009 – Upper Columbia River and Snake River
- August 2009 – Upper Columbia River and Mid-Columbia River
- September 2009 – Northern and Southern California
- October 2009 – Lower Columbia, Willamette, Mainstem Columbia Rivers and Snake River and Puget Sound
- November 2009 – Alaska
- December 2009 – Coastal Oregon
- February 2010 – Coastal Washington
- October 2010 – Second Willamette River

We documented the information collected at the 4th Field Hydrologic Unit (HUC) (with the exception of California which used a broader scale, see the California regional chapter) on maps and a regional template. The template for collecting information at the 4th Field HUC was designed to consistently record the information collected. Participants in the regional work sessions were also queried about ongoing conservation actions and research in the region as well as needed conservation actions and research, monitoring, and evaluation (RM&E). These actions and RM&E were recorded for each region and in some cases prioritized. Due to time and information constraints, general conservation actions and research needs (in a number of cases identified in other lamprey or salmonid plans) are listed in the regional chapters in lieu of specific ongoing regional actions and needs for Pacific Lamprey. The area covered in each regional chapter and the EPA Level III Ecoregions that they include can be seen in Figure 3-1. Ecoregion Descriptions are found in Appendix A.

Information collected at the regional meetings was used to develop the regional components of the Assessment which includes: assessing the relative risk to lamprey persistence by watershed; prioritize threats; identification of actions to be taken to improve Pacific Lamprey abundance, distribution and habitat; and identify research, monitoring and evaluation needs.

Background and Context for Methods

Lampreys are among some of the most poorly studied groups of fishes on the west coast of the United States, despite their diversity (numerous species) and presence in many rivers including coastal streams (Moyle et al. 2009). It has been recognized that a systematic evaluation of lamprey status (Luzier et al. 2009; Moyle et al. 2009), in particular the anadromous form of the species, is lacking. Lampreys are an important dietary and cultural component of the Native American tribes of the west coast of the United States (CRITFC 2008; Petersen Lewis 2009), but have not been historically important to commercial or recreational fisheries of the west coast, likely explaining the paucity of information on abundance and distribution collected by state and federal agencies. Although the USFWS efforts herein reflect primarily the river lifestages most likely to be affected by human activity, we recognize and emphasize that future effort and resulting actions should be inclusive of lamprey's salt water life history stage.

This lack of information for anadromous lamprey appears to repeat across the globe. Thiel et al. (2009) identify that more detailed information is urgently needed about the status of River Lamprey *Lampetra fluviatilis* and Sea Lamprey, especially in their estuarine, coastal and offshore marine habitats. For instance, for the southern Baltic Sea, there is no complete description of the past and present distribution or a detailed analysis of the temporal and spatial development of the commercial catches in these areas. Thiel et al. (2009) stressed that studies would be important to define conservation requirements for anadromous lampreys in the southern Baltic Sea and as a basis to determine if rebuilding programs for these species are necessary, and where and how they should be implemented. Through a systematic assessment using available information, they identified that restoring habitat connectivity by the removal of barriers or installation of fish passage would restore access to spawning and nursery areas for River Lamprey. Kelly and King (2001) identified that three species of lamprey (Sea, River, and Brook *Lampetra planeri*) recorded in Ireland had limited detailed scientific information to assess the distribution, status, habitat use and conservation requirements. Information was largely composed of known spawning locations, with little literature on direct aspects of ecology. However, they reviewed extensive European and North American literature to provide a detailed and comparative account of lamprey ecology, particularly those river lifestages most likely to be affected by human activity, and identified areas where more information is needed to form a basis for decision-making regarding conservation requirements for lamprey species in Ireland.

Lampreys are considered to be endangered in much of Europe (Maitland 2003). Brook, River, and Sea Lamprey are listed under Annex II of the European Commission Habitats directive (92/33/EEC) and member states are obliged to create special areas of conservation for these lamprey species (Goodwin et al. 2008). During assessments, loss of larval habitat (Kirchhoefer 1996), migration barriers (Igoe et al. 2004; Goodwin et al. 2008) and water quality and habitat issues (Igoe et al. 2004) have been identified as causes for the decline of lamprey species in Europe and Great Britain. In Canada, a lack of information on the distribution and population sizes and trends of the native lamprey species exists (Renaud et al. 2009). They note that most lamprey species status have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and NatureServe conservation rankings have been applied to a number of lamprey species at the national and subnational levels (www.NatureServe.org, Master et al. 2003, Faber-Langendoen et al. 2009; Master et al. 2009). Pacific Lamprey in Canada have

not been ranked through NatureServe at the national level, but in British Columbia they have been ranked secure at the subnational level (Renaud et al. 2009). Moyle et al. (2009) conducted a systematic analysis using available information for lamprey in California. This approach used criteria that included aspects of lamprey biology, vulnerability to environmental change, and limiting factors; and they found that all species are either declining, in low numbers, or are isolated populations.

Most of these evaluations related to lamprey conservation around the world have been challenged with the scarcity of information on historic and current distribution, abundance, biology and ecology for anadromous lamprey species. However, a recurring approach to conservation for lamprey populations has been to pool information on populations, and to synthesize information on the biology, ecology, and habitat requirements for lamprey species of interest and other lamprey species. Most of these systematic analyses also focused considerable effort on specifically identifying the threats or limiting factors that are impacting the lamprey populations of concern. Many of the conservation plans and recommendations address threats that have been identified through these systematic evaluations that lacked a preponderance of data on lamprey distribution and abundance. The USFWS and partner agencies have applied similar systematic assessment approaches to evaluate aquatic species status and guide development of conservation plans (Lenstch et al. 2000; USFWS 2008). The USFWS has specifically used NatureServe to evaluate the relative conservation status of Bull Trout at a core area level (USFWS 2005, 2008). This systematic NatureServe approach of assessing an aquatic migratory species' status has been useful in evaluating status with limited information and accepted by the USFWS's partners.

Adelman et al. (2004) conducted a review of protocols for selecting species at risk in the context of viability assessments for the U.S. Forest Service. They reviewed nine published protocols (including NatureServe Ranking, USFWS Listing factors, International Union for Conservation of Nature (IUCN) classification system, and others). They concluded all were useful, but those that explicitly include threats analysis were most useful in determining which species were likely to be adversely affected by proposed management activities. The authors note that the best method for identifying and classifying risk will depend on the management scenarios proposed, the amount of data available, the time frame within which the assessment must be completed, and the scale at which the assessment is to be made (Lehmkuhl et al. 2001). Adelman et al. (2004) concluded the NatureServe Ranks may be the most suitable of the nine existing protocols for identifying species at risk on national forests because of the flexibility of scale, potential for use of existing information, and ability to integrate threats analyses.

Assessment Approach

As systematic approaches have been widely applied for assessing lamprey status (or other aquatic species with limited biological data) and informing conservation, we decided to apply this type of system to guide our conservation planning for Pacific Lamprey. Also, given the direction from our October 2008 workshop to provide step-down conservation guidance at regional levels, we decided to employ an approach that would provide consistency across the range and still accommodate regional needs. Our search for a process that was scientifically supported, well documented and widely used led us to apply the NatureServe Conservation approach to collect a suite of factors to assess the conservation of a species by evaluating the risk

of extirpation at discrete geographic groupings. The outcome of researching and recording information on the conservation factors is the assignment of a conservation rank with supporting documentation. By using a consistent approach to gathering data on these factors, we form the backbone of information to be used to assess risk and guide conservation measures.

We used a modification of the NatureServe ranking system (Faber-Langendoen et al. 2009; Master et al. 2009) for discrete geographic units (primarily watersheds at the 4th Field HUC, approximately 3rd Field HUC in California) to rank the risk to Pacific Lamprey relative to their vulnerability of extirpation. Data used to rank 4th Field HUCs consisted of updated information on population abundance, distribution, population trend, and threats to lamprey which were summarized by 4th Field HUC in the Subregional Template documents. These relative ranks of risk calculated for each 4th Field HUC were then summarized by regional area.

We conducted a structured evaluation of existing population data and threat information available to us in a variety of formats. We spatially evaluated Pacific Lamprey at discrete watershed units at the 4th Field HUC and larger regional groupings in order to assess overall patterns of risk and to identify any relative strongholds or weak areas for Pacific Lamprey conservation. We reasoned that a successful process would allow us to maximize use of data collected at the watershed levels, where the highest degree of specificity occurs and threats are most appropriately characterized. We then integrated the analysis into larger blocks for assessing risk in the larger conservation context. A strong point of this process was that it could be applied on multiple scales and would therefore be an appropriate tool for quantifying conservation risk of Pacific Lamprey.

Conservation Rank Approach

NatureServe and its member programs and collaborators use a suite of factors to assess the extinction or extirpation (regional extinction) risk of plants, animals, and ecosystems (or “elements” of biodiversity). By researching and recording information on a set of factors, biologists can assign a conservation rank to these elements at both global and regional (i.e., national/subnational) scales. The protocol for assigning a conservation rank is based on scoring an element against ten conservation factors, which are grouped into three categories based on the characteristic of the factor: rarity, trends, and threats. We chose this approach to rank the relative risk of Pacific Lamprey for various watersheds, given the lack of demographic information available across the range. Information for all ten conservation factors is not required to assign a rank. We used a modified suite of factors (seven) to assess the relative risk ranking of Pacific Lamprey by watershed throughout its range. The following seven factors were selected because of our ability to collect the required information for them over the majority of geographic populations.

The set of factors we used to assess Pacific Lamprey conservation status, by category, are:

- **Rarity Category**

1. **Range Extent** (historic distribution) – We used several strategies for obtaining historical distribution estimates throughout the presumed range of Pacific Lamprey. First, we reviewed the published literature and state and federal agency records and documents to determine if accurate, specific distribution records for Pacific Lamprey exist. Although a few publications do document species occurrence, information is

disjointed, incomplete, or absent. Through a series of discussions with biologists with the Columbia River Basin tribes and NMFS, the Team concluded that the historic spawning distribution of Steelhead (anadromous rainbow trout, *Oncorhynchus mykiss*) populations would represent a conservative estimate of the historic habitat available for Pacific Lamprey to spawn because both species use similar spawning habitat. The NMFS recovery planning process for listed Steelhead populations in the Columbia River Basin had estimated the intrinsic potential of the habitat to support historic Steelhead populations. These methods for intrinsic potential estimates are summarized in Sheer et al. (2009). As a result, the Team based historical distributions upon the Steelhead intrinsic potential (SIP) estimated through the NMFS Steelhead recovery planning process. The use of the SIP distributions appear best for estimating Pacific Lamprey historical distributions for the Columbia River Basin and many watersheds in Washington and Oregon. In many HUCs in the California Region and coastal Oregon watersheds, Coho Salmon distribution was used in addition to SIP as a surrogate for historic Pacific Lamprey range extent because of the similarity in those distributions. The estimate based on SIP and Coho distribution is considered conservative because the range extent of Pacific Lamprey may be even larger due to the fact that they are able to scale some natural barriers that block salmonids. There are some circumstances where lamprey distribution could be less than that estimated from Coho distribution and SIP because of life history requirements for lamprey. In addition to using these surrogate measures of range extent, we used the field experiences of experts (via regional meetings) to modify the estimated range extent (e.g., the location of traditional tribal fishing camps for lamprey in some of the watersheds).

2. **Area of Occupancy** (current distribution) – Current distribution data were provided primarily from experts within the field via regional meetings. Survey data/occurrences specific to Pacific Lamprey were recorded. Incidental data where species identification was not confirmed was noted as such. Additional information was collected from experts who were not in attendance at the regional meetings, from published literature, and state and federal agency records. Very few targeted Pacific Lamprey surveys have been conducted and therefore current distribution data are sparse.
3. **Population Size** – Several strategies were used for obtaining current abundance estimates throughout Pacific Lamprey’s presumed range. First, we reviewed the published literature and state and federal agency records and documents to determine if accurate, specific abundance records for Pacific Lamprey exist. Although a few publications do document species abundance, information is disjointed, incomplete, or does not exist. Second, we attempted to obtain specific information from experts within the field via regional meetings; however, some additional information was acquired following the meetings.
4. **Ratio of Area of Occupancy to Range Extent** – The ratio of current to historic distribution was calculated because of the uncertainty of historic distribution for Pacific Lamprey and our use of SIP and Coho Salmon distribution as surrogates. The

addition of ratio lets us factor in the risk associated with rearing and spawning in less spatially diverse areas. The Team placed much greater confidence or certainty on the value of this ratio for each region compared to the estimated values for each of the two factors separately.

- **Trends Category**

5. **Short-term trend** – The trend in population size over 3 lamprey generations (27 years). Generation time for a species or population is defined as the average age of adults when they reproduce.

- **Threats Category**

- 6.-7. **Threat Impact** (Generated by considering the scope and severity of the major threats. **Scope and severity are counted as one factor each**). The categories of threats we assessed have been described above or are described below. Major threat categories that were considered in the regional meetings are:

- *Passage (dams, culverts, water diversions, tide gates, other barriers).*
- *Dewatering and Flow Management (reservoirs, water diversions, instream projects).*
- *Stream and Floodplain Degradation (channelization, loss of side channel habitat, scouring).*
- *Water Quality (Water temperature, chemical poisoning and toxins, accidental spills, chemical treatment, sedimentation, non-point source).*
- *Harvest/Overutilization.*
- *Predation.*
- *Translocation* – Risks identified by translocating lamprey are primarily from reducing the abundance of the donor population and the potential for disease transmission.
- *Disease.*
- *Small Effective Population Size.*
- *Lack of Awareness.*
- *Climate Change.*
- *Mainstem Passage (if applicable)* – see details in the mainstem passage section.

The values used to rank each of these categories are displayed in Table 3-1.

We attempted to collect quantitative information for lack of awareness, ocean conditions, and climate change. Little is known about the effects of these latter metrics on Pacific Lamprey; consequently those metrics were not included in the analysis and will require additional evaluation as more data becomes available.

We made the following changes to the default rank calculator values to better reflect the quality of the information for Pacific Lamprey demographics, trends and threats: 1) changed the weighting of the rarity factors (historic distribution, current distribution, population size and ratio of current to historic distribution) so all equal 1. The information on current distribution for Pacific Lamprey is not adequate to give it double weight. 2) added a new rarity factor, the ratio

of current to historic distribution, to decrease the weight of the historic distribution factor (since most of what we have for historic is SIP). The addition of this ratio lets us factor in the risk associated with rearing and spawning in less spatially diverse areas. This factor was also given a weight of 1, equal to both historic range extent and current distribution. 3) changed the relative weights of the three major categories (Rarity, Trends and Threats) from 0.65, 0.2 and 0.15 to 0.6, 0.1 and 0.3. This change increases the weight for threats from standard NatureServe ranks reflecting the fact that most of our information is on threats and our trend data is severely lacking (Table 3-2). Hence, our adjustments to the weights applied to the ranking factors reflects relative confidence in the data for those factors.

NatureServe has developed the 2009 version of the rank calculator to facilitate the process of assigning conservation status ranks through automation (NatureServe 2009). The updated ranking system and new calculator provide improvements for rank standardization by helping to increase the consistency, objectivity, and transparency of the conservation assessments, and facilitate maintenance of the ranks. A more detailed description of how conservation status ranks are calculated with the 2009 version of the rank calculator can be found in NatureServe 2009 and summary details of the score values used to calculate status ranks can be found in Appendix A.

Information on the conservation factors above was collected from participants at the regional meetings. A rank for each factor was determined by participant input using the NatureServe Rank Key (Table 3-1) and those data were entered into the NatureServe rank. In addition to factors being ranked, the uncertainty for each factor was categorized based on the following scale:

- “0” = No information available.*
- “1” = Best professional judgment based on expansion of data for other species (e.g., Steelhead).*
- “2” = Largely undocumented but based on extent of habitat, suspected barriers and/or anecdotal information.*
- “3” = Partial adult, juvenile, or nest survey data in one-half or less of the potential spawning and rearing habitat in the watershed.*
- “4” = Partial adult, juvenile, or nest survey data in more than one-half of the potential spawning and rearing habitat in the watershed with some estimate of error.*
- “5” = Comprehensive adult, juvenile, or nest survey data in more than 90% of the watershed incorporating some estimate of error.*

Threat data was also collected by consensus at the regional meetings. The scope and severity of several categories of threats were ranked as high, moderate, low, insignificant or unknown. Within each major category were subcategories (e.g., the passage category had dams, culverts, etc.). Specific information about issues in each threat category or subcategory was recorded (e.g., locations and installation dates of barriers). Additional threats that were applicable to a specific region were added as needed. The scope and severity of the major categories of threats were entered into spreadsheets. The NatureServe rank only accepts one overall ranking for scope and severity so the highest rank recorded for the major threat category was used for the risk assessment calculation.

Once assigned, scores for the individual factors within each of these categories are pooled and the resulting three summary scores are combined to yield an overall numeric score, which is translated into a calculated rank. The risk calculated for these HUCs is from the subnational NatureServe procedure (Masters et al. 2009). NatureServe definitions listed here are for interpreting NatureServe conservation ranks at the subnational (S-rank) levels. The following are the subnational (S) conservation ranks and rank definitions we used:

SX Presumed Extirpated.—Species or ecosystem is believed to be extirpated from the jurisdiction (i.e., nation, or state/province). Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered. (= “Regionally Extinct” in IUCN Red List terminology).

SH Possibly Extirpated.—Known from only historical records but still some hope of rediscovery. There is evidence that the species or ecosystem may no longer be present in the jurisdiction, but not enough to state this with certainty. Examples of such evidence include: (1) that a species has not been documented in approximately 20–40 years despite some searching or some evidence of significant habitat loss or degradation; or (2) that a species or ecosystem has been searched for unsuccessfully, but not thoroughly enough to presume that it is no longer present in the jurisdiction.

S1 Critically Imperiled.—Critically imperiled in the jurisdiction because of extreme rarity or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the jurisdiction.

S2 Imperiled.—Imperiled in the jurisdiction because of rarity due to very restricted range, very few occurrences, steep declines, or other factors making it very vulnerable to extirpation from the jurisdiction.

S3 Vulnerable.—Vulnerable in the jurisdiction due to a restricted range, relatively few occurrences, recent and widespread declines, or other factors making it vulnerable to extirpation.

S4 Apparently Secure.—Uncommon but not rare; some cause for long-term concern due to declines or other factors.

S5 Secure.—Common, widespread, and abundant in the jurisdiction.

The application of these calculated rank scores were not used to determine conservation status. The purpose of this assessment was to evaluate relative risk amongst geographic population groupings from population attributes and threats. These relative rankings are then used to systematically guide prioritizing potential conservation measures within a geographic grouping and among geographic groupings in a region. The ranking of secure would have the lowest relative risk and the rank of presumed extirpated would be associated with the highest relative risk.

Regional Group Summaries

Once the ranks were calculated for each geographic unit (approximately 4th Field HUC), the results were summarized by regional grouping. Maps by region were constructed to display the spatial arrangement of risk by watershed. The objective was to provide the range of ranks for the watersheds within a regional grouping, and to consider the spatial arrangement of risk levels for

these watersheds. In addition, the maps identified priority threats within these regional groupings that influence the risk rankings.

The next step was to identify ongoing conservation actions that may address these priority threats, and to determine gaps in addressing threats to Pacific Lamprey by regional groupings. In some of the regional groupings, actions to address the priority threats (that were not presently considered by ongoing conservation plans for lamprey or other fish species) were identified. In addition for each regional grouping, research monitoring and evaluation needs were identified to assess Pacific Lamprey status and assess the efficacy of conservation measures.

Table 3-1. NatureServe factors used to assess conservation rank, by category, and applied to Pacific Lamprey.

Rarity 1 Factor Group

Range Extent (Historic Distribution)

- Z = Zero (no occurrences believed extant)
- A = <100 square km (< about 40 square mi)
- B = 100-250 square km (about 40-100 square mi)
- C = 250-1,000 square km (about 100-400 square mi)
- D = 1,000-5,000 square km (about 400-2,000 square mi)
- E = 5000-20,000 square km (about 2,000-8,000 square mi)
- F = 20,000-200,000 square km (about 8000-80,000 square mi)
- G = 200,000-2,500,000 square km (about 80,000-1,000,000 sq mi)
- H = >2,500,000 square km (> 1,000,000 square mi)

Area of Occupancy

- X = Extinct (no occurrences extant)
- Z = Zero (no occurrences believed extant)
- A = <0.4 square km (less than about 100 acres)
- B = 0.4-4 square km (about 100-1,000 acres)
- C = 4-20 square km (about 1,000-5,000 acres)
- D = 20-100 square km (about 5,000-25,000 acres)
- E = 100-500 square km (about 25,000-125,000 acres)
- F = 500-2,000 square km (about 125,000-500,000 acres)
- G = 2,000-20,000 square km (about 500,000-5,000,000 acres)
- H = >20,000 square km (greater than 5,000,000 acres)

Rarity 2 Factor Group

Population Size

- | | |
|--|-------------------------------------|
| X = Extinct (no occurrences extant) | D = 1,000 – 2,500 individuals |
| Z = Zero, no individuals believed extant | E = 2,500 - 10,000 individuals |
| A = 1 - 50 individuals | F = 10,000 - 100,000 individuals |
| B = 50 - 250 individuals | G = 100,000 - 1,000,000 individuals |
| C = 250 – 1,000 individuals | H = >1,000,000 individuals |

Rarity 3 Factor Group

Ratio of Historic and Current Distribution (Values in percent of historic distribution)

- | | |
|-----------|----------|
| Z = 0.001 | E = 0.5 |
| A = 0.05 | F = 0.75 |
| B = 0.1 | G = 0.9 |
| C = 0.25 | H = 1.0 |
| D = 0.37 | |

Trend Factor Group

Short-Term Trend (Past 27 yrs or 3 generations whichever is longer)

- A = Severely declining (decline of >70% in population, range, area occupied, and/or # or condition of occurrences)
- B = Very rapidly declining (decline of 50-70%)
- C = Rapidly declining (decline of 30-50%)
- D = Declining (decline of 10-30%)
- E = Stable (unchanged or within +/- 10% fluctuation in population, range, area occupied, and/or number or condition of occurrences)
- F = Increasing (increase of >10%)

Table 3-1. (Continued). NatureServe factors used to assess conservation rank, by category, and applied to Pacific Lamprey.

Threats Factor Group

Threat Scope

- High = 71-100% of total population, occurrences, or area affected
- Moderate = 31-70% of total population, occurrences, or area affected
- Low = 11-30% of total population, occurrences, or area affected
- Insignificant = <10% of total population or area affected
- Unknown = Scope could not be determined

Threat Severity

- High = Near-total destruction of suitable habitat and/or functional loss of Pacific Lamprey from this watershed; (>100 years for recovery)
- Moderate = Long-term degradation or reduction of suitable habitat and/or functional loss of Pacific Lamprey from this watershed (50-100 years for recovery)
- Low = Reversible degradation of or reduction of habitat and/or measurable reduction of Pacific Lamprey in watershed (2-3 generations for recovery).
- Insignificant = Essentially no reduction or degradation due to threats or able to recover quickly from minor temporary loss (within 2 generations)
- Unknown = Severity could not be determined

Table 3-2. Weightings for individual factors and factor categories for Pacific Lamprey NatureServe Rank calculator.

Factor Category	Category Weight ^a	Factor	Factor Weight ^b
Rarity	0.6	Range Extent	1.0
		Area of Occupancy	1.0
		Population Size	1.0
		Ratio of Area of Occupancy to Range Extent	1.0
Trend	0.1	Short-term Trend	1.0
Threats	0.3	Threat Impact (scope and severity are separate factors that combine to form impact)	1.0

^a The category weights are used to calculate overall score from category sub-scores.

^b Factor weights are used to calculate category sub-score.

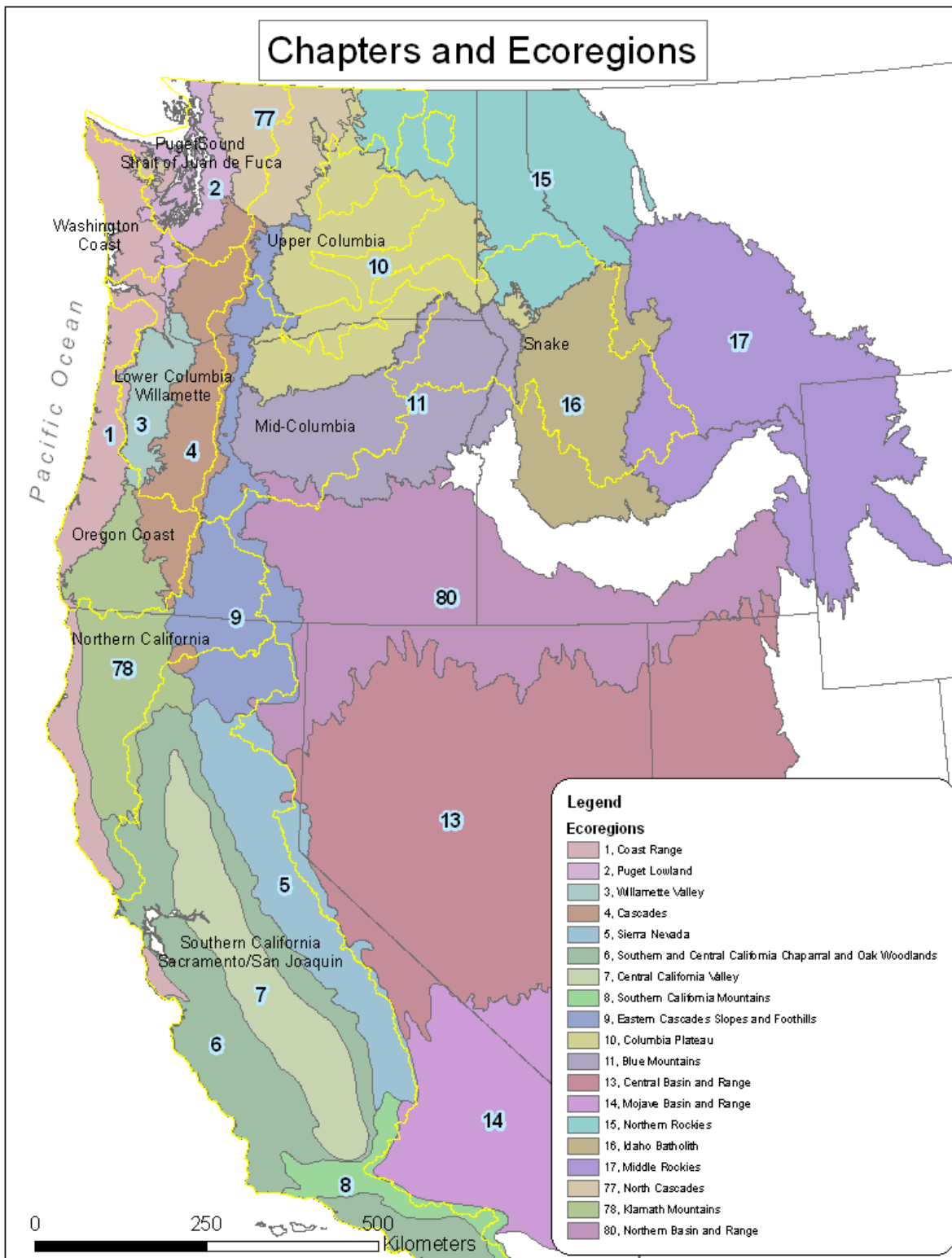


Figure 3-1. The area covered by each Regional Chapter and the EPA Level III Ecoregions within each.

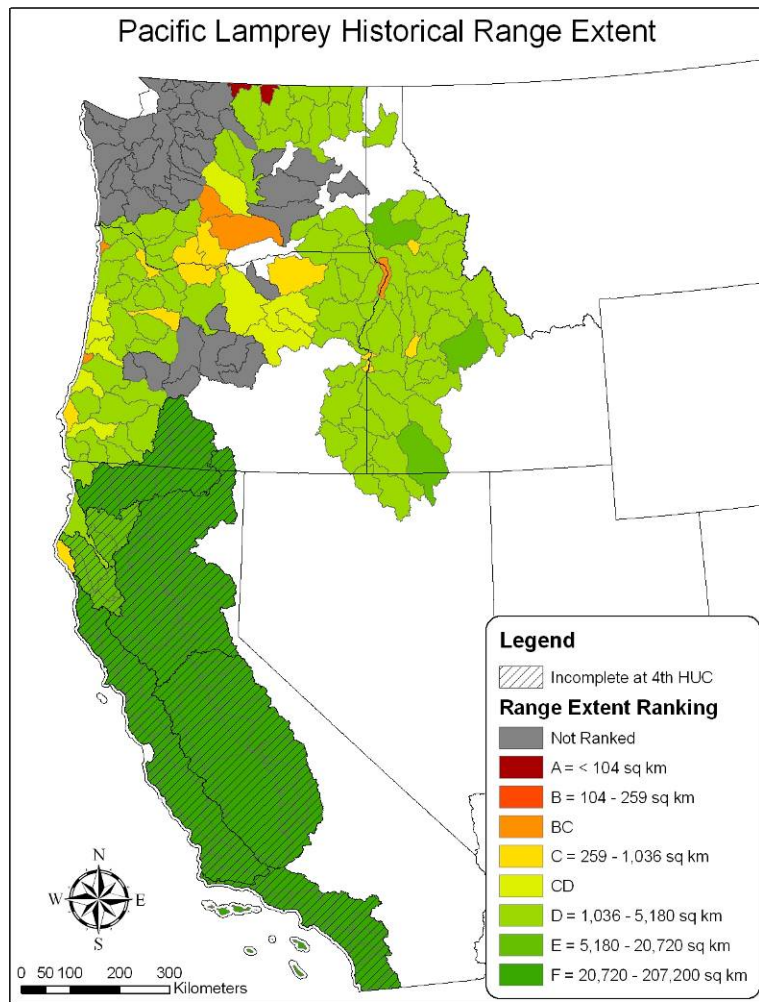
4. SUMMARY OF RISK ASSESSMENTS AND CONSERVATION NEEDS FOR PACIFIC LAMPREY

Rangewide

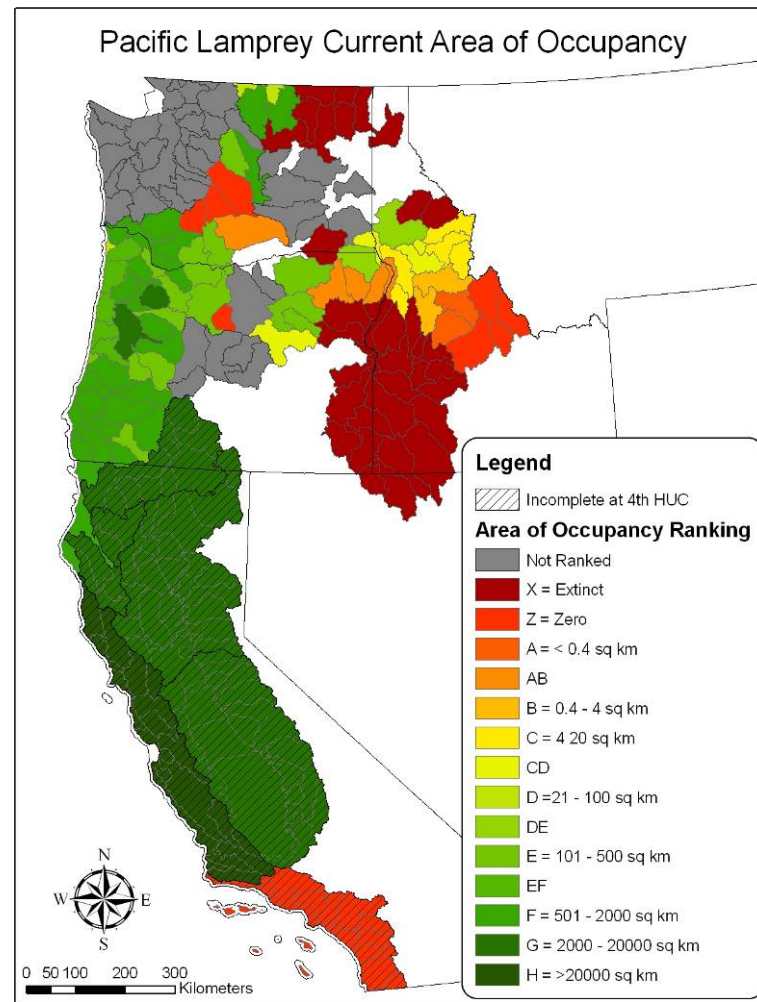
Demographic and threat information was collected for all regions except Alaska. This information was used to calculate NatureServe rankings, provide risk assessments and guide conservation measures for a majority of the regions. However, due to lack of time at regional meetings to collect demographic and threats information or a paucity of information, the risk assessment for the Puget Sound Region is not complete at this time. The information collected in California was completed at a larger geographic scale than we applied to other regions and future work will be focused on refining the data at the geographic 4th Field HUC scale. We attempted to summarize the initial draft risk assessment results for the California Region. We believe it is instructive to include the initial results of the NatureServe assessment to help guide the future data collection and risk assessments at a geographic scale that is better aligned with watershed management measures. This information is subject to change before it is finalized.

Historic Range Extent varied by HUC and by region (Figure 4-1a). The uncertainty with which it was determined was high because of lack of historical records for Pacific Lamprey. Nevertheless, the current occupancy rangewide (Figure 4-1b) appeared to be significantly smaller than historic range extent (Figure 4-1a) in most HUCs. Current occupancy also varied by watershed within regions. Uncertainty was high for this demographic as well because of few targeted lamprey surveys. Besides a few exceptions where extensive survey work has been completed, current occupancy was most often largely undocumented but based on extent of habitat, suspected barriers and/or anecdotal information. Due to decreases seen in current occupancy, the ratio of current occupancy to historic range extent (Figure 4-2) and population size (Figure 4-3) were estimated to be small rangewide. Short term trend (Figure 4-4) is thought to be declining in most HUCs rangewide. Cases where short term trend was categorized as stable are because the declines occurred more than 27 years (3 lamprey generations) ago.

The most serious threats rangewide included barriers to mainstem and tributary passage, stream and floodplain degradation, streamflow management and low water quality (Figure 4-5a and Figure 4-5b). Research and monitoring needs applicable to many populations are species identification, distribution, screening criteria, passage criteria, habitat preferences, and restoration. Actions and research in place to address these threats and critical uncertainties rangewide include, but are not limited to: 1) modifications to fish ladders and entranceways at major hydroelectric facilities; 2) culvert modifications and replacements; 3) restoration of side channels and floodplains; 4) consideration of lampreys during in-stream work (salvage operations); 5) water transactions; 6) water quality restoration



a)



b)

Figure 4-1. Historical Range Extent (a) and Current Area of Occupancy (b) of Pacific Lamprey. Data collection for Puget Sound has not been completed. California was not assessed at 4th Field HUC level.

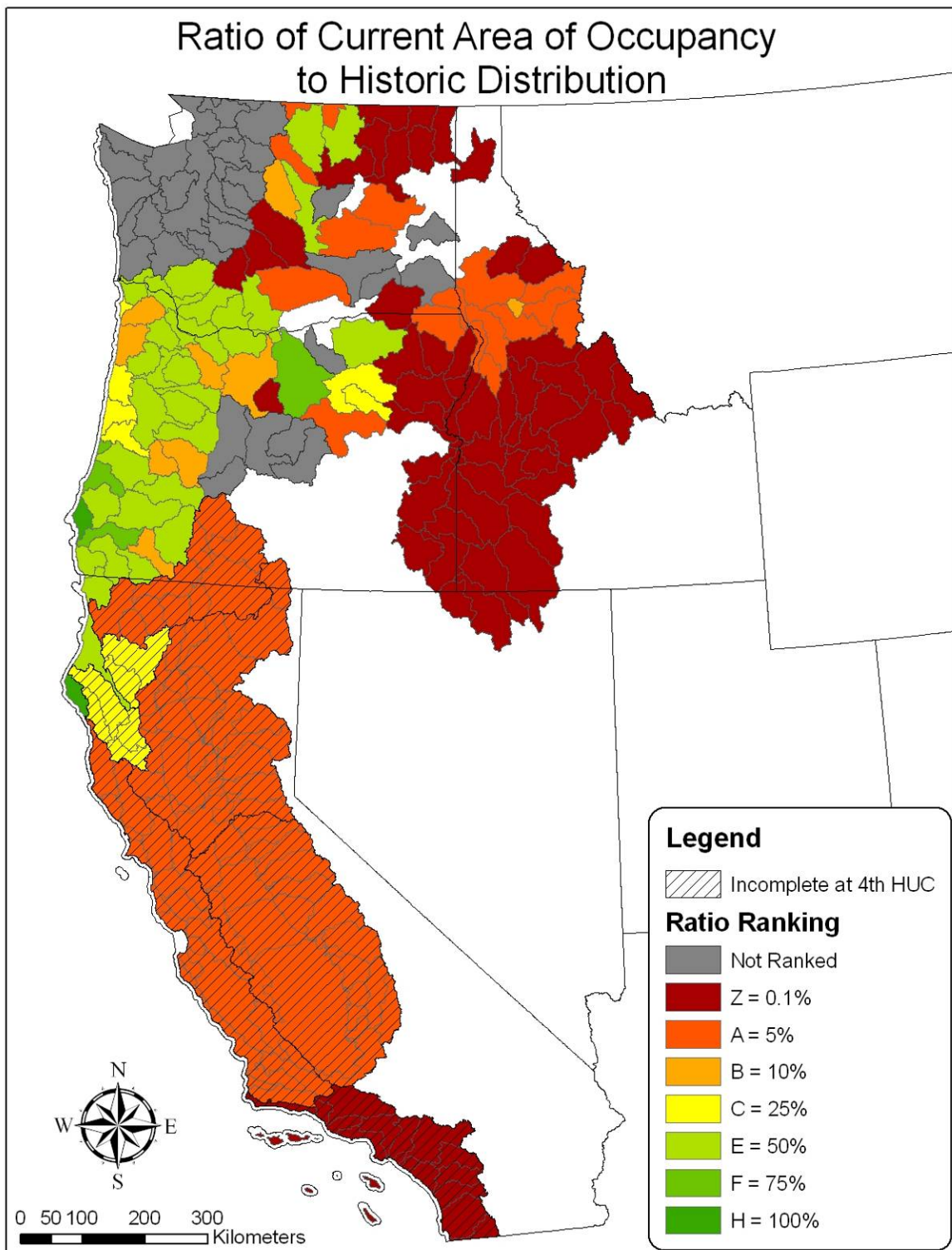


Figure 4-2. Ratio of Current Area of Occupancy to Historic Range Extent for Pacific Lamprey. Data collection for Puget Sound has not been completed. California was not assessed at 4th Field HUC level.

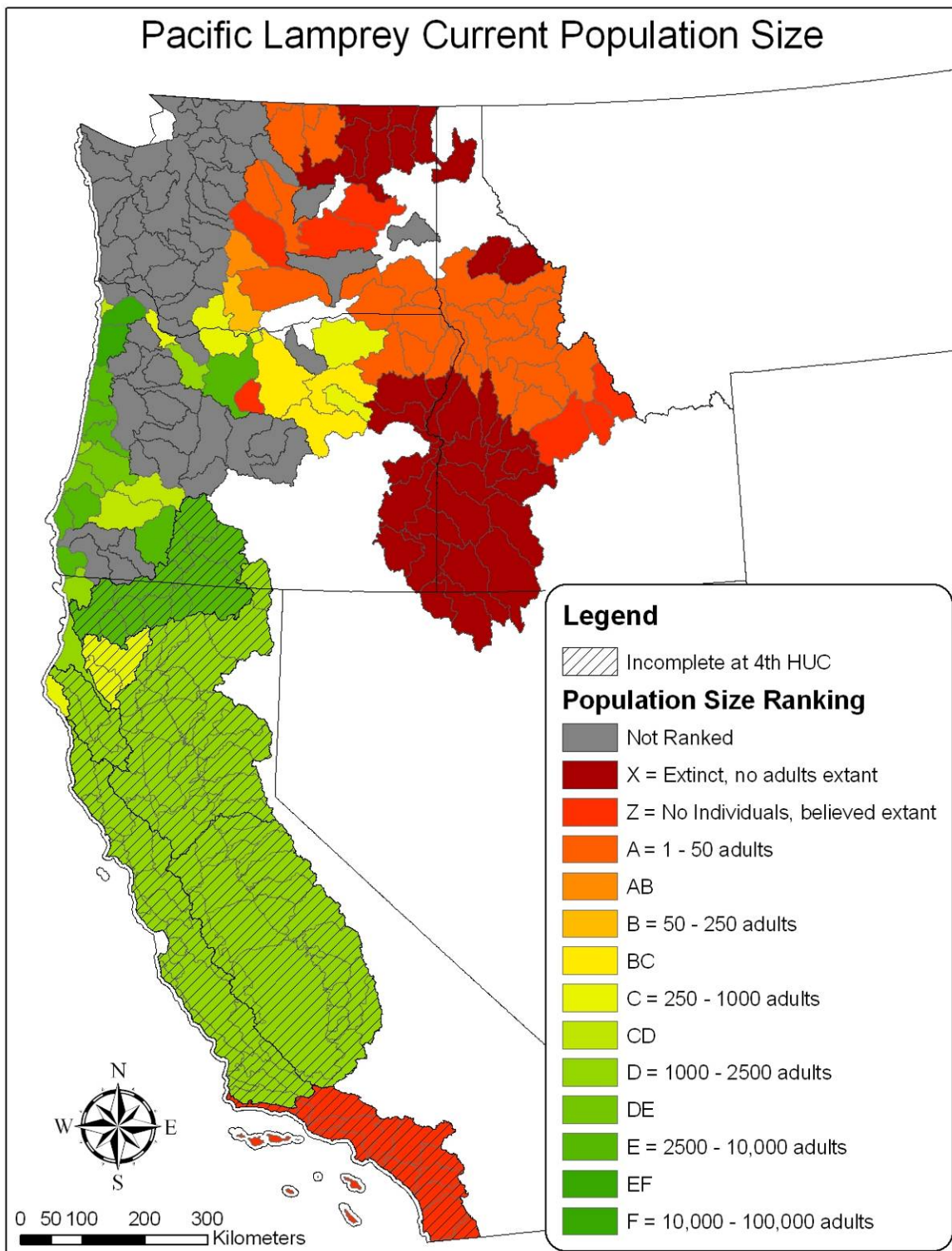


Figure 4-3. Current population size of Pacific Lamprey. Data collection for Puget Sound has not been completed. California data was not assessed at 4th Field HUC level.

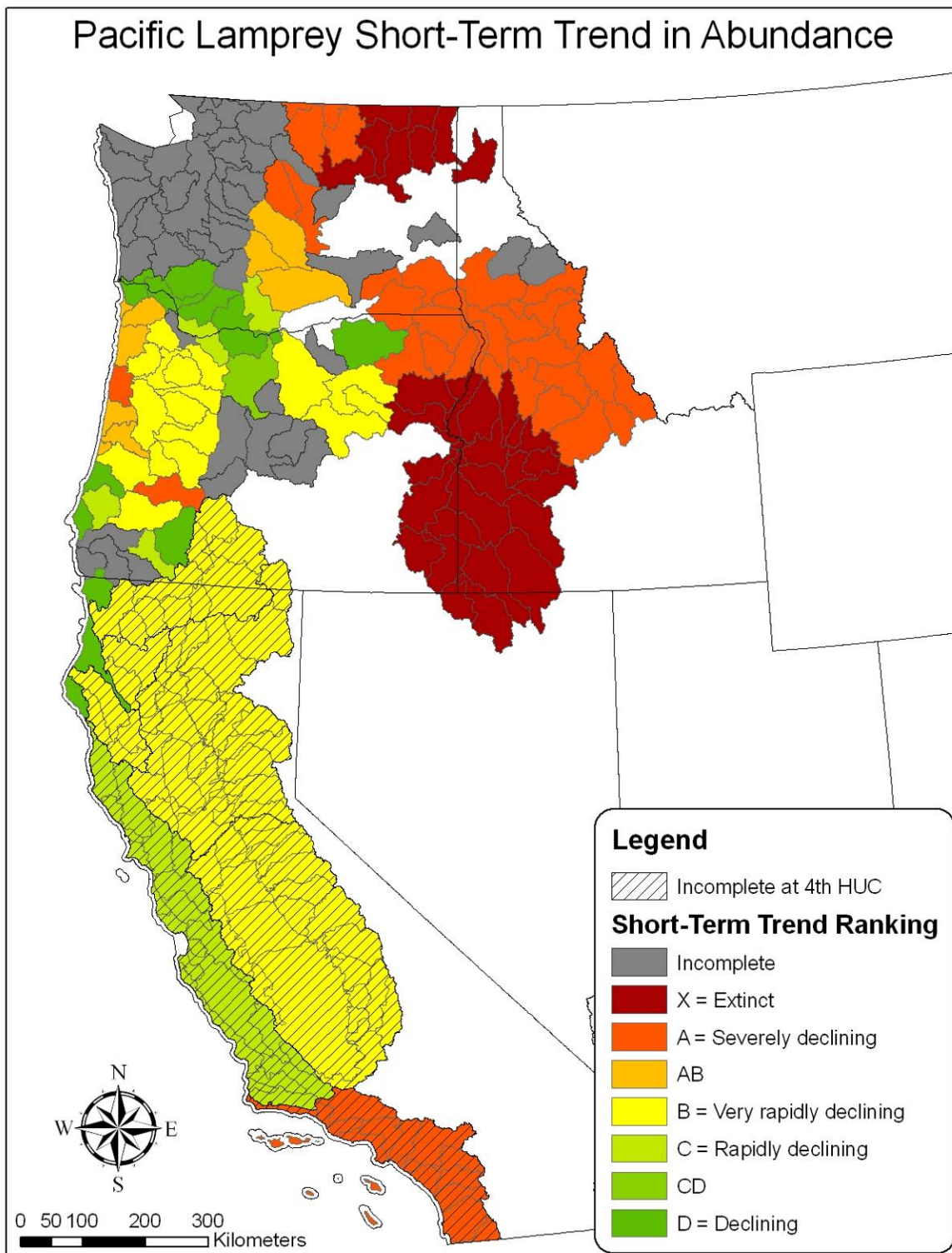
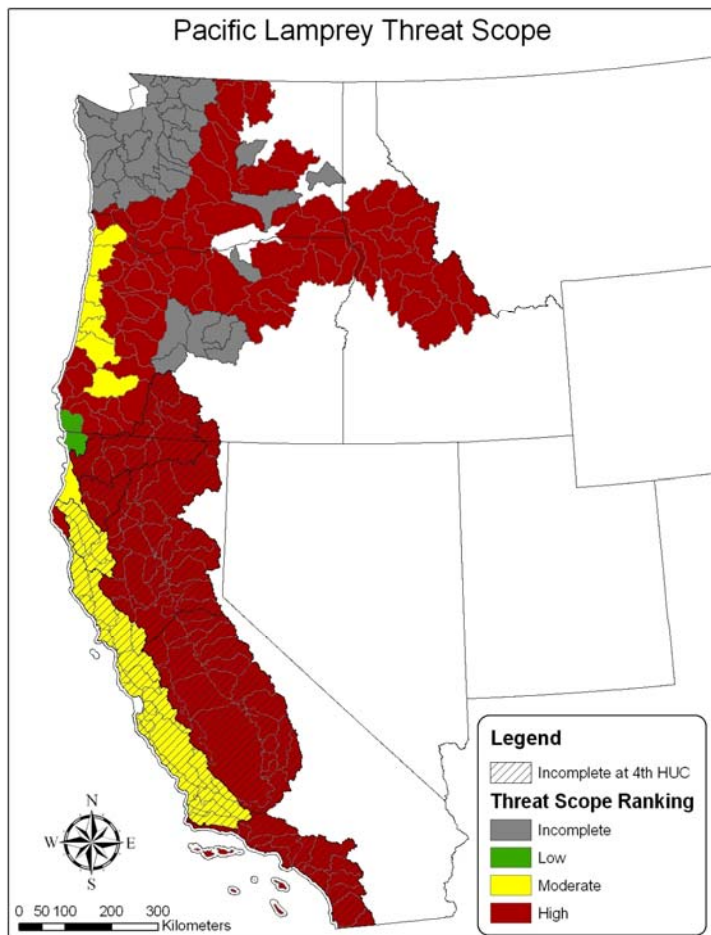
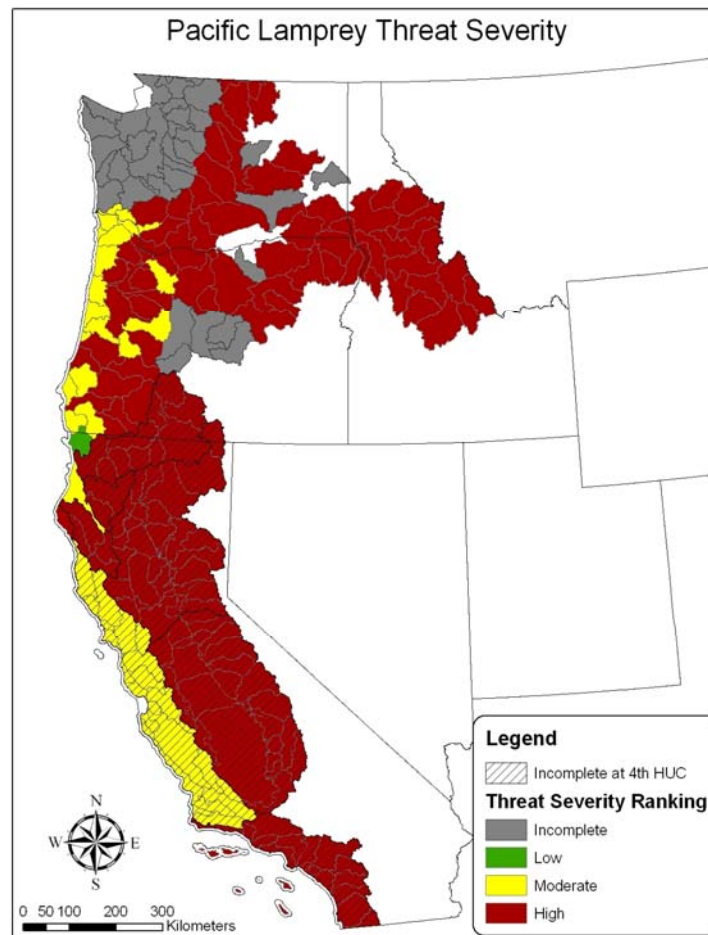


Figure 4-4. Short term trend in abundance of Pacific Lamprey. Data collection for Puget Sound has not been completed. California data was not assessed at 4th Field HUC level.



a)



b)

Figure 4-5. Identified threats by scope (a) and severity (b) to Pacific Lamprey. Data collection for Puget Sound has not been completed. California data was not assessed at 4th Field HUC level.

(sediments, toxicity studies, restoration of flow to reduce high temperatures; 7) identification guides for field biologists and smolt trap operators; and 8) lamprey specific surveys for distribution and habitat. These actions and research are being conducted irregularly throughout the range of Pacific Lamprey, more conservation actions and RM&E like those mentioned above need to occur rangewide

Based on the data collected to date, the results of the NatureServe rankings for Pacific Lamprey populations show that the highest relative risk ranking are those in the Snake River and Upper Columbia River regions (Figure 4-6). All of the HUCs in these areas are ranked at a high risk level. Additionally, there are no low risk populations nearby to aid in population re-establishment. Areas such as parts of the Mid-Columbia, the Lower Columbia and Coastal Oregon watersheds were ranked imperiled; again with no secure populations nearby to aid in re-establishment.

The following is a summary of population factors, threats, ongoing and needed actions and RM&E for each region. A more detailed summary of findings per region can be found in each regional chapter (chapters 5-14).

Puget Sound/Strait of Juan de Fuca and the Washington Coast

Historic Range Extent.—Only two HUCs in the Puget Sound and Strait of Juan de Fuca Region had sufficient information for a historical range extent to be determined. The Dungeness-Elwha was categorized as 1,000-5,000 km² and Crescent-Hoko was categorized as 250-5,000 km². Most HUCs in the Washington Coast Region were categorized as having a historical range extent of 1,000 – 5,000 km². One exception is the Grays Harbor HUC which was categorized as 250-5,000 km². The uncertainty associated with determining historic range extent in this area was high in most HUCs because of the lack of fishing records and dam counts for Pacific Lamprey. In most cases the uncertainty was categorized as “best professional judgment” based on expansion of data for other species.

Current Occupancy.—Current occupancy was estimated for five of the watersheds in this region. The Dungeness-Elwha is estimated at 500-2,000 km², and the Crescent-Hoko is estimated at 100-2,000 km². The Upper and Lower Chehalis and Willapa Bay all fell into the 20–2,000 km². All other HUCs in this region were not ranked for current occupancy because of lack of information. Uncertainty associated with current occupancy is high.

Population Size.—Population size was only ranked for three watersheds in this region. The Crescent-Hoko watershed fell into the 20-250+ category, the Upper Chehalis was in the 250-2,500 category and the Lower Chehalis was in the 1,000-2,500 category. Uncertainty was high.

Short Term Trend.—The Dungeness-Elwha and Crescent-Hoko watersheds were determined to have declined very rapidly in the last three generations (27 years). A decline of >70% is estimated. All other watersheds in this region were not ranked because of a lack of information.

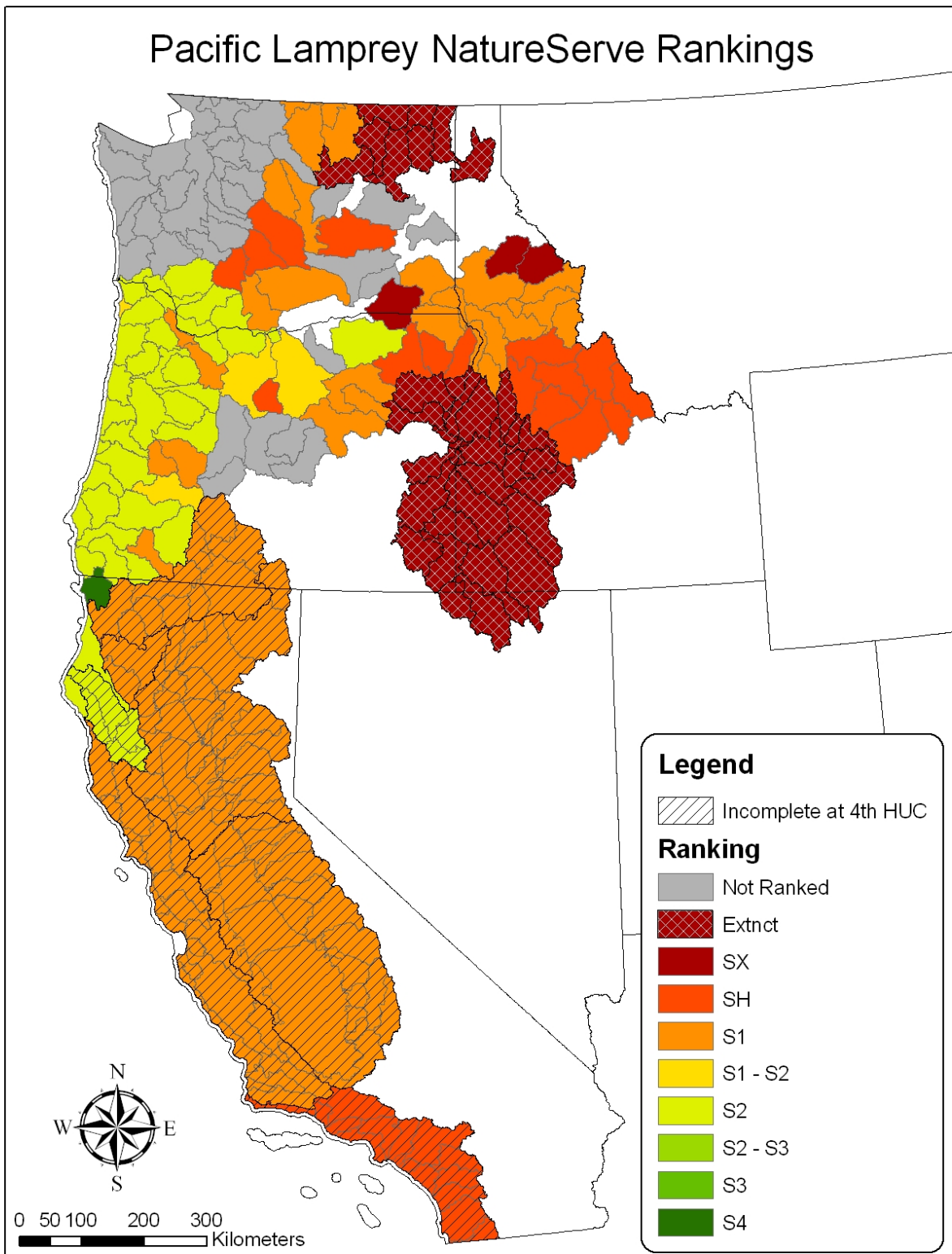


Figure 4-6. Calculated NatureServe relative risk ranks for Pacific Lamprey (see Tables 4-1 through 4-6 for details). Data collection for Puget Sound has not been completed. California data was not assessed at the 4th Field HUC level.

Threats.—Threats specific to the Skokomish, Dungeness-Elwha and Crescent-Hoko watersheds were identified but not prioritized. Threats include dams, impassable or partial barrier culverts and irrigation diversions; streamflow management (due to over appropriation of water); channelization, channel incision and loss of side channels, loss of estuarine habitat, diking, and water quality. No specific threat information was gathered for watersheds in the Washington Coast Region. General threats in existing salmonid limiting factors analysis and recovery plans were suggested as being applicable for Pacific Lamprey in this region

Risk Assessment.—Due to the lack of information on population and threat factors, HUCs in the Puget Sound/Strait of Juan de Fuca and Washington Coast Regions were not assessed with the NatureServe rank approach.

Ongoing and Needed Actions and Research Monitoring and Evaluation (RM&E).—Pacific Lamprey are listed as a Priority Species in Washington State. There are a number of ongoing actions that either directly or indirectly affect them. Salmon recovery plans, Salmon Recovery Funding Board, Washington Department of Natural Resources Habitat Conservation Plans, and Limiting Factor Analyses are examples of ongoing actions indirectly affecting Pacific Lamprey in this region. Fishing regulations, smolt trap monitoring, targeted lamprey surveys, and a field identification guide are examples of actions ongoing in the region that directly affect Pacific Lamprey.

Recommended conservation actions include restoration of stream and floodplain degradation and water quality, flow management, improving tributary passage, and more targeted lamprey distribution surveys.

Columbia River Region (Including Upper, Middle, Lower Columbia and Snake River Regions)

Historic Range Extent.—Most HUCs in the Columbia River Regions were categorized as having a historical range extent of 1,000 – 5,000 km² (Figure 4-1a). Exceptions include the Lower Clearwater and Upper Salmon watersheds in the Snake River Region which were categorized as 5,000-20,000 km². Several watersheds were significantly smaller at 250-1,000 km² (e.g., Middle Fork Clearwater – Snake, Umatilla – Mid-Columbia, Lower Yakima – Upper Columbia). Additionally, several watersheds had unknown historical range extent (e.g., Upper and Little Deschutes, Upper and Lower Crooked - Mid-Columbia; and Crab Creek, Chelan – Upper Columbia). The uncertainty associated with determining historic range extent was high in most HUCs because of the paucity of fishing records and dam counts for Pacific Lamprey. In most cases the uncertainty was categorized as “best professional judgment” based on expansion of data for other species (e.g., SIP).

Current Occupancy.—Current occupancy, or distribution, ranged from zero to 500-2,000 km² (Figure 4-1b). Current occupancy in the Lower Columbia River Region was primarily 500-2,000 km², Mid- and Upper Columbia watersheds had much smaller current occupancy ranging from extinct to 100-500 km² (with the exception of the Entiat watershed which was 500-2,000 km²). HUCs in the Snake River River had the smallest current occupancy with several thought to be extinct and most falling into the <0.4 to 0.4, 0.4-4 and 4-20 km² categories. Uncertainty of the

current occupancy data was most often categorized as “largely undocumented” but based on extent of habitat, suspected barriers and/or anecdotal information. Exceptions include the Lower, Middle and South Fork Clearwater and Lower Snake-Asotin watersheds in the Snake River Region. In these watersheds partial adult, juvenile, or nest survey data in one-half or less of the potential spawning and rearing habitat (with some estimate of error) were used to determine current occupancy. In the Walla Walla, Umatilla, Lower Deschutes and Trout Creek watersheds in the Mid-Columbia River Region and the Lower and Upper Yakima and Methow watersheds in the Upper Columbia River Region partial adult, juvenile, or nest survey data in more than one-half of the potential spawning and rearing habitat (with some estimate of error) were used to determine current occupancy.

Ratio of Current Occupancy to Historic Range Extent.—The ratio of current occupancy to historic range extent was low in most watersheds in the Columbia River Regions (Figure 4-2). Overall it ranged from 0.1% to 75% of historic range extent; however, most watersheds fell into the 0.1% to 10% categories. Umatilla, post supplementation, and the Lower Columbia watersheds were examples of HUCs that had 50-75% of historic range extent.

Population Size.—Population size, defined as the number of adults, ranged from presumed extinct to a high of 2500-10,000 in the Lower Deschutes – Mid-Columbia (Figure 4-3). Population size was unknown in all of the Lower Columbia River Region and three watersheds in the Upper Columbia River Region (Chelan, Upper and Lower Yakima). In the Snake River Region current population size was determined to be 1-50 in all watersheds except for the Lower and Upper North Fork Clearwater where they are presumed extinct. In the Upper Columbia River Region the majority of the watersheds were in the zero or 1-50 category with the exception of Wenatchee and Entiat which were estimated to be in the 250-1000 category. In the Umatilla watershed in the Mid-Columbia River Region, population size has increased from 1-50 adults to 250-1000 due to supplementation. Uncertainty for population size is the same as current occupancy because survey data was used to determine both.

Short Term Trend.—Short term trend was defined as the percent decline in the population over the last three generations (27 years). The Lower Columbia River Region had the lowest decline at 10-30%, excluding the Sandy which was estimated at 30-50%. The Upper Columbia River Region declines of 10% are for a longer timeframe than 27 years. Most other watersheds in the Columbia River have an estimated decline of >70% (Figure 4-4). The Umatilla watershed is the only one with a positive short term trend but this is due to supplementation. Umatilla population decline was estimated at >70% pre-supplementation versus 10-30% decline post-supplementation. The uncertainty associated with short term trend is the same as current occupancy and population size.

Threats.—The threats identified most often in watersheds in the Columbia River and Snake River Regions are mainstem passage, stream and floodplain degradation, water quality, dewatering and flow management, and tributary passage. Each HUC in the Columbia River Region had a threat that was ranked high in scope and severity (Figures 4-5a and 4-5b). Depending on where in the Columbia and Snake River system the watersheds are located, this suite of major threats and additional smaller scale threats impact Pacific Lamprey in varying combinations and degrees.

Risk Assessment.—For the Columbia and Snake River lamprey populations, the risk calculated for these HUCs (51 total) from the sub national NatureServe procedure (Masters et al. 2009) ranged from SX to S2 (Figure 4-6, Tables 4-1, 4-2, 4-3, 4-4). There were seven HUCs with an estimated rank of SX meaning the populations in these areas are presumed extirpated. The Upper and Lower North Fork Clearwater watersheds in the Snake River Region, the Walla Walla watershed in the Mid-Columbia River Region, and the Kettle, Colville, and Sanpoil in the Upper Columbia River Region fall into this category. Severe declines in population from serious threats have caused them to be extirpated from the HUCs. Sixteen HUCs were estimated to be at SH risk which means these lamprey populations are possibly extirpated. There is not enough evidence to say they are extirpated from the HUCs; however, lack of presence during surveying and impacts from serious threats indicate possible extirpation. Ten of the HUCs ranked SH were from the Snake River Region, four were from the Upper Columbia River Region, and one each were from the Mid- and Lower Columbia River Regions.

Twenty-four HUCs were estimated to be at a S1 risk level. This means that a majority of the HUCs fall into the category of imperiled, due to restricted range, few occurrences, steep declines, or other factors making them vulnerable to extirpation. HUCs ranked S1 were found in all areas of the Columbia River Basin, with the Snake River Region having 13, the Upper Columbia River Region seven and the Mid-Columbia River Region four. Two HUCs from the Mid-Columbia River Region were ranked a combination of S1-S2 and the remaining seven HUCs were ranked S2, imperiled. Five of six Lower Columbia River Region HUCs were included in this category as well as two HUCs from the Mid-Columbia River Region.

Ongoing and Needed Actions and Research Monitoring and Evaluation (RM&E).—Conservation measures and RM&E are ongoing throughout the Columbia River Basin. Distribution and habitat surveys, barrier removals and improvements, irrigation diversion fish screening, and general habitat restoration projects are positively impacting Pacific Lamprey in these regions. Needed actions and RM&E include passage improvements at mainstem and tributary dams (upstream passage and downstream passage and turbine screening), lamprey specific surveys, water quality improvements, stream and floodplain restoration, species identification workshops, and education and outreach. Needed actions and RM&E identified in the Draft CRITFC Tribal Restoration Plan (2008), USACE 10-year Passage Plan, Mid-Columbia PUD Pacific Lamprey Management Plans and the Columbia River Basin Lamprey Technical Workgroup critical uncertainties are applicable throughout the Columbia and Snake River regions.

Oregon Coast

Historic Range Extent.—Most HUCs in the Oregon Coast Region were categorized as having a historical range extent of 1,000 – 5,000 km² (Figure 4-1a). Several watersheds were significantly smaller at 250-1,000 km² (e.g., Siletz-Yaquina, Alsea, Sixes) and 100-250 km² (Necanicum and Siltcoos). The uncertainty associated with determining historic range extent was high in most HUCs because of the paucity of surveys, fishing records, and dam counts for Pacific Lamprey. In most cases the uncertainty was categorized as “best professional judgment” based on expansion of data for other species (e.g., Coho Salmon distribution and SIP).

Current Occupancy.—Current occupancy, or distribution, ranged from zero to 20-2,000 km² (Figure 4-1b). Current occupancy in the North Coast was primarily 100-2,000 km², South Coast watersheds had slightly higher occupancy predominantly ranging from 500-2,000 km². Regarding uncertainty, the current occupancy data was most often categorized as largely undocumented but based on extent of habitat, lamprey nest encountered during Coho Salmon redd surveys, suspected barriers and/or anecdotal information.

Ratio of Current Occupancy to Historic Range Extent.—The ratio of current occupancy to historic range extent was between 0.1-0.75 in most watersheds in the Oregon Coast Region (Figure 4-2). Overall current occupancy ranged from 10% to 99% of historic range extent. The North Coast of Oregon exhibited generally a much lower ratio (0.1 – 0.25) than in the South Coast (0.25-0.99).

Population Size.—Population size, defined as the number of adults, ranged from 250 to a high of 10,000 or greater in a number of South Coast HUCs (Figure 4-3). Population size was unknown in a number of South Coast watersheds (Middle Rogue, Applegate, Lower Rogue, and Illinois). Uncertainty of population size in the North Coast is primarily based on partial adult and nest survey data in one-half or less of the potential spawning and rearing habitat in the watershed. However, the uncertainty for population size in the South Coast is considerably greater for more watersheds, primarily ranging from “best professional judgment” based on expansion of data for other species, to unknown.

Short Term Trend.—Short term trend was defined as the percentage of decline in the population over the last three generations (27 years). The Oregon Coast Region decline ranged from >70% to as low as 10-30% (Figure 4-4). On average the North Coast watersheds exhibited steeper declines between <70% to 50%. The uncertainty associated with short term trend is the same as current occupancy and population size.

Threats.—The threats that were identified most often in the Oregon Coast Region watersheds are stream and floodplain degradation, water quality, dewatering and flow management, and tributary passage. Each HUC in the Oregon Coast Region had a threat that was ranked moderate in scope and severity (Figures 4-5a and 4-5b), with the exception of the Lower Rogue and Chetco that exhibited lower levels of threats. Watershed location affects the degree to which the suite of major threats, and additional smaller scale threats, impact Pacific Lamprey in varying combinations and degrees. The North Coast watersheds consistently exhibit moderate threats from stream and floodplain degradation in both scope and severity. The majority of South Coast watersheds exhibit moderate (or greater) stream and floodplain degradation threats in both scope and severity, and the most of these watersheds exhibit moderate (or greater) water quality threats in both scope and severity.

Risk Assessment.—For the Oregon Coast lamprey populations that inhabit the 4th order HUC watersheds, the risk calculated for these HUCs from the sub national NatureServe procedure (Masters et al. 2009) exhibited a narrow range (Table 4-5, Figure 4-6). The Oregon Coast risk categories ranged from S1 to S3 for the 18 HUCs inhabited by Pacific Lamprey. The majority of the HUCs were estimated to be at a S2 risk level (15 out of 18). A majority of the HUCs fall into

the category of imperiled, which is because of rarity due to restricted range, few occurrences, steep declines, or other factors making it vulnerable to extirpation from the HUCs. In the northern portion of the Oregon Coast the risk categories were estimated in a very narrow range between S2 and S1/S2 for the seven HUCs, with the majority categorized as S2. The southern portion of the Oregon Coast showed greater range of risk. The Chetco HUC exhibited the least risk at S3, which is vulnerable in the HUC due to a restricted range, relatively few occurrences, recent and widespread declines, or other factors making it vulnerable to extirpation. The Pacific Lamprey population that inhabits the Middle Rogue HUC exhibited the highest risk on the coast at S1, which is critically imperiled in the HUC because of extreme rarity or because of other factor(s) such as steep declines making it especially vulnerable to extirpation from the HUC.

Ongoing and Needed Actions and Research Monitoring and Evaluation (RM&E).—Ongoing actions in the Oregon Coast Region consist of salmonid recovery plans and restoration projects. Needed actions and RM&E include more lamprey specific surveys, water quality improvements, passage improvements and development of passage criteria for culvert replacements, instream work salvage operation guidance, and species identification.

California

The information collected in California is incomplete at the 4th field HUC and future work will be focused on completing this section. We attempted to summarize the initial draft risk assessment results for the California Region. We believe it is instructive to include the initial results of the NatureServe risk assessment at the approximately 3rd field HUC level to help guide the future data collection and risk assessments, although this information is subject to change before it is finalized. Citation of this information should be postponed to the release of the completed section anticipated to be in winter 2012.

Historic Range Extent.—Most HUCs in the California Region were categorized as having a historical range extent of 2,500 →10,000 km². However, the scale at which the information was collected was at a larger order HUC (3rd) than in other regions (4th). The uncertainty associated with determining historic range extent was high in most HUCs because of the paucity of surveys, fishing records, and dam counts for Pacific Lamprey. In most cases, the uncertainty was categorized as “best professional judgment” based on expansion of data for other species (e.g., anadromous salmonids).

Current Occupancy.—Current occupancy, or distribution, primarily ranged from 0-51,000 km². Current occupancy in the North Coast was primarily 500-51,000 km², Central and South of Pt. Conception, Sacramento, and San Joaquin watersheds had a similar range of occupancy 0-51,800 km². Regarding uncertainty, the current occupancy data was most often categorized as largely undocumented but based on population genetic surveys (Goodman et al. 2008), extent of habitat, lamprey nests encountered during salmonid redd surveys, suspected barriers and/or anecdotal information.

Table 4-1. Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey population groupings within the Lower Columbia River Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size ^b (#)	Short Term Trend (% decline)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
Lower Columbia-Sandy	17080002	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	C (30-50)	High	High
Lewis	17080003	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	D (10-30)	High	High
Lower Columbia-Clatskanie	17080004	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	D (10-30)	High	Moderate
Upper Cowlitz	17080005	SH	D (1,000-5,000)	Z (0)	Z (0.001)	U	NA	High	High
Lower Cowlitz	17080006	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	D (10-30)	High	High
Lower Columbia	17080007	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	D (10-30)	High	Moderate
Middle Fork Willamette	17090001	S1	D (1,000-5,000)	E (100-500)	B (0.10)	U	B (50-70)	High	High
Coast Fork Willamette	17090002	S1	D (1,000-5,000)	E (100-500)	B (0.10)	U	B (50-70)	High	Moderate
Upper Willamette	17090003	S2	D (1,000-5,000)	(2,000-20,000)		U	B (50-70)	High	High
Mckenzie	17090004	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	B (50-70)	High	Moderate
North Santiam	17090005	S2	C (250-1000)	E (100-500)	D (0.37)	U	B (50-70)	High	High
South Santiam	17090006	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	B (50-70)	High	High

^a SH = Possibly Extirpated; S2 =Imperiled.

^b U = Unknown.

Table 4-1. (Continued). Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey population groupings within the Lower Columbia River Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size ^c (#)	Short Term Trend (% decline)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
Middle Willamette	17090007	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	B (50-70)	High	High
Yamhill	17090008	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	B (50-70)	High	High
Molalla-Pudding	17090009	S2	D (1,000-5,000)	(2,000-20,000)		U	B (50-70)	High	High
Tualatin	17090010	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	B (50-70)	High	High
Clackamas	17090011	S1	D (1,000-5,000)	E (100-500)	B (0.10)	U	B (50-70)	High	Moderate
Lower Willamette	17090012	S1	C 250-1000	E (100-500)	D (0.37)	U	B (50-70)	High	High

^b U = Unknown.

Table 4-2. Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey population groupings within the Mid-Columbia River Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size (#)	Short Term Trend (% decline)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
Walla Walla	17070103	SX	D (1,000-5,000)	X (0)	Z (0.001)	ZA (0-50)	A (>70)	High	High
Umatilla	17070104	S2	C (250-1,000)	E (100-500)	E (0.5)	C (250-1,000)	D (10-30)	High	High
Willow	17070105	NA							
Mid-Columbia-Hood	17070106	S2	C (250-1,000)	E (100-500)	E (0.5)	C (250-1,000)	D (10-30)	High	High
Klickitat	17070107	S1	C (250-1,000)	E (100-500)	E (0.5)	B (50-250)	C (30-50)	High	High
Upper John Day	17070202	S1	CD (250-5,000)	CD (4-100)	A (0.05)	BC (50-1,000)	B (50-70)	High	High
North Fork John Day	17070203	S1	CD (250-5,000)	E (100-500)	C (0.25)	BC (50-1,000)	B (50-70)	High	High
Middle Fork John Day	17070204	S1	CD (250-5,000)	E (100-500)	C (0.25)	C (250-1,000)	B (50-70)	High	High
Lower John Day	17070205	S1S2	CD (250-5,000)	U	F (0.75)	BC (50-1,000)	B (50-70)	High	High
Upper Crooked	17070305	NA							
Lower Crooked	17070306	NA							
Lower Deschutes	17070307	S1S2	D (1,000-5,000)	E (100-500)	B (0.1)	E (2,500-10,000)	CD (10-50)	High	High
Trout	17070308	SH	U	Z (0)	Z (0)	Z (0)	U	High	High
Beaver S. Fork	17070304	NA							
Upper Deschutes	17070302	NA							
Little Deschutes	17070303	NA							

^a SX = Presumed Extirpated; SH = Possibly Extirpated; S1 = Critically Imperiled; S1S2 = Imperiled to Critically Imperiled; S2 = Imperiled; NA = Not Assessed.

Table 4-3. Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey population groupings within the Upper Columbia River Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size (#)	Short Term Trend (% decline) (U or +/- 10%)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
Crab Creek	17020013, 016	SH	U	U	A (0.05)	Z (0)	UE (U or +/- 10%)	High	High
Wenatchee	17020012	S1	D (1,000-5,000)	E (100-500)	B (0.1)	A (1-50)	A (>70)	High	High
Entiat	17020011	S1	D (1,000-5,000)	F (500-2,000)	E (0.5)	A (1-50)	A (>70)	High	High
Chelan	17020009	S1	U	U	A (0.05)	U	U	High	High
Methow	17020009	S1	D (1,000-5,000)	F (500-2,000)	E (0.5)	A (1-50)	A (>70)	High	High
Okanogan	17020007	S1	D (1,000-5,000)	F (500-2,000)	E (0.5)	A (1-50)	A (>70)	High	High
Smilkameen	17020008	S1	A (<100)	D (20-100)	A (0.05)	A (1-50)	A (>70)	High	High
Kettle, Colville, Sanpoil	17020002-005	SX		Z (0)	Z (0.001)	X (0)	NA		
Upper Yakima	17030002	SH	CD (250-5,000)	Z (0)	Z (0.001)	ZU (U-0)	AB (50->70)	High	High
Naches	17030003	SH	BC (100-1,000)	ZA (0-0.4)	Z (0.001)	AB (1-250)	AB (50->70)	High	High
Lower Yakima	17030004	S1	BC (100-1,000)	AB (>0-4)	A (0.05)	AU (U-50)	AB (50->70)	High	High

^a SX = Presumed Extirpated; SH = Possibly Extirpated; S1 = Critically Imperiled.

Table 4-4. Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey populations within the Snake River Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size (#)	Short Term Trend (% decline)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
Lower Clearwater	17060307	S1	E (5,000-20,000)	DE (20-500)	A (0.05)	A (1-50)	A (>70)	High	High
Lower North Fork Clearwater	17060309	SX	D (1,000-5,000)	X (0)	Z (0.001)	X (0)		High	High
Upper North Fork Clearwater	17060308	SX	D (1,000-5,000)	X (0)	Z (0.001)	X (0)		High	High
Middle Fork Clearwater	17060305	S1	C (1,000-5,000)	CD (4-100)	B (0.1)	A (1-50)	A (>70)	High	High
South Fork Clearwater	17060306	S1	D (1,000-5,000)	CD (4-100)	A (0.05)	A (1-50)	A (>70)	High	High
Lochsa	17060304	S1	D (1,000-5,000)	C (4-20)	A (0.05)	A (1-50)	A (>70)	High	High
Lower Selway	17060303	S1	D (1,000-5,000)	C (4-20)	A (0.05)	A (1-50)	A (>70)	High	High
Upper Selway	17060302	S1	D (1,000-5,000)	C (4-20)	A (0.05)	A (1-50)	A (>70)	High	High
Lower Snake-Asotin	17060104	S1	D (1,000-5,000)	CD (4-100)	A (0.05)	A (1-50)	A (>70)	High	High
Mainstem Snake River Hells Canyon	17060102	S1	BC (100-1,000)	AB (<0.4-4)	A (0.05)	A (1-50)	A (>70)	High	High
Above Hells Canyon		SX		E	Z	X			

^a SX = Presumed Extirpated; SH = Possibly Extirpated; S1 = Critically Imperiled.

Table 4-4. Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey populations within the Snake River Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size (#)	Short Term Trend (% decline)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
Lower Grande Ronde	17060107	S1	D (1,000-5,000)	DE (20-500)	A (0.05)	A (1-50)	A (>70)	High	High
Upper Grande Ronde	17060105	SH	D (1,000-5,000)	AB (<0.4-4)	Z (0.001)	A (1-50)	A (>70)	High	High
Wallowa	17060106	SH	D (1,000-5,000)	AB (<0.4-4)	Z (0.001)	A (1-50)	A (>70)	High	High
Imnaha	17060103	SH	D (1,000-5,000)	AB (<0.4-4)	Z (0.001)	A (1-50)	A (>70)	High	High
Lower Snake-Tucannon	17060108	S1	D (1,000-5,000)			A (1-50)	A (>70)	High	High
Lower Snake	17060111	S1	D (1,000-5,000)			A (1-50)	A (>70)	High	High
Lower Salmon	17060210	S1	D (1,000-5,000)	C (4-20)	A (0.05)	A (1-50)	A (>70)	High	High
Little Salmon	17060211	S1	D (1,000-5,000)	C (4-20)	A (0.05)	A (1-50)	A (>70)	High	High
South Fork Salmon	17060209	SH	D (1,000-5,000)	B (0.4-4)	Z (0.001)	A (1-50)	A (>70)	High	High
Middle Salmon-Chamberlain	17060208	SH	D (1,000-5,000)	B (0.4-4)	Z (0.001)	A (1-50)	A (>70)	High	High
Lower Middle Fork Salmon	17060207	SH	D (1,000-5,000)	A (<0.4)	Z (0.001)	A (1-50)	A (>70)	High	High
Upper Middle Fork Salmon	17060206	SH	D (1,000-5,000)	A (<0.4)	Z (0.001)	A (1-50)	A (>70)	High	High

^a SH = Possibly Extirpated; S1 = Critically Imperiled.

Table 4-4. Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey populations within the Snake River Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size (#)	Short Term Trend (% decline)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
Middle Salmon-Panther	17060204	SH	D (1,000-5,000)	Z (0)	Z (0.001)	A (1-50)	A (>70)	High	High
Lemhi	17060205	SH	D (1,000-5,000)	Z (0)	Z (0.001)	XZ (0)	A (>70)	High	High
Pahsimeroi	17060203	SH	D (1,000-5,000)	Z (0)	Z (0.001)	XZ (0)	A (>70)	High	High
Upper Salmon	17060202	SH	E (5,000-20,000)	Z (0)	Z (0.001)	XZ (0)	A (>70)	High	High

^a SH = Possibly Extirpated.

Table 4-5. Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey population groupings within the Oregon Coast Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size (#)	Short Term Trend (% decline)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
North Umpqua	17100302	S1S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	CD (250-2,500)	A (>70)	High	High
South Umpqua	17100303	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	CD (250-2,500)	B (50-70)	Moderate	High
Umpqua	17100304	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	DE (1,000-10,000)	B (50-70)	Moderate	High
Coos	17100305	S2	CD (250-5,000)	F (500-2,000)	F (0.75)	DE (1,000-10,000)	D (10-30)	High	High
Coquille	17100306	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	E (2,500-10,000)	C (30-50)	High	Moderate
Sixes	17100307	S2	C (1,000-5,000)	F (500-2,000)	H (1)	E (2,500-10,000)	D (10-30)	High	Moderate
Upper Rogue	17100308	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	E (2,500-10,000)	D (10-30)	High	High
Middle Rogue	17100309	S1	D (1,000-5,000)	E (100-500)	B (0.1)	U	C (30-50)	High	High
Applegate	17100310	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U		High	High
Lower Rogue	17100311	S2	CD (250-5,000)	F (500-2,000)	F (0.75)	U	U	High	High
Illinois	17100313	S2	D (1,000-5,000)	F (500-2,000)	E (0.5)	U	U	High	Moderate
Chetco	17100313	S3	D (1,000-5,000)	F (500-2,000)	E (0.5)	E (2,500-10,000)	U	Low	Moderate

^a S1 = Critically Imperiled; S1S2 = Imperiled to Critically Imperiled; S2 = Imperiled; S3 = Vulnerable.

Table 4-5. Categorical rank inputs and resulting NatureServe ranks for Pacific Lamprey population groupings within the Oregon Coast Region.

Watershed	HUC	Calculated Risk Rank ^a	Distribution		Ratio of Current to Historic Distribution	Population Size (#)	Short Term Trend (% decline)	Threat	
			Historic (km ²)	Current (km ²)				Scope	Severity
Necanicum	17100202	S1S2	BC (100-1,000)	D (20-100)	C (0.25)	CD (250-2,500)	AB (50->70)	Moderate	Moderate
Nehalem	17100203	S2	D (1,000-5,000)	EF (100-2,000)	B (0.1)	EF (2,500-100,000)	AB (50->70)	Moderate	Moderate
Wilson-Trask-Nestucca	17100204	S2	D (1,000-5,000)	EF (100-2,000)	B (0.1)	EF (2,500-100,000)	AB (50->70)	Moderate	Moderate
Siletz-Yaquina	17100205	S2	CD (250-5,000)	EF (100-2,000)	C (0.25)	E (2,500-10,000)	A (>70)	Moderate	Moderate
Alsea	17100206	S2	CD (250-5,000)	EF (100-2,000)	C (0.25)	E (2,500-10,000)	AB (50->70)	Moderate	Moderate
Siuslaw	17100207	S2	CD (250-5,000)	EF (100-2,000)	C (0.25)	E (2,500-10,000)	AB (50->70)	Moderate	Moderate
Siltcoos	17100208	S2	BC (100-1,000)	E (100-500)	F (0.75)	D (1,000-2,500)	AB (50->70)	Moderate	Moderate
Clackamas	17090013	S1?				CD (250-2,500)		High	High

Ratio of Current Occupancy to Historic Range Extent.—The ratio of current occupancy to historic range extent was between 0.05-0.5 in most watersheds in the California Region (Table 4-6). Overall current occupancy ranged from >1% to 99% of historic range extent. The North Coast of California exhibited generally a much higher ratio (0.25– 0.5) than in the South of Pt. Conception, Sacramento, and San Joaquin watersheds (0.001-0.05).

Population Size.—Population size, defined as the number of adults, ranged from 0 to a range of 2,500-10,000. The North Coast had the highest population levels between 1,000-10,000 adult lamprey. The South of Pt. Conception, Sacramento, and San Joaquin watersheds abundance range was much lower, between 0 – 1,000. Uncertainty for population size is considerably greater for a larger number of watersheds than in other regions, primarily ranging from best professional judgment based on expansion of data for other species to unknown.

Short Term Trend.—Short term trend was defined as the percentage of decline in the population over the last three generations or approximately 27 years. The California Region decline ranged from >70% to as low as 10-30%. On average the South of Pt. Conception, Sacramento, and San Joaquin watersheds exhibited steeper declines between <70% to 50%. The uncertainty associated with short term trend is the same as current occupancy and population size.

Threats.—The threats that were identified most often in the California Region watersheds are stream and floodplain degradation, water quality, dewatering and flow management, and tributary passage. Each HUC in the California Coast had a threat that was ranked moderate in scope and severity, with the exception of the Smith River that exhibited lower levels of threats. The threats in the South of Pt. Conception, Sacramento, and San Joaquin watersheds were consistently ranked high in both scope and severity. The ranks in this Southern portion of the region are primarily related to threats from urbanization and agricultural impacts.

Risk Assessment.—For the California Region lamprey populations that inhabit approximately 3rd order HUC watersheds, calculated risk from the sub national NatureServe procedure (Master et al. 2009) primarily exhibited a narrow range. The California Region risk categories ranged from SH to S4 for the 10 HUCs inhabited by Pacific lamprey. The majority of the HUCs were estimated to be at a S1 & S2 risk level (8 out of 10). This means that a majority of the HUCs fall into a relatively high risk category, which is because of rarity due to very restricted range, few occurrences, steep declines, or other factors making it vulnerable to extirpation from the HUCs. The highest risk level for the California Region was South of Pt. Conception watershed (at SH) and the lowest risk was in the Smith (18010101) HUC at S4. In the northern portion of the California Region the risk categories were estimated in a range between S4 and S1. The southern portion of the California Region showed narrower range of risk.

Table 4-6. Categorical rank inputs and resulting draft NatureServe ranks for Pacific Lamprey population groupings within the California Region at a primarily 3rd Field HUC Level.

Watershed	HUC	Calculated Risk Rank	Range Extent	Current Distribution	Ratio Historic to Current Distribution	Population Size	Short Term Trend	Threat: Scope	Threat: Severity
Smith	18010101	S4	D	F	E	D	D	Low	Low
Klamath	18010201-210	S1	F	G	A	E	B	High	High
Trinity	18010211-212	S1	E	G	C	C	B	High	High
Humboldt Bay, Mad River, Redwood Creek	18010102	S2	D	F	E	D	D	Moderate	Moderate
Eel	18010103-106	S2	E	G	C	D	B	Moderate	High
Mattole and Bear River	18010107	S2	C	F	H	C	D	High	High
Central Coast	18010108-111; 18050001-006; 18060001-0012	S1	F	H	A	D	C	Moderate	Moderate
Sacramento	18020003-129	S1	F	G	A	D	B	High	High
San Joaquin	18030001-012; 1804001-014	S1	F	G	A	D	B	High	High
South of Pt. Conception	18060013; 18070101-107; 18070201-204; 18070301-305	SH	F	Z	Z	Z	A	High	High

Risk Summary and Actions

Puget Sound/Strait of Juan de Fuca and the Washington Coast

Very little information is available regarding Pacific Lamprey populations in this region. Our inability to rank population factors and threats in most of the HUCs highlights the need for lamprey surveys and threat analysis. The few watersheds that were analyzed in Puget Sound and Strait of Juan de Fuca show severe decline, and based on the general and specific threats identified the other HUCs are likely equally at risk. Based on the decline in current occupancy in the three watersheds that were analyzed in the Washington Coast Pacific Lamprey are likely at risk in the Washington Coast Region. Risk assessments will be completed as new data is gathered for Puget Sound, the Strait of Juan de Fuca and the Washington Coast.

There are several actions in place to address the threats that affect Pacific Lamprey in this region.

Columbia River Region (Including Upper, Middle, Lower Columbia and Snake River Regions)

Historic distribution for Pacific Lamprey was difficult to determine in many areas. There is a lack of fishing records, except from historical tribal fisheries, and count data at dams are mostly unavailable historically. Steelhead intrinsic potential (SIP) was used as a surrogate for historical range extent in many HUCs. Because Steelhead use very similar habitat for spawning it was determined that Pacific Lamprey likely co-occurred in these areas historically. The range extent of lamprey may be even larger than SIP due to the fact that lamprey are able to scale some natural barriers. Even in watersheds where SIP was considered a viable surrogate, the uncertainty of the historic range extent is still high.

Current occupancy was also difficult to determine because very few lamprey targeted surveys have been completed. Lamprey occurrence data is sometimes collected incidentally during salmonid surveys, but often does not provide accurate counts or identification by species. Typical salmonid surveys and sampling techniques do not use accepted protocols or sampling methods for lamprey and thus are inefficient at sampling. Furthermore, ammocoetes under 60mm are often unidentifiable to species (Goodman et al. 2009). Some watersheds have had lamprey surveys, and in those areas the certainty of current occupancy data is much higher. For example, the Clearwater watershed in the Snake River Region and the Walla Walla, Umatilla, Lower Deschutes and Trout Creek watersheds in the Mid-Columbia River Region have had lamprey specific surveys completed in more than half of the watershed.

Because the uncertainty remains high for both historic and current distribution in many of the Columbia River Region watersheds, the ratio of current to historic occupancy was added to the NatureServe risk assessment as an equally weighted factor. The percentage of historic range extent was very low in most watersheds and decreases moving upstream in the upper Columbia and Snake rivers. Additionally, population size decreases and short term trend declines increase as you move upstream. It is here that the threats combine and magnify to create serious impacts for Pacific Lamprey.

Pacific Lamprey are at risk throughout the Columbia Basin. Risk increases moving upstream from the Lower Columbia, where most of the watersheds were categorized as imperiled (Table 4-1), to the Mid-Columbia, where the majority were categorized as critically imperiled (Table 4-2), to the Upper Columbia and Snake basins, where the majority of the populations are possibly or presumed extirpated (Tables 4-3 and 4-4, respectively).

Pacific Lamprey in the Snake River Basin have to pass eight Columbia and Snake River dams migrating upstream as adults and downstream as juveniles. Dam counts of adults decrease sharply at consecutive upstream dams. The total count over Bonneville Dam (the most downstream dam) in 2009 was 8,622 and over Lower Granite (the most upstream dam) was 12 (Table 1-1). Mainstem Columbia and Snake river passage was identified as the most serious threat impacting Pacific Lamprey in the Snake River Region (and throughout the Columbia River Region). Actions in place to improve the upstream passage of adults include modifications to fish ladders and entranceways at dams. Research has identified that modification to turbine juvenile bypass screens may reduce impingement of juvenile lampreys on their downstream seaward migration. Lamprey passage structures that bypass the regular fishways, flow reductions, rounding of sharp corners, and screen modifications are examples of actions being taken to improve lamprey passage at mainstem dams.

Another threat identified as serious in the Snake River Region is small population size. Even with the modification of mainstem dams to improve lamprey passage, rebounding from small numbers may be difficult without supplementation. Translocation has been suggested as a stop-gap measure (and is being implemented) to slow the further extirpation of Upper Columbia and Snake River populations (CRITFC 2008). With the other Columbia River populations also imperiled, the decision to donate stocks to supplement areas such as the Snake River, which still have passage issues, is difficult to make.

A region of relatively moderate risk in the Columbia basin is the Lower Columbia River (watersheds include: Lower Columbia-Sandy, Lewis; Lower Columbia-Clatskanie, Lower and Upper Cowlitz and Lower Columbia). The most serious threat in this area is tributary passage. Smaller dams, culverts and water diversions are impacting Pacific Lamprey in the Lower Columbia River Region. Dewatering and flow management, stream degradation and water quality are factors resulting in a risk assessment of imperiled in the Lower Columbia River Region.

Actions in place to address some of these threats are the removal of dams (e.g., Marmot Dam on the Sandy River, Powderdale Dam on the Hood River, Condit Dam on the White Salmon River), culvert modifications, and habitat and water quality restoration projects. Though a few projects have been initiated more actions are needed to address the major threats in the Lower Columbia River Region to improve the risk.

The spatial arrangement of risk for the Columbia River Region is fairly homogenous. No areas of low risk are in close proximity for the potential rescue of populations at high risk. Snake River and Upper Columbia River watersheds, the populations most at risk, are surrounded by other high risk watersheds. The Lower Columbia River watersheds, though less at risk, are still

not healthy enough to restore this region given the condition of HUCs in the upper basin with the current mainstem passage issues in place.

Oregon Coast

Historic distribution for Pacific Lamprey was difficult to determine in many areas. There is a lack of fishing records, except from historical tribal fisheries, and count data at dams are mostly unavailable historically. As a surrogate SIP and Coho salmon distribution was used for historical range extent in many HUCs in the Oregon Coast Region. Because Steelhead and Coho Salmon use very similar habitat for spawning it was determined that Pacific Lamprey probably occurred in these areas historically as well. The range extent of lamprey may be even larger than SIP and Coho Salmon distribution due to the fact that lampreys are able to scale some natural barriers that anadromous salmonids cannot. Even in watersheds where SIP and Coho Salmon distribution was considered a viable surrogate the uncertainty of the historic range extent is still high.

Current occupancy was also difficult to determine because few targeted lamprey surveys have been completed. Often lamprey occurrence data is collected incidentally during salmonid surveys and as such identification by species is not made or is made by untrained surveyors. Furthermore, ammocoetes under 60mm are nearly unidentifiable to species (Goodman et al. 2009). Few watersheds have had surveys specific to lamprey and in those areas that have, the certainty of the current occupancy data is much higher. A majority of current distribution information for the Oregon Coast is derived from salmon spawning ground surveys, where lamprey nests are enumerated incidentally to the salmon redds (S. Gunkel, ODFW, personal communication).

Because the uncertainty remains high for both historic and current distribution in many of the Oregon Coast Region watersheds, the ratio of current to historic was added to the NatureServe risk assessment as an equally weighted factor. The percentage of historic range extent was low in most watersheds and decreases as you move south to north along the coastal watersheds. Additionally, population size decreases and short term trend declines increase as you move north, but the uncertainty for these categories is greater in the South Coast. It is in the North watersheds that the threats combine with population attributes and magnify to create serious impacts, which yield the predominantly imperiled status for Pacific Lamprey in the north.

The most serious threat in this category for the Oregon Coast Region is from channelization, loss of side channels, and scouring. These impacts are related to historic timber and agricultural practices. Many current impacts are related to urbanization along stream banks. Both were ranked moderate in scope and severity throughout the watersheds of the Oregon Coast. Threats to water quality including elevated temperature, chemical, physical and biological factors were generally ranked the most significant threat in the south Oregon Coast watersheds. Urbanization, agriculture and logging were some of the activities that contribute to poorer water quality in the south Oregon Coast. Dissolved oxygen (D.O.) levels were observed to be below the Oregon Department of Environmental Quality (ODEQ) rearing and incubation criteria for juvenile salmonids in 6th order and smaller systems for a number of south Oregon Coast HUCs. Threats to water quality including elevated temperature, chemical, physical and biological factors were

generally ranked low in the north Oregon Coast HUCs. Some exceptions are chemical inputs from commercial forestry and agricultural practices in the Wilson, Siletz, Alsea Siuslaw, and Siltcoos HUCs, where the scope and severity were moderate. Urbanization, agriculture and logging were some of the activities that contribute to poorer water quality when applicable in the north Oregon Coast.

The Oregon Coast Region is active in restoring aquatic habitat through the following sets of activities: numerous habitat restoration projects associated with the Coastal Coho Salmon recovery plan and ODFW's Chinook Salmon and Steelhead conservation plan and actions (Nicholas et al. 2006); passage improvements for salmonids (culvert replacement activities); Watershed Councils' watershed assessment limiting factors analysis; and water quality standards, and plans to meet aquatic criteria. However, there are a number of threats and uncertainties that specifically apply to Pacific Lamprey populations that have been identified to initiate restoration. These activities and actions are identified in detail in the Oregon Coast chapter.

Many of the recommendations of the Columbia River Lamprey Technical Workgroup apply to Coastal Oregon watersheds (CBLTWG 2005, Appendix C). In addition, a number of longer term research, monitoring, and evaluation needs were identified to promote Pacific Lamprey restoration and conservation (details contained in the Oregon Coast chapter).

Pacific Lamprey are at risk throughout the Oregon Coast Region. Summarizing the risk level for the Oregon Coast watersheds, it appears that the majority are imperiled with only one HUC showing a lower vulnerable risk level (Table 4-5). Given that the predominant expression of risk is imperiled and with a low chance of healthy watersheds providing a rescue effect, the risk status for this region should be viewed as imperiled. In terms of connectivity among watersheds, it is typical that the lower portions of watersheds are impacted by urbanization or agricultural practices. Lastly, the scope or severity of threats is either high or moderate for all the HUCs in the Oregon Coast Region.

California

Several critical steps are needed to complete this section of the Conservation Assessment. Stakeholder input is the primary source for drainage-specific information and risk assessment analyses that form the core of this project. Promotion of communication and collaboration among stakeholders is also a primary objective of the PLCI. We plan to review and update the current stakeholder database to be as inclusive as possible.

In addition, we will collect additional current and historical distributional information in California at a finer geographic scale. Distributional information, both historical and current, is essential for assessing the status of Pacific Lamprey, extent of historic range loss and potential for range expansion into currently unoccupied drainages or habitat. The development of a rangewide map of historical and current distribution is an objective of the Pacific Lamprey Conservation Assessment. We will accomplish this objective with a review of the appropriate regional and national museum collections for vouchered locality data. We will also identify the lowest impassable barriers (natural or artificial) in each watershed in order to identify the

maximum upstream extent of potential habitat (historic and current). This information will then be processed into ArcGIS shapefile format suitable for incorporation into the rangewide Conservation Initiative dataset.

Standardized questionnaires and risk assessment spreadsheets form the basis for the NatureServe assessment (see Methods) to be used in the California regional and rangewide Assessment sections. This data is not completed for California at the finer geographic level (4th field HUC) which is necessary to inform conservation measures at the watershed level. We will review available stakeholder questionnaires and information developed in 2009 stakeholder work sessions to identify missing or incomplete information fields. We will contact stakeholders for drainages with missing information and complete. We will produce the initial draft of questionnaire and risk assessment spreadsheet for each 4th field HUC which will be provided to stakeholders for review. Stakeholder comments will then be incorporated into the analyses and local work sessions will be held if necessary to resolve substantial disagreement. This process will result in a revised questionnaire and risk assessment for each 4th field HUC drainage grouping.

This dataset will be summarized and processed into the California chapter of the Conservation Assessment. In addition, the range wide section of the Conservation Assessment will be updated with the finer geographic scale California information. This document will then be sent out for review by stakeholders. Stakeholder comments will be incorporated into the document and the Conservation Assessment finalized in winter 2012 with the California region.

However, despite the shortcomings of the initial NatureServe assessment (described above) for the California Region, we have summarized the larger geographic scale findings to date. Historic distribution for Pacific Lamprey was difficult to determine in many areas. There is a lack of fishing records, except from historical tribal fisheries, and count data at dams are mostly unavailable historically. As a surrogate for historical range extent, Coho Salmon and Steelhead distribution were used in many HUCs in the California Region. Because Coho Salmon and Steelhead use similar habitat for spawning it was determined that Pacific Lamprey probably occurred in these areas historically as well. The range extent of Pacific Lamprey may be even larger than Coho Salmon and Steelhead distribution due to the fact that they are able to scale some natural barriers therefore this may be a conservative estimate. In watersheds where Coho Salmon and Steelhead distribution was considered a viable surrogate the uncertainty of the historic range extent is still high.

Current occupancy was also difficult to determine because few lamprey targeted surveys have been completed. Often lamprey occurrence data is collected incidentally during salmonid surveys and as such identification by species is not made or is made by untrained surveyors. Furthermore, ammocoetes under 60mm are nearly unidentifiable to species (Goodman et al. 2009). Very few watersheds have had thorough lamprey surveys and where they have been conducted, the certainty of the current occupancy data is much higher

Because the uncertainty remains high for both historic and current distribution in many of the California Region watersheds, the ratio of current to historic was added to the NatureServe risk assessment. The percentage of historic range extent was low in most watersheds and decreases

as you move from north to south watersheds. Additionally, population size decreases and short term trend declines increase as you move south, but the uncertainty for these categories is greater in the Southern portion of the California Region. It is in the southern watersheds that the threats combine with population attributes to create serious impacts, which yield the predominantly high risk ranks for Pacific Lamprey geographic groupings. The threats in the South of Pt. Conception, Sacramento, and San Joaquin watersheds were consistently ranked high in both scope and severity. The ranks in the Southern portion of the region are primarily related to threats from urbanization and agricultural impacts.

The threats identified most often in the California Region include stream and floodplain degradation, water quality, dewatering and flow management, and tributary passage. Actions and research, monitoring and evaluation needed in this region include, but are not limited to, restoration from urbanization and agricultural impacts; tributary passage improvements; and more lamprey specific distribution surveys.

Based on this preliminary assessment for large geographic groupings, Pacific Lamprey appears to be at risk throughout the California Region (Table 4-6). Summarizing the risk level for the California Region watersheds, it appears that the majority are at relatively high risk rank with only one HUC (Smith River, 18010101) showing a lower risk level at secure. Given that the risk ranking for geographic groupings in this region is predominantly high and there is a low chance of a proximal healthy watershed to provide a rescue effect, the relative risk level for lamprey is of concern for this region. In terms of connectivity among watersheds, it is typical that the lower portions of these watersheds are impacted by urbanization or agricultural practices.

Conclusion

Overall Risk Summary

From this analysis Pacific Lamprey populations at the highest relative risk ranking are those in the Snake and Upper Columbia River Regions. All HUCs in these areas are ranked either presumed extirpated, possibly extirpated or critically imperiled. Additionally, there are no low risk populations nearby to aid in recovering them. Lower risk areas such as parts of the Mid-Columbia River, the Lower Columbia River and Coastal Oregon watersheds were still ranked imperiled; again with no secure populations nearby to aid recovery. These findings are generally consistent with the systematic analysis of Moyle et al. (2009) for the limited information on lamprey in California. Moyle et al. (2009) found that all species are either declining, in low numbers, or isolated populations. In addition, risk could not be evaluated for the Puget Sound and Washington Coast Regions due to insufficient data on distribution and abundance.

A variety of threats impacting Pacific Lamprey are prevalent throughout their U.S. range. Mainstem and tributary passage, stream and floodplain degradation, dewatering and flow management, and water quality were identified in all regions. There are a number of restoration and recovery plans for salmonid populations that overlap a good portion of the range for Pacific Lamprey. Many of these habitat restoration actions have been implemented fairly recently. It will take some time for the benefits of these actions to improve freshwater habitat conditions for lamprey. In addition, a number of unidentified threats will not be addressed for Pacific Lamprey

conservation through these salmonid recovery and restoration plans and actions such as research, monitoring, and evaluation of lampreys during their ocean phase. Many of these gaps in addressing threats to Pacific Lamprey have been identified through the status review and risk assessment process (contained in this document). Pacific Lamprey research and conservation actions are ongoing in several watersheds and the mainstem Columbia and Snake rivers to address some of the threats; however, many threats remain unaddressed. The reasons are related to lack of funding, conflicting issues with recovery actions for other species, lack of awareness, unresolved critical uncertainties concerning biology and ecology of lamprey, difficulty obtaining lamprey for studies when numbers are low, and uncertainty about the efficacy of various restoration actions for Pacific Lamprey conservation.

Work to be Completed

The analysis of risk for Pacific Lamprey throughout their range is not complete. The Puget Sound, the Strait of Juan de Fuca and Coastal Washington Regions need more information on population status and identification and prioritization of threats so the HUCs in those regions can be assessed for risk. The Snake River Region needs to identify research, monitoring and evaluation needs; identify priority restoration opportunities; and complete additional surveys and improve distribution mapping. The Mid-Columbia River Region needs more information on population status and threats for several of the watersheds so risk can be assessed, as well as identifying ongoing and needed actions and research for many HUCs of the Mid-Columbia River Region. Ongoing and needed actions and research need to be expanded for most regions. Finally, the assessment for California is in progress with a completion date of winter 2012.

The next step in the process is working with our partners to develop an integrated implementation strategy to move forward on meeting conservation objectives (see next steps section). These integrated implementation strategies can be accomplished on a region by region basis. This regional approach is so implementation for a region moves forward and does not need to wait for the completion of assessments for all regions.

Next Steps

While analysis in some areas still needs to be completed, many watersheds are complete (pending review) with what current data are available. In these areas threats have been prioritized and needed actions and research have been identified in conjunction with other applicable plans (e.g., CRITFC Draft Tribal Restoration Plan, USACE 10 Year Lamprey Plan, PUD lamprey plans). The objectives of the USFWS PLCI are to facilitate the effective protection and enhancement of Pacific Lamprey throughout their range; coordinate management activities and integrate other plans; promote conservation partnerships and on-the-ground efforts; increase opportunities for funding, technical support and coordination; guide research, monitoring and evaluation to reduce uncertainties; and help prevent the need to list the species. The next step in the process is working with our partners to construct a Conservation Agreement and develop an implementation strategy to move forward on these objectives. The following are the objectives of the second implementation phase of the PLCI.

1. Complete data gathering on population and threats and risk analysis for incomplete regions and appropriate review.

2. Schedule meetings with regional policy and decision makers to present the Pacific Lamprey Conservation Assessment outcome and elicit guidance on best strategies for regional implementation.
3. Develop and Implement a Conservation Agreement.
4. Construct regional implementation plans:
 - a. Identify partnerships and participants for implementation.
 - b. Identify regional strategies and prioritize actions to address threats (that were identified in the regional conservation assessment chapters) and promote restoration and conservation of Pacific Lamprey.
 - c. Prioritize and implement research, monitoring and evaluation to improve status assessments and the efficacy of conservation measures.
 - d. Develop restoration goals and population outcomes that will be modified as we learn from RM&E work (adaptive management approach).
 - e. Identify potential funding sources and partnerships to address priority actions.
 - f. Identify potential funding sources and partnerships for research, monitoring and evaluation.
 - g. Identify priority tasks by region and develop implementation schedules
5. Develop regional strategy for conservation initiative and outreach needs
 - a. Coordinate with regional policy and decision makers to get support for integrated implementation plan.
 - b. Create an outreach and information program specific to Pacific Lamprey.
 - c. Identify region specific progress in research, restoration and conservation of Pacific Lamprey.
6. Update assessment as threats are mitigated, new threats are identified and conservation measures are implemented.
7. Coordinate among regions to share information to promote effective and efficient restoration actions.

5. PUGET SOUND/STRAIT OF JUAN DE FUCA REGION

Geographic Description of the Region

The Puget Sound/Strait of Juan de Fuca Region is bordered by the Strait of Juan de Fuca to the west, the Cascade Range to the east, Puget Sound systems to the south, and the U.S.–Canada border to the north. The Puget Sound/Strait of Juan de Fuca Region includes all Washington river basins flowing into the Puget Sound, Hood Canal, and Strait of Juan de Fuca and includes all or portions of Whatcom, Skagit, Snohomish, King, Pierce, Thurston, Mason, Kitsap, Island, San Juan, Clallam, and Jefferson counties. The major river basins in the Puget Sound initiate from the Cascade Range and flow west, discharging into Puget Sound, with the exception of the Fraser River system, which flows northwest into British Columbia. All of the major river basins in Hood Canal and the Strait of Juan de Fuca originate in the Olympic Mountains.

More detailed descriptions of the geology, land use, hydrology and climate of these sub-regions evaluated in this chapter can be found in the individual watershed templates and in the Salmon and Steelhead Habitat Limiting Factor Analysis reports produced by the Washington State Conservation Commission for each Water Resource Inventory Area (WRIA). The Puget Sound/Strait of Juan de Fuca Region includes WRIs 1–19.

The Puget Sound/Strait of Juan de Fuca Region supports a number of salmonids, including spring and fall Chinook Salmon *O. tshawytscha*, Coho Salmon *O. kisutch*, summer and fall Chum Salmon *O. keta*, winter and summer Steelhead, Pink Salmon *O. gorbuscha*, Sockeye Salmon, Dolly Varden *Salvelinus malma*, Bull Trout *Salvelinus confluentus*, and sea-run Cutthroat Trout *O. clarkii*. Steelhead, Chinook Salmon, summer Chum Salmon, and Bull Trout are listed under the ESA as threatened.

The Puget Sound/Strait of Juan de Fuca Region within the boundaries of the Pacific Lamprey Conservation Assessment is comprised of four Level III Ecoregions described by the Environmental Protection Agency (EPA) (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm) and twenty-one 4th Field Hydrologic Unit Code (HUC) Watersheds. Descriptions of each ecoregion (Pater et al. 1998) can be found in Appendix A. The 21 HUCs ranged in size from 435–6,604 km², and fall within 1–3 ecoregions. See Table 5-1 for the HUCs location within the ecoregions and Figure 5-1 for a map of the HUCs and ecoregions.

More detailed descriptions of the geology, land use, hydrology and climate of the 4th Field HUCs reviewed in this chapter can be found in the individual watershed templates and as follows:

- Salmon and Steelhead Habitat Limiting Factors in WRIA 1, the Nooksack Basin (Smith 2002).
- Salmon and Steelhead Habitat Limiting Factors, WRIs 3 and 4, the Skagit and Samish Basins (Smith et al. 2003).

- Salmon Habitat Limiting Factors Final Report, WRIA 5, Stilliguamish Watershed (Washington State Conservation Commission 1999).
- Salmon and Steelhead Habitat Limiting Factors Analysis Snohomish River Watershed WRIA 7 (Haring 2002).
- Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (WRIA 8) (Kerwin 2001b).
- Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds, WRIA 9 and Vashon Island (Kerwin and Nelson 2000).
- Salmon Habitat Limiting Factors Report for the Puyallup River Basin (WRIA 10) (Kerwin 2001a).
- Salmon and Steelhead Habitat Limiting Factors, WRIA 11 (Kerwin 1999).
- Salmonid Habitat Limiting Factors Analysis, Chambers-Clover Creek Watershed, WRIA 12 (Runge et al. 2003).
- Salmon Habitat Limiting Factors Final Report, WRIA 13 (Haring and Konovsky 1999).
- Salmonid Habitat Limiting Factors WRIA 14, Kennedy-Goldsborough Basin (Kuttel 2002).
- Salmonid Habitat Limiting Factors, WRIA 15 (East), Final Report (Haring 2000).
- Salmon and Steelhead Habitat Limiting Factors, WRIA 16, Dosewallips-Skokomish Basin (Correa 2003).
- Salmon and Steelhead Habitat Limiting Factors, WRIA 17, Quilcene-Snow Basin (Correa 2002).
- Salmon and Steelhead Habitat Limiting Factors, WRIA 18 (Haring 1999).
- Salmon and Steelhead Habitat Limiting Factors in the Western Strait of Juan de Fuca (Smith 1999a).

Table 5-1. Drainage size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the Puget Sound/Strait of Juan de Fuca Region.

Watershed	HUC Number	Drainage Size (km ²)	Level III Ecoregion(s)
Fraser	17110001	645	Puget Lowland, North Cascades
Strait of Georgia	17110002	2,473	Puget Lowland, North Cascades
San Juan Islands	17110003	1,621	Puget Lowland
Nooksack	17110004	1,282	Puget Lowland, North Cascades
Upper Skagit	17110005	4,222	North Cascades
Sauk	17110006	1,919	North Cascades
Lower Skagit	17110007	1,158	Puget Lowland, North Cascades
Stillaguamish	17110008	1,823	Puget Lowland, North Cascades
Skykomish	17110009	2,209	Puget Lowland, North Cascades
Snoqualmie	17110010	1,795	Puget Lowland, Cascades, North Cascades
Snohomish	17110011	720	Puget Lowland, North Cascades
Lake Washington	17110012	1,603	Puget Lowland, Cascades, North Cascades
Duwamish	17110013	1,261	Puget Lowland, Cascades, North Cascades
Puyallup	17110014	2,580	Puget Lowland, Cascades
Nisqually	17110015	1,880	Puget Lowland, Cascades
Deschutes	17110016	435	Puget Lowland, Cascades
Skokomish	17110017	642	Coast Range, Puget Lowland, North Cascades
Hood Canal	17110018	2,479	Coast Range, Puget Lowland, North Cascades
Puget Sound	17110019	6,604	Coast Range, Puget Lowland
Dungeness-Elwha	17110020	3,289	Coast Range, Puget Lowland, North Cascades
Crescent-Hoko	17110021	2,005	Coast Range, Puget Lowland



Figure 5-1. Map of Strait of Juan de Fuca/Puget Sound watersheds and Level III Ecoregions.

Ranked Population Status of Pacific Lamprey in the Puget Sound/Strait of Juan de Fuca Region

The population status of Pacific Lamprey in the Puget Sound/Strait of Juan de Fuca Region is difficult to assess because: 1) most freshwater observations are based on juveniles that are difficult to differentiate from other lamprey species, 2) data are often incidental to salmon monitoring programs, and 3) there are no historical datasets on lamprey populations in existence. Because of this lack of information, population parameters have not been ranked and NatureServe status ranks have not been calculated for most watersheds. However, when some data was available, an attempt was made to rank the range extent and occupancy, current population size, and recent trend of Pacific Lamprey in a few of the watersheds (Table 5-2).

Table 5-2. Population status of the Pacific Lamprey in the Puget Sound/Strait of Juan de Fuca Region, as ranked by participants at the regional meetings.

Watershed	Occupancy (km ²)		Current Population	Short Term Trend
	Historic	Current	Size (Adults)	
Fraser	No rank	No rank	No rank	No rank
Strait of Georgia	No rank	No rank	No rank	No rank
San Juan Islands	No rank	No rank	No rank	No rank
Nooksack	No rank	No rank	No rank	No rank
Upper Skagit	No rank	No rank	No rank	No rank
Sauk	No rank	No rank	No rank	No rank
Lower Skagit	No rank	No rank	No rank	No rank
Stillaguamish	No rank	No rank	No rank	No rank
Skykomish	No rank	No rank	No rank	No rank
Snoqualmie	No rank	No rank	No rank	No rank
Snohomish	No rank	No rank	No rank	No rank
Lake Washington	No rank	No rank	No rank	No rank
Duwamish	No rank	No rank	No rank	No rank
Puyallup	No rank	No rank	No rank	No rank
Nisqually	No rank	No rank	No rank	No rank
Deschutes	No rank	No rank	No rank	No rank
Skokomish	No rank	No rank	No rank	No rank
Hood Canal	No rank	No rank	No rank	No rank
Puget Sound	No rank	No rank	No rank	No rank
Dungeness-Elwha	1,000–5,000	500–2,000	Unknown	Decline of 10–70%
Crescent-Hoko	250–5,000	100–2,000	20–250+	Decline of 10–70%

Threats to Pacific Lamprey in the Puget Sound/Strait of Juan de Fuca Region

Pacific Northwest Threats

The primary factor impacting USFWS trust species in the Pacific Northwest is habitat loss through conversion, fragmentation, and degradation. Approximately 70% of estuarine wetlands, 50–90% of riparian habitat, 90 % of old growth forest, 70% of arid grasslands, and more than 50% of the shrub steppe habitat in the State of Washington has been lost. About 75% of Puget Sound's estuaries and their adjacent habitats, such as grasslands, mixed woodlands and floodplain forests, have been modified so significantly that they no longer provide original functions (WDFW 2005). Water diversions have diminished fish habitat in streams. Dams for water storage, hydroelectric power, irrigation, or flood control blocked fish access to many watersheds. Streams and rivers were channelized, reducing diversity and quantity of habitats within floodplains. Water quality has been degraded by the input of agricultural chemicals and sediments into the streams. Other contaminant inputs from industry, mining, and urban runoff also affect water quality in the Pacific Northwest. A large percentage of surface waters do not meet State water quality criteria and many kilometers of streams have fish consumption advisories for a variety of pollutants. Throughout the Pacific Northwest, working farms, ranches, and private forests have long provided homes for fish and wildlife; however many of these areas are being converted into residential and commercial developments.

Loss of habitat has been compounded by increased fragmentation and introduction of non-native plant species which alter the native species composition and structure. These changes have significantly impacted fish and wildlife resources with resulting declines in listed plants and butterflies, migratory birds, anadromous fish, and other species. Invasive plant species such as non-native knotweeds and knapweeds, reed canary grass, Himalayan blackberry, melaleuca, cheat grass, English ivy, Eurasian water milfoil, purple loosestrife, yellow star thistle, non-native marine algae, and non-native submerged aquatic vegetation are causing significant impacts to native species. Bohemian, giant, and Japanese knotweeds have invaded many areas in Washington. Knotweeds quickly colonize large areas and out-compete native plants for light and soil resources. They often invade riparian and instream gravel bar areas first, taking advantage of regular flooding disturbance and ultimately displacing native shrubs and trees that provide important wildlife habitat and erosion control. Knotweed invasion on gravel bars prevents natural streambed movements. Reed canary grass can create large dense monocultures that effectively exclude almost all other plant species, displacing wildlife due to its limited habitat value and altering sedimentation, hydrology, and nutrient cycling in wetland and riparian areas.

Puget Sound/Strait of Juan de Fuca Region Threats

Specific information on threats was only gathered on three watersheds within the Region, the Skokomish, the Dungeness-Elwha, and the Crescent-Hoko Watersheds. At the Strait of Juan de Fuca/Hood Canal and South Puget Sound meetings, it was suggested that threats listed in existing salmonid limiting factors analysis and recovery plans be used to identify lamprey threats within these watersheds. Limiting factors analyses and recovery and restoration plans were reviewed and an unranked summary of threats identified is found below. The documents reviewed for threat information include the draft Recovery Plan for the Coastal-Puget Sound

Distinct Population Segment of Bull Trout, the Puget Sound Salmon Recovery Plan, Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Recovery Plan, the salmonid habitat limiting factors reports for WRIAs 1–19, the State of the Sound Report of 2007, and the Puget Sound Partnership Action Agenda.

Current land and water management activities that degrade fish habitat in this Region include residential and urban development, dams and water diversions, hydropower development, forestry, agriculture, and fisheries management. Dams and water diversion structures impede or limit migration, entrain individuals, and impair downstream habitat. Forestry activities decrease recruitable large woody debris (LWD), increase water temperatures from reduced shading, decrease pools and habitat complexity, and increase sedimentation from timber harvesting on unstable slopes and road construction. Past forest management practices have left long-term impacts, and stream systems continue to be impacted from these practices even today. Agricultural practices add inputs of nutrients, pesticides, herbicides and sediment; and reduce riparian vegetation, recruitable large woody debris, and habitat complexity by diking, stream channelization, and bank hardening. Road construction and maintenance impact fish through added channel constrictions, impassible culverts, bank hardening, sedimentation, reduction in riparian shading, contaminant inputs, and impervious surfaces. Development and urbanization impact fish through reduced water quality, changed hydrology, reduced riparian shading, sedimentation, and reduced channel complexity from increased bank hardening and channel constrictions. Portions of Puget Sound are undergoing rapid conversion from rural forest and agriculture to an urban/suburban landscape resulting in habitat that has become fragmented, paved, or degraded.

Threats identified at the sub-regional meetings, and in existing salmonid limiting factors analysis and restoration and recovery plans include:

Passage

Dams and diversion structures that impede or limit migration, entrain individuals, and impair downstream habitat were identified in the Region. All of the watersheds have anadromous fish passage issues. The vast majority of them are impassible or partial barrier culverts in tributaries and scattered irrigation diversions throughout the area.

The Elwha River contains two dams that completely block fish passage to more than 70 miles of mainstem and tributary habitat (95% of the historic habitat for Elwha Chinook), and the dams have impeded water quality, quantity, and sediment transport (Puget Sound Partnership 2009).

The North Fork Skokomish River is entirely blocked to fish passage by the Cushman Dam, which generates power for the city of Tacoma (Puget Sound Partnership 2009).

Several other large dams or diversions present are on the Cedar (water supply), Green (flood management and water supply), and Puyallup and White rivers (hydroelectric and flow management). Attempts have been made to achieve improvements in altered flows associated with the dams and diversions but instream flows remain a severe challenge.

Dewatering and Flow Management

Currently, 11 of 19 Puget Sound rivers are at levels that impair salmon due to low seasonal flows and over-allocation of water uses (Puget Sound Partnership 2009). In particular, the Nooksack, Snohomish, Lake Washington, Green, White, Puyallup, Dungeness, and Elwha are considered to be “water critical” basins for salmon because of over-allocated water rights and low flow conditions.

Water supply is also a critical issue in the eastern Strait of Juan de Fuca.

Stream and Floodplain Degradation

Across all watersheds, stream and floodplain degradation were listed as a concern for fish. Channelization, channel incision, and loss of side channels within the lower reaches of watersheds were the most common habitat degradations identified. Timber harvest, road construction, farming, and urbanization were the main causal factors. Historical logging practices in some watersheds have left a legacy of instability. For example, more than 900 shallow, rapid landslides in the upper South Fork Nooksack have contributed sediment to streams and altered the channel structure. Floodplain degradation and land conversion practices have also been linked to causing decreased summer flows and increased peak flows in a few of the watersheds. Saltmarsh habitat at the mouths of the major rivers near urban centers is essentially gone, and riparian forest has been eliminated along many water courses. Vegetation removal along much of the creeks, rivers, and marine shorelines has reduced shade, increased temperatures, eliminated the delivery of wood for stream structure, and decreased the filtration of pollutants before they enter the water.

The continuing loss and fragmentation of habitat is identified as one of the two highest priority threats for sustaining Puget Sound into the future (Puget Sound Partnership 2009). Three-quarters of the saltwater marsh habitat that existed in Puget Sound historically has been lost through dikes and drainage. Ninety percent of estuarine and adjacent riverine wetlands has been lost and one third of the Puget Sound shoreline has been armored. For example, an estimated 80–90% of the Snohomish and Skagit estuaries have been diked and ditched, cutting off tidal marshes and channels that supported fish. Roadways exist along the Hood Canal marine shoreline and traverse many creeks, river mouths, and estuaries and the resulting fill has removed or modified saltmarsh and other wetlands (approximately 22% of shoreline has been modified).

Large modifications of entire ecosystems have also occurred in Puget Sound. Large rivers, such as the White, Cedar, and Black rivers have been re-routed, and the Lake Washington system was re-plumbed when the Hiram M. Chittenden Locks were constructed. The lower Puyallup and other rivers are heavily diked and straightened, cutting off meanders, side channels, flood plains, and wetlands.

Chronic water shortages occur in Eastern Strait of Juan de Fuca river basins where water has been over-appropriated.

The South Fork Skokomish River runs completely dry in the summer and early fall because of channel sedimentation, blocking all anadromous fish passage.

Water Quality

Poor water quality has been identified as a threat to fish species in many of the watersheds, sub-watersheds, and the Puget Sound. Several watersheds within the region have issues with high temperatures, sediment, low dissolved oxygen and fecal coliform. For example, many of the streams and tributaries in the Skagit, Snohomish, and Stillaguamish River systems do not meet standards for fecal coliform, dissolved oxygen, temperature, ammonia, nutrients, or other measures (Puget Sound Partnership 2009). Fecal coliform bacteria counts result in shellfish closures in many bays, including Drayton Harbor, Portage Bay, and Chuckanut Bay. Freshwater quality has also been impaired from the metals and hydrocarbons that wash from roads and parking lots. In addition, “Endocrine disrupting compounds” from pharmaceuticals and personal care products have been found in water samples in King County.

The ongoing input of toxic substances to Puget Sound is identified as one of two highest priorities for sustaining Puget Sound into the future (Puget Sound Partnership 2009). Industrial actions have left toxic contamination in the lower Duwamish River (Seattle) and Commencement Bay in Tacoma, which are now EPA-designated Superfund sites. Several hazardous waste facilities are also present in Puget Sound.

Many bays and marine water bodies in Puget Sound also experience hypoxia – the low oxygen conditions that result in widespread kills of marine life (Puget Sound Partnership 2009). In particular, South Puget Sound, Hood Canal, and Whidbey Basin are subject to poor water circulation and high nutrient inputs that result in low dissolved oxygen conditions and can lead to massive fish kills. In recent years, these two areas have been experiencing more frequent and extreme hypoxia events.

Other

Harvest, translocation, disease, small population size, and lack of awareness were not identified as threats or concerns to salmonids or lamprey within the documents and reports evaluated.

In PSP’s Action agenda, climate change was identified as a concern to Puget Sound’s health (Puget Sound Partnership 2009). Temperatures in the Pacific Northwest have risen faster than the global average, and Puget Sound waters are warmer. Most climate change models predict increasing temperatures, diminishing snowpack, earlier runoff, reduced summer flows, rising sea levels, and more acidic ocean waters in Puget Sound in the 21st century. Climate change may exacerbate current threats from invasive species. Snowpack in the low- and mid-elevations of the Cascades has a high sensitivity to surface temperatures. Projected warming in the future will substantially diminish springtime snowpack in these watersheds and cause large changes in the timing of stream flows. Altered weather regimes associated with climate change will likely compound many existing threats to surface and groundwater supply and availability.

Suites of Actions to Address Threats

Current protection of fish resources in Washington State is achieved in partnership with landowners, cities, counties, tribes, the State of Washington, federal agencies, and others through voluntary conservation efforts and under various laws and regulations. These include the Growth Management Act, Shoreline Management Act, State and Federal Environmental Policy Acts, Forest Practices Act, the Endangered Species Act, and other similar laws and planning processes. Newer cooperative strategies, such as Washington's Comprehensive Wildlife Conservation Strategy and the Biodiversity Conservation Strategy, recommend ways to prevent fish and wildlife from declining to levels at which they will be listed. The Puget Sound Partnership, a new state agency, is working to protect and restore Puget Sound and rivers and streams that drain into it.

In addition, WDFW identifies fish and wildlife resources that are a priority for management and preservation. Pacific Lamprey are listed as a Priority Species in Washington State (WDFW 2008). The Priority Habitat Species program (PHS) 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. PHS is the agency's primary means of transferring fish and wildlife information from our resource experts to those who can protect habitat. PHS information is used to screen 12,000 - 15,000 Forest Practice Applications, 10,000 - 18,000 Hydraulic Project Applications, and over 3,000 SEPA reviews annually; by a majority of cities and counties to meet the requirements of the Growth Management Act; for the development of Habitat Conservation Plans on state, federal, and private lands; by state, federal, and tribal governments for landscape-level planning and ecosystem management; and, for statewide oil spill prevention planning and response.

There are also watershed planning processes, salmonid recovery activities (e.g., site specific restoration projects), and other conservation efforts underway throughout the state and within the Washington Coast Region. These activities within the coastal region include, but are not limited to, the following actions:

- Puget Sound Partnership and Shared Strategy – The 1999 ESA listing of Puget Sound Chinook prompted local partnerships, in particular the Shared Strategy for Puget Sound, to protect and restore salmon runs across Puget Sound. In 2005, the collaborative efforts of this partnership, with input from the National Marine Fisheries Service, resulted in a Puget Sound Chinook recovery plan (Puget Sound Salmon Recovery Plan (Shared Strategy Development Committee 2007)) that is based on both local and regional participation, including active participation by stakeholders. In 2008, the Shared Strategy transferred responsibility for salmon recovery plan implementation to a new state agency, the Puget Sound Partnership (PSP) (Puget Sound Partnership 2009). The PSP is tasked with defining a 2020 Action Agenda that identifies work needed to protect and restore Puget Sound, based on science and with clear and measurable goals for recovery. The most current Action Agenda was released in May 2009 and includes recommended near term actions necessary to protect and restore Puget Sound. These recommendations are by seven geographic “action areas” in Puget Sound to address problems specific to those areas. Actions, in order of priority, include: 1) protection of intact ecosystem processes,

structures, and functions; 2) restore ecosystem processes, structures, and functions; 3) reduce sources of water pollution; 4) work effectively and efficiently together on priority actions; and 5) build an implementation, monitoring, and accountability management system. While plans and reports produced by the PSP focus on salmonids and restoring Puget Sound, many of the recommended future restoration activities identified to date will benefit lamprey species.

- **Salmon Recovery Plans** – The Puget Sound/Strait of Juan de Fuca Region includes two salmon recovery regions, Hood Canal and Puget Sound. The federally listed salmonids in this region are Steelhead, Chinook Salmon, Summer Chum Salmon, and Bull Trout, all listed as threatened. Recovery planning documents include the Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Recovery Plan (Brewer et al. 2005), the Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout (USFWS 2004b), and the Puget Sound Salmon Recovery Plan (Shared Strategy Development Committee 2007; National Marine Fisheries Service 2006). The Puget Sound Salmon Recovery Plan focuses on Puget Sound Chinook Salmon. These recovery plans for salmonid species outlines activities needed to ensure the long-term persistence of self-sustaining, complex interacting groups of fish populations. While these plans target salmonids, most of the habitat restoration activities listed will benefit lamprey species. More specific information on the identified actions to address threats to fishery resources listed in the recovery plans is included in the individual Watershed Templates.
- **Salmon Recovery Funding Board** – In 1999, the Washington State Legislature created the Salmon Recovery Funding Board. The board provides grants to protect or restore salmon habitat and assist related activities. Grants focus on salmon recovery, estuary restoration, fish passage, and Puget Sound acquisition and restoration. Since grants began in 1999, more than \$438 million in grants have been awarded for 1,727 projects. Many of these projects directly benefit lamprey species.
- **Washington State Department of Natural Resources (WDNR)** – WDNR has and is developing Habitat Conservation Plans (HCP) for state owned lands. These management plans define how the lands will be administered and the measures that will be applied to ensure long-term landscape-based protection of federally listed and non-listed species considered being at risk of extinction. In the Puget Sound Region, plans include a State Trust Lands HCP (WDNR 1997), a Forest Practices HCP (WDNR 2005), and a draft HCP for state-owned aquatic lands (under development).
- **Forest and Fish Agreement** – In 2000, State forest practice regulations were significantly revised following the Forest and Fish Agreement (USFWS et al. 1999; WFPB 2001). These regulations increased riparian protection, unstable slope protection, recruitment of large wood, and improved road standards significantly over the old regulations. Because there is biological uncertainty associated with some of the prescriptions, the Forest and Fish agreement relies on an adaptive management program for assurance that the new rules will meet the conservation needs of listed species. The updated regulations will significantly reduce the level of future timber harvest impacts to streams on private lands, however, most legacy threats from past forest practices will likely continue to be a threat for decades.
- **Fishing Regulations** – It is currently illegal to fish for or possess lamprey for bait in Washington State.

- Watershed Planning Act – State law requires plans to be developed that must balance competing resource demands. The plans are required to address water quantity by undertaking an assessment of water supply and use within the watershed. Elements that may be addressed in the plan include instream flow, water quality, and habitat. Plans completed to date include the following WRIAs in the Puget Sound Region: WRIA 1, 6, 11, 16, and 17.
- Limiting Factors Analyses – The Salmon Recovery Act of 1998 directs the Washington State Conservation Commission, in consultation with local governments and treaty tribes, to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a technical advisory group for each Water Resource Inventory Area (WRIA) of Washington State. Water Resource Inventory Areas are generally equivalent to the State’s major watershed basins. The purpose of the technical advisory group is to develop a report identifying habitat limiting factors for salmonids. Reports on salmon and Steelhead limiting factors were completed for all WRIAs in the Washington Coast Region. While these reports target salmonids, most of the recommended activities listed will benefit lamprey species. More specific information on the identified actions to address limiting factors to fishery resources is included in the individual Watershed Templates.
- Total Maximum Daily Loads – TMDLs for several sub-watersheds within HUCs identify measures to provide management direction for addressing TMDLs.
- Land Use Planning for Salmon, Steelhead and Trout – The intent of this guidance is to assist local governments working on comprehensive updates to Growth Management Act (GMA) and Shoreline Management Act (SMA) planning programs and related regulatory and incentive-based programs (Knight 2009). The GMA and the SMA are the two most significant state laws governing local land use planning decisions to protect critical salmonid habitat. The GMA requires special consideration be given to conservation or protection measures necessary to preserve or enhance critical anadromous fish resources. The SMA requires no net loss to fish and wildlife conservation areas which includes anadromous fish habitat. To address these requirements, this guidance provides science-based management recommendations in the form of model policies and regulations. These recommendations can be incorporated into local GMA and SMA planning programs including critical area ordinance updates under the GMA and shoreline master program updates under the SMA.
- WDFW Fish Passage Barrier Inventories – Inventories of fish passage barriers and water diversions have been or are being conducted on each of the Wildlife Areas owned or managed by WDFW (Till and Caudill 2003). The inventories and habitat surveys document and prioritize for correction of all human-made fish passage barriers and unscreened or inadequately screened diversions to ensure compliance with Washington State laws. Reports are available with plans and recommendations to correct the problems identified.
- State Highways Fish Passage Barrier Inventories – In 1991, WSDOT committed funding from its Highway Construction Program to develop an inventory of fish passage barriers to anadromous fish species at state highway crossings (Wilder and Barber 2010). WSDOT contracted with Washington Department of Fisheries (prior to the merger of Washington Departments of Fisheries and Wildlife) to conduct the inventory and habitat studies

necessary to prioritize state route barriers for correction. In October 2007, the inventory on all fish bearing streams was completed on the entire state route system of 11,335.45 kilometers (7,043.52 miles). This inventory is now used to facilitate the integration of fish passage barrier repairs within road construction projects.

- Smolt Trap Data – The WDFW and tribes run numerous smolt traps in Puget Sound every spring that target outmigrating juvenile salmonids. Other entities operate traps on systems intermittently or for one season. These smolt traps also collect juvenile lamprey. When feasible, efforts are often made to enumerate and categorize the lamprey collected. For example, the Squaxin Island Tribe operates smolt traps at seven sites in South Puget Sound from April to June. At these sites, they have collected and enumerated juvenile lamprey at six of the sites from 2001–2009. There is also interest in collecting genetic samples and more detailed information on lamprey collected at WDFW smolt traps in the future.
- Lamprey Surveys in the Strait of Juan de Fuca – The Lower Elwha Tribe has surveyed many of these systems for lamprey. In addition, USGS is currently working with the Lower Elwha Tribe to evaluate sampling methods for juvenile lamprey in the Strait of Juan de Fuca watersheds. They are also expanding their studies to the Oregon Coast.
- Field Identification Guide – The Elwha Klallam Tribe funded the development of a field guide for identifying Olympic Peninsula lampreys.
- USGS 2010 Proposed Study – The purpose of this study is to map the distribution of Pacific Lamprey within the watersheds of Puget Sound. They are hoping to obtain data from collections of juvenile (or adult) lamprey indicating presence or absence of the species in each watershed and collect additional data in watersheds where lamprey have been found to exist.
- Strait of Juan de Fuca Basin – Proposed large-scale restoration projects in the Strait include the removal of the Elwha dams within Olympic National Park, the restoration of the Dungeness River delta, continued water conservation implementation in the Dungeness, and many other salmon recovery projects throughout the region by counties, tribes, cities, conservation districts, private landowners, and volunteer organizations.
- Hood Canal Watersheds – Key strategies for the Canal include the protection and acquisition of large tracts of land with intact and highly functional habitat; finding and implementing solutions to the dissolved oxygen problems in the canal; large scale restoration projects for the Skokomish and Big Quilcene rivers; implementation of the Hood Canal Summer Chum Recovery Plan; and implementation of other salmon recovery projects throughout the Straits by counties, tribes, conservation districts, private landowners, and volunteer organizations.
- North Central Puget Sound – Key strategies for this area include low impact development methods; coordination of land use, water supply and wastewater treatment; revising development regulations to prioritize protection of ecosystems; water conservation programs; protect and restore shoreline habitat; and acquisition of critical habitat areas.
- South Puget Sound – Key strategies include the implementation of salmon recovery work plans, water conservation and reuse, stormwater retrofits, water quality cleanup plans prepared by the shellfish protection districts, septic and wastewater upgrades; acquisition of critical habitats and clean up of industrial pollution sites.

- South Central Puget Sound – Key action strategies for this area are largely directed at preventing additional loss of ecosystem function related to growth, restoring degraded areas and contaminated sites, implementing recovery plans; active stewardship and acquisition programs; restricting shoreline armoring; conserving water; restoring instream flows and fish passage; managing stormwater and wastewater; and improving floodplains.
- North Puget Sound – Top strategies in the area are focused on protecting habitat by acquiring important areas along streams and nearshore areas; improving enforcement; improving water quality; improving forest and farm management; utilizing alternatives to bulkhead construction; implementing low impact development; implementing salmon recovery plans; sustaining open spaces and rural lifestyles; and providing education, outreach and technical assistance to landowners.

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6. WASHINGTON COAST REGION

Geographic Description of the Region

The Washington Coast Region is bordered by the Pacific Ocean to the West, Cape Flattery to the North, Olympic Mountain Range and Willapa Hills to the East, and the Columbia River to the South. This region includes all Washington river basins flowing directly into the Pacific Ocean and it extends across all or portions of Clallam, Jefferson, Grays Harbor, Mason, Thurston, Pacific, and Lewis counties. The Washington Coast Region includes the Hoh-Quillayute, Queets-Quinault, Upper and Lower Chehalis, Grays Harbor, and Willapa Bay sub-regions, also described as 4th field hydrologic units (Seaber 1987). More detailed descriptions of the geology, land use, hydrology and climate of these sub-regions evaluated in this chapter can be found in the individual watershed templates and in the Salmon and Steelhead Habitat Limiting Factor Analysis reports produced by the Washington State Conservation Commission for each Water Resource Inventory Area (WRIA). The Washington Coast Region includes WRIs 20–24.

The Washington Coast Region fronts roughly 241 km (150 miles) of ocean shoreline (Washington Biodiversity Project Fact Sheet), and the two largest estuaries are Grays Harbor and Willapa Bay. The largest rivers in the Northern region include the Soleduck, Bogachiel, Hoh, Queets, Quinault, Humptulips, and Wynoochee. Between the high Olympic Mountain peaks and shoreline, a coastal plain extends through much of the peninsula. In contrast, the Willapa Hills to the south tops 945 m (3,100 ft). The Chehalis River, the second largest river basin in the state, flows through the Willapa Hills and empties into Grays Harbor.

The combination of maritime weather system and high local topographic relief results in large differences in local precipitation. Annual rainfall in the region is the highest in the State, and ranges from 200 cm (80 in) near the coast to 609 cm (240 in) in the Olympic Mountains (McHenry et al. 1996). In the higher peaks of the Olympics, heavy snowfall of up to three meters is frequent. In the coastal valleys, summer fog and cool temperatures are common.

The Region contains many unique terrestrial and aquatic ecosystems ranging from nearly pristine to areas with extensive timber harvest, agriculture, or urbanization. In the north, the region encompasses the lower elevation portions of the Olympic National Park. This area includes over 97 km (60 miles) of undeveloped Pacific coast, (the largest section of wilderness coast in the lower 48 states) and the largest remaining old growth and temperate rain forests in the Pacific Northwest.

The Coast Region was once densely forested, but timber harvest has occurred extensively throughout the coastal mountains and is an ongoing industry in the region. The low mountains of the Coast Range were covered by coniferous forests. Sitka spruce and coastal redwood forests originally dominated the coast and western red cedar, western hemlock, and Douglas-fir were found in inland areas. Douglas-fir plantations are now common on the intensively logged and managed landscape. Dairy cattle operations, including forage/grain cultivation and feedlots, are concentrated in larger valleys and along the coast.

Human development within the region is concentrated on land bordering water, particularly ocean bays. The region has many small communities and one metropolitan area, Aberdeen-Hoquiam in Grays Harbor County. Within the region, more than 50% of the land is privately held, primarily by timber companies. Another 30% is federally owned. The largest federal land holdings within the region include portions of the Olympic National Forest and the Olympic National Park. The remainder is held by the state, local, and tribal governments.

The Washington Coast Region supports a number of salmonids, including spring and fall Chinook Salmon, Coho Salmon, Chum Salmon, winter and summer Steelhead, Pink Salmon, Sockeye Salmon *O. nerka*, Dolly Varden, Bull Trout, and sea-run Cutthroat Trout. Lake Ozette Sockeye Salmon and Bull Trout are both listed under the ESA as threatened.

The Washington Coast Region within the boundaries of the Pacific Lamprey Conservation Assessment is comprised of four Level III Ecoregions described by the Environmental Protection Agency (EPA) (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm) and six 4th Field Hydrologic Unit Codes (HUC) Watersheds. Descriptions of each ecoregion (Pater et al. 1998) can be found in Appendix A. The six HUCs reviewed for the Conservation Assessment ranged in size from 1,471–3,393 km², and fall within 1–3 ecoregions. See Table 6-1 for how the HUCs fall within the ecoregions and Figure 6-1 for a map of the HUCs and ecoregions.

More detailed descriptions of the geology, land use, hydrology and climate of the 4th Field HUCs reviewed in this chapter can be found in the individual watershed templates and as follows:

- Salmon and Steelhead Habitat Limiting Factors in the North Washington Coastal Streams of WRIA 20 (Smith 2000).
- Salmon and Steelhead Habitat Limiting Factors in the Washington Coastal Streams of WRIA 21 (Smith and Caldwell 2001).
- Salmon and Steelhead Habitat Limiting Factors, Chehalis Basin and Nearby Drainages, Water Resource Inventory Areas 22 and 23 (Smith and Wenger 2001).
- The Chehalis Basin Salmon Habitat Restoration and Preservation Strategy for WRIAs 22 and 23: 2010 update (Chehalis Basin Partnership 2010).
- Salmon and Steelhead Habitat Limiting Factors in the Willapa Basin (Smith 1999b).

Table 6-1. Drainage size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the Washington Coast Region.

Watershed	HUC Number	Drainage Size	
		(km ²)	Level III Ecoregion(s)
Hoh-Quillayute	17100101	3,186	Coast Range, North Cascades
Queets-Quinault	17100102	3,082	Coast Range, North Cascades
Upper Chehalis	17100103	3,393	Coast Range, Puget Lowland, Cascades
Lower Chehalis	17100104	2,170	Coast Range, Puget Lowland
Grays Harbor	17100105	1,471	Coast Range
Willapa Bay	17100106	2,849	Coast Range

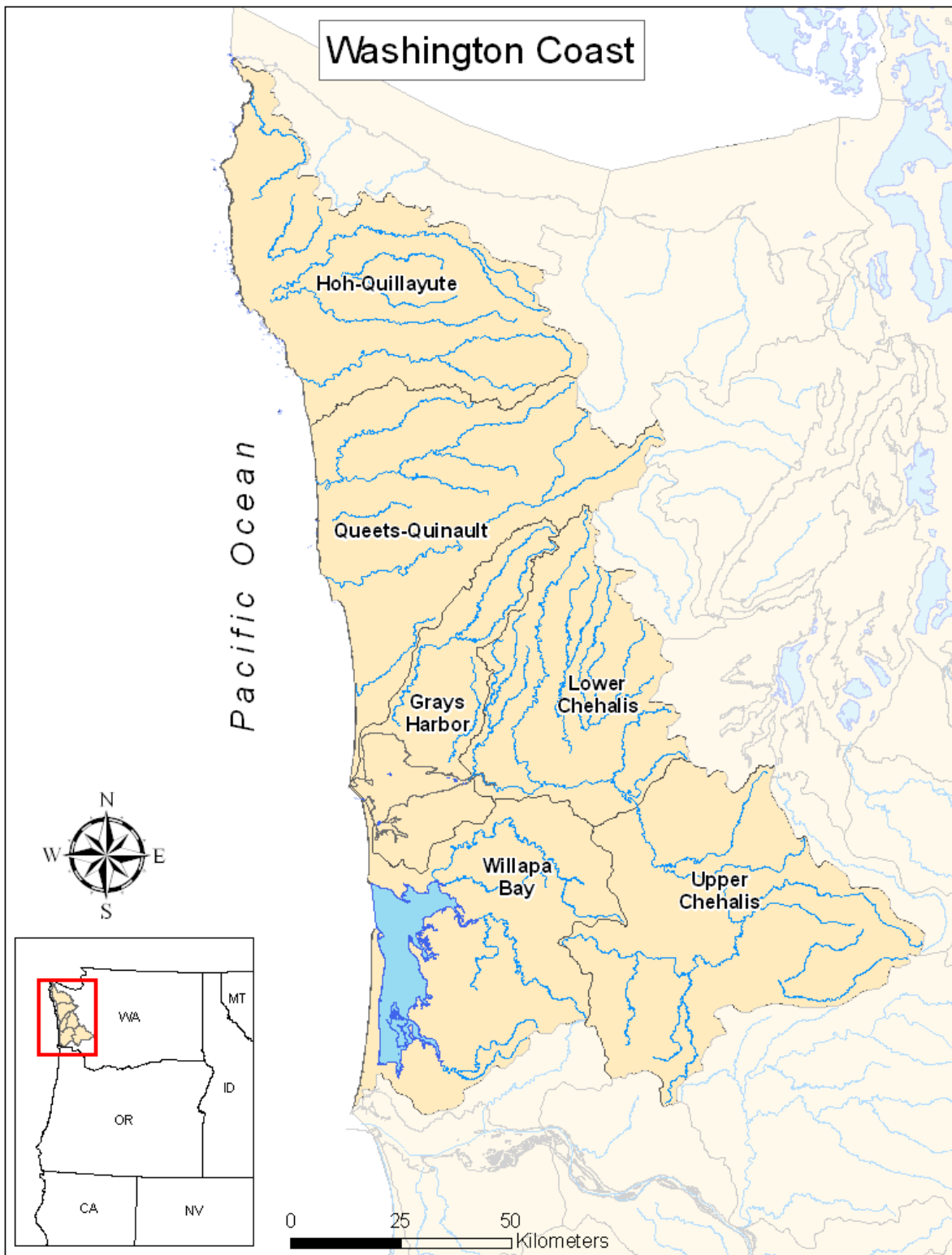


Figure 6-1. Map of Washington Coast Region watersheds and Level III Ecoregions.

Ranked Population Status of Pacific Lamprey in the Washington Coast Region

NatureServe status ranks are not yet calculated for Pacific Lamprey populations in this Region because many of the population parameters and the threats to the species have not been ranked. However, an attempt was made to rank the range extent and occupancy, and current population size in a few of the watersheds (Table 6-2).

Table 6-2. Population status of the Pacific Lamprey in the Washington Coast Region, as ranked by participants at the regional meetings.

Watershed	Occupancy (km ²)		Current Population Size (Adults)	Short Term Trend
	Historic	Current		
Hoh-Quillayute	1,000–5,000	No rank	No rank	No rank
Queets-Quinault	1,000–5,000	No rank	No rank	No rank
Upper Chehalis	1,000–5,000	20–2,000	250–2,500	No rank
Lower Chehalis	1,000–5,000	20–2,000	1,000–2,500	No rank
Grays Harbor	250–5,000	No rank	No rank	No rank
Willapa Bay	1,000–5,000	20–2,000	No rank	No rank

Threats and Limiting Factors to Pacific Lamprey in the Washington Coast Region

Pacific Northwest Threats

The primary factor impacting USFWS trust species in the Pacific Northwest is habitat loss through conversion, fragmentation, and degradation. Approximately 70% of estuarine wetlands, 50–90% of riparian habitat, 90% of old growth forest, 70% of arid grasslands, and more than 50% of the shrub steppe habitat in the State of Washington has been lost. Water diversions have diminished fish habitat in streams. Dams for water storage, hydroelectric power, irrigation, or flood control blocked fish access to many watersheds. Streams and rivers were channelized, reducing diversity and quantity of habitats within floodplains. Water quality has been degraded by the input of agricultural chemicals and sediments into the streams. Other contaminant inputs from industry, mining, and urban runoff also affect water quality in the Pacific Northwest. A large percentage of surface waters do not meet State water quality criteria and many kilometers of streams have fish consumption advisories for a variety of pollutants. Throughout the Pacific Northwest, working farms, ranches, and private forests have long provided homes for fish and wildlife; however many of these areas are being converted into residential and commercial developments.

Loss of habitat has been compounded by increased fragmentation and introduction of non-native plant species which alter the native species composition and structure. These changes have significantly impacted fish and wildlife resources with resulting declines in listed plants and butterflies, migratory birds, anadromous fish, and other species. Invasive plant species such as non-native knotweeds and knapweeds, reed canary grass, Himalayan blackberry, melaleuca, cheat grass, English ivy, Eurasian water milfoil, purple loosestrife, yellow star thistle, non-native

marine algae, and non-native submerged aquatic vegetation are causing significant impacts to native species. Bohemian, giant, and Japanese knotweeds have invaded many areas in Washington. Knotweeds quickly colonize large areas and out-compete native plants for light and soil resources. They often invade riparian and instream gravel bar areas first, taking advantage of regular flooding disturbance and ultimately displacing native shrubs and trees that provide important wildlife habitat and erosion control. Knotweed invasion on gravel bars prevents natural streambed movements. Reed canary grass can create large dense monocultures that effectively exclude almost all other plant species, displacing wildlife due to its limited habitat value and altering sedimentation, hydrology, and nutrient cycling in wetland and riparian areas. It is widespread in low-elevation wetlands along the Washington Coast.

Washington Coast Region Threats

No specific information on threats was gathered at the Washington Coast Regional meetings. At these meetings, it was suggested that threats listed in existing salmonid limiting factors analysis and recovery plans be used to identify lamprey threats within these watersheds. Limiting factors analyses and recovery and restoration plans were reviewed and an unranked summary of threats identified is found below and in Table 6-3. The documents reviewed for threat information include the draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout, the salmonid habitat limiting factors reports for WRIAs 20–24, and the Chehalis Restoration and preservation report.

Historically, within the Washington Coast Region, dams and water diversions, hydropower development, forestry, agriculture, fisheries management, and residential and urban development are the primary activities that have impacted fish and fish habitats. Current land and water management activities that degrade fish habitat in this Region include some operation of water diversion structures, forest management practices, agriculture practices, road construction and maintenance, and residential development and urbanization.

Dams and water diversion structures impede or limit migration, entrain individuals, and impair downstream habitat. Forestry activities decrease recruitable large woody debris, increase water temperatures from reduced shading, decrease pools and habitat complexity, and increase sedimentation from timber harvesting on unstable slopes and road construction. Past forest management practices have left long-term impacts, and stream systems continue to be impacted from these practices even today. Agricultural practices add inputs of nutrients, pesticides, herbicides, sediment; and reduce riparian vegetation, recruitable large woody debris, and habitat complexity by diking, stream channelization, and bank hardening. Road construction and maintenance impact fish through added channel constrictions, impassible culverts, bank hardening, sedimentation, reduction in riparian shading, contaminant inputs, and impervious surfaces. Development and urbanization impact fish through reduced water quality, changed hydrology, reduced riparian shading, sedimentation, and reduced channel complexity from increased bank hardening and channel constrictions.

Threats identified in existing salmonid limiting factors analysis and recovery plans include:

Passage

Dams and diversion structures that impede or limit migration, entrain individuals, and impair downstream habitat were identified in the Region. All of the watersheds have anadromous fish passage issues. The vast majority of them are impassable or partial barrier culverts in tributaries and scattered irrigation diversions throughout the area. Fish passage issues at the Hoquiam, Wynoochee, and Skookumchuck Dams were also identified as priority concerns. There are also possible passage barriers at fish rearing facilities in the Hoh-Quillayute, Queets-Quinault, and Willapa Watersheds (Barber et al. 1997; USFWS 2004b).

Dewatering and Flow Management

Low summer flow was identified as a concern in watersheds where either natural conditions or land management causes flows to become very low or intermittent in the summer time (Upper and Lower Chehalis). During low flow periods, many of these systems also experience degradation in water quality parameters, such as dissolved oxygen and temperature.

Stream and Floodplain Degradation

Across all watersheds, stream and floodplain degradation were listed as a concern for fish. Channelization, channel incision, and loss of side channels within the lower reaches of watersheds were the most common habitat degradations identified. Timber harvest, road construction, farming, and urbanization were the main causal factors. Floodplain degradation and land conversion practices have also been linked to causing decreased summer flows and increased peak flows in a few of the watersheds (Lower and Upper Chehalis, Grays Harbor).

Water quality

Poor water quality has been identified as a threat to fish species in many of the watersheds and sub-watersheds. Several watersheds within the region have issues with high temperatures, sediment, low dissolved oxygen and fecal coliform. These watersheds include Upper and Lower Chehalis, Willapa, and Grays Harbor.

Other

Increased predation as a result of behavioral modifications due to high levels of boat traffic was listed as a threat in the Lower Chehalis Watershed.

Harvest, translocation, disease, small population size, lack of awareness, and climate change were not identified as threats or concerns to salmonids or lamprey within the documents and reports evaluated.

Table 6-3. Threats to Pacific Lamprey and their habitats within the Washington Coast Region. These threats to fishery resources were identified in limiting factors analyses and recovery and restoration plans that focus on salmonids.

Watershed	Threats				
	Passage	Dewatering and Flow Management	Stream and Floodplain Degradation	Water Quality	Predation
Hoh-Quillayute					
Queets-Quinault					
Upper Chehalis	X	X	X	X	
Lower Chehalis	X	X	X	X	X
Grays Harbor	X	X	X	X	
Willapa	X	X	X	X	

Suites of Actions to Address Threats

Current protection of fish resources in Washington State is achieved in partnership with landowners, cities, counties, tribes, the State of Washington, federal agencies, and others through voluntary conservation efforts and under various laws and regulations. These include the Growth Management Act, Shoreline Management Act, State and Federal Environmental Policy Acts, Forest Practices Act, the Endangered Species Act, and other similar laws and planning processes. Newer cooperative strategies, such as Washington’s Comprehensive Wildlife Conservation Strategy and the Biodiversity Conservation Strategy, recommend ways to prevent fish and wildlife from declining to levels at which they will be listed.

In addition, WDFW identifies fish and wildlife resources that are a priority for management and conservation. Pacific Lamprey are listed as a Priority Species in Washington State (WDFW 2008). The Priority Habitat Species program (PHS) 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. PHS is the agency's primary means of transferring fish and wildlife information from our resource experts to those who can protect habitat. PHS information is used to screen 12,000–15,000 Forest Practice Applications, 10,000–18,000 Hydraulic Project Applications, and over 3,000 SEPA reviews annually; by a majority of cities and counties to meet the requirements of the Growth Management Act; for the development of Habitat Conservation Plans on state, federal, and private lands; by state, federal, and tribal governments for landscape-level planning and ecosystem management; and, for statewide oil spill prevention planning and response.

There are also watershed planning processes, salmonid recovery activities (e.g., site specific restoration projects), and other conservation efforts underway throughout the state and within the Washington Coast Region. These activities within the coastal region include, but are not limited to, the following actions:

- Salmon Recovery Planning – The Washington Coastal Salmon Recovery Region includes all Washington river basins flowing directly into the Pacific Ocean and includes all or

portions of Clallam, Jefferson, Grays Harbor, Mason, Thurston, Pacific, and Lewis counties. The federally listed salmonids in this region are Lake Ozette sockeye and bull trout, both listed as threatened. Recovery planning documents include the Lake Ozette Sockeye ESA Recovery Plan (Haggerty et al. 2009) and the Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout (*Salvelinus confluentus*) (USFWS 2004b). The draft recovery plan for bull trout outlines activities needed to ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout populations within the Coastal and Puget Sound Distinct Population Segment. Within the Washington Coast Region, actions are focused on the bull trout core populations in the Hoh, Quinault, and Queets rivers. While this draft plan targets bull trout, most of the habitat restoration activities listed will benefit lamprey species. More specific information on the identified actions to address threats to fishery resources listed in the recovery plans is included in the individual Watershed Templates.

- Washington State Department of Natural Resources (WDNR) – WDNR has and is developing Habitat Conservation Plans (HCP) for state owned lands. These management plans define how the lands will be administered and the measures that will be applied to ensure long-term landscape-based protection of federally listed and non-listed species considered being at risk of extinction. On the Washington Coast, plans include a State Trust Lands HCP (WDNR 1997), a Forest Practices HCP (WDNR 2005) and a draft HCP for state-owned aquatic lands (under development).
- Forest and Fish Agreement – In 2000, State forest practice regulations were significantly revised following the Forest and Fish Agreement (USFWS et al. 1999; WFPB 2001). These regulations increased riparian protection, unstable slope protection, recruitment of large wood, and improved road standards significantly over the old regulations. Because there is biological uncertainty associated with some of the prescriptions, the Forest and Fish agreement relies on an adaptive management program for assurance that the new rules will meet the conservation needs of listed species. The updated regulations will significantly reduce the level of future timber harvest impacts to streams on private lands, however, most legacy threats from past forest practices will likely continue to be a threat for decades.
- Fishing Regulations – It is currently illegal to fish for or possess lamprey for bait in Washington State.
- Washington Coast Sustainable Salmon Partnership (WCSSP) – WCSSP works to protect and maintain existing healthy salmon stocks, restore degraded habitats and recover diminished salmon populations throughout the watersheds that empty directly into the Pacific.
- Watershed Planning Act – State law requires plans to be developed that must balance competing resource demands. The plans are required to address water quantity by undertaking an assessment of water supply and use within the watershed. Elements that may be addressed in the plan include instream flow, water quality, and habitat. Plans completed in the Washington Coastal Region include the Sol Duc-Hoh (Golder Associates 2009) and Lower/Upper Chehalis River Watershed Management Plans (Chehalis Basin Partnership 2004).
- The Salmon Recovery Act of 1998 – This law directs the Washington State Conservation Commission, in consultation with local governments and treaty tribes, to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene

as a technical advisory group for each Water Resource Inventory Area (WRIA) of Washington State. Water Resource Inventory Areas are generally equivalent to the State's major watershed basins. The purpose of the technical advisory group is to develop a report identifying habitat limiting factors for salmonids. Reports on salmon and Steelhead limiting factors were completed for all WRIs in the Washington Coast Region. While these reports target salmonids, most of the recommended activities listed will benefit lamprey species. More specific information on the identified actions to address limiting factors to fishery resources is included in the individual Watershed Templates.

- Redd Surveys – WDFW began systematically surveying Steelhead spawning grounds for Pacific Lamprey redds in the Willapa and Chehalis basins in 2002 (C. Holt, WDFW, personal communication). The redd data collected prior to 2010 is a conservative estimate because it is collected incidental to Steelhead surveys and some lamprey likely spawn after the Steelhead surveys are completed. However, the redd data can provide information on lamprey distribution and reference for trend analyses. USFWS funded WDFW to extend redd surveys beyond the steelhead spawning period in 2010 to capture the entire lamprey spawning period. Efforts are also currently underway by WDFW to incorporate all lamprey red data into a Geographic Information System (GIS) application database to be shared with partners.
- Chehalis Basin Restoration and Preservation Plan – The Chehalis Basin Partnership (2010) gathered information on salmonid limiting factors within the Upper Chehalis, Lower Chehalis, and Grays Harbor Watershed and identified suites of actions needed to improve habitat conditions. While this reports targets salmonids, most of the recommended activities listed will benefit lamprey species. More specific information on the identified actions to address fisheries concerns is included in the individual Watershed Templates.
- Total Maximum Daily Loads – TMDLs for several sub-watersheds within HUCs identify measures to provide management direction for addressing TMDLs.
- Land Use Planning for Salmon, Steelhead and Trout – The intent of this guidance is to assist local governments working on comprehensive updates to Growth Management Act (GMA) and Shoreline Management Act (SMA) planning programs and related regulatory and incentive-based programs (Knight 2009). The GMA and the SMA are the two most significant state laws governing local land use planning decisions to protect critical salmonid habitat. The GMA requires special consideration be given to conservation or protection measures necessary to preserve or enhance critical anadromous fish resources. The SMA requires no net loss to fish and wildlife conservation areas which includes anadromous fish habitat. To address these requirements, this guidance provides science-based management recommendations in the form of model policies and regulations. These recommendations can be incorporated into local GMA and SMA planning programs including critical area ordinance updates under the GMA and shoreline master program updates under the SMA.

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Mike Norton	Pacific Coast Conservation District
Jeff Skriletz	WDFW Region 6 Montesano

7. MAINSTEM COLUMBIA RIVER AND SNAKE RIVER REGION

Geographic Description of the Region

Pacific Lamprey historically migrated through mainstem corridors as adults into the Snake River basin and the upper Columbia River basin to spawn and reproduce. Because of this type of anadromous life-history, lampreys need to migrate from these headwater spawning areas through the present mainstem migration corridor to reach the ocean during the juvenile life stage. Therefore, Pacific Lamprey originating in the Snake River basin would migrate through eight mainstem hydroelectric dams as juveniles during their seaward migration and again as returning adults. Pacific Lamprey originating in the upper Columbia River basin would migrate through between four and nine mainstem hydroelectric dams. Pacific Lamprey originating from the middle Columbia River basin would migrate between one and four mainstem hydroelectric dams. Moser and Mesa (2009) found that hydropower dams can delay or obstruct adults, and turbine entrainment or screen impingement can kill or injure juveniles. In order to assess the impacts of the configuration and continued operation of the hydroelectric dams on Pacific Lamprey, we divided the threats assessment into four sub-regional areas to be applied to the watershed units in these sub-regions (Figure 7-1). The mainstem Snake and Columbia River Region consists of the following areas:

Snake Basin – Mainstem habitats of the Snake River. Major tributaries to this area include the Salmon and Clearwater rivers. See Chapter 8 for geographic descriptions on the Snake River Region.

Upper Columbia – Mainstem Columbia River above the confluence of the Snake River. Major tributaries to this area include the Yakima, Naches, Wenatchee, Entiat, Methow, and Okanogan rivers. See Chapter 9 for geographic descriptions on the Upper Columbia River Region

Mid-Columbia – Mainstem Columbia River from Bonneville Dam to the confluence of the Snake River. Major tributaries to this area include the Hood, Klickitat, Umatilla, Walla Walla, John Day, and Deschutes rivers. See Chapter 10 for geographic descriptions on the Mid-Columbia River Region.

Lower Columbia – Mainstem Columbia River below Bonneville Dam. Major tributaries to this area include the Sandy, Lewis, Cowlitz, and Clatskanie rivers. See Chapter 11 for geographic descriptions on the Lower Columbia River Region.

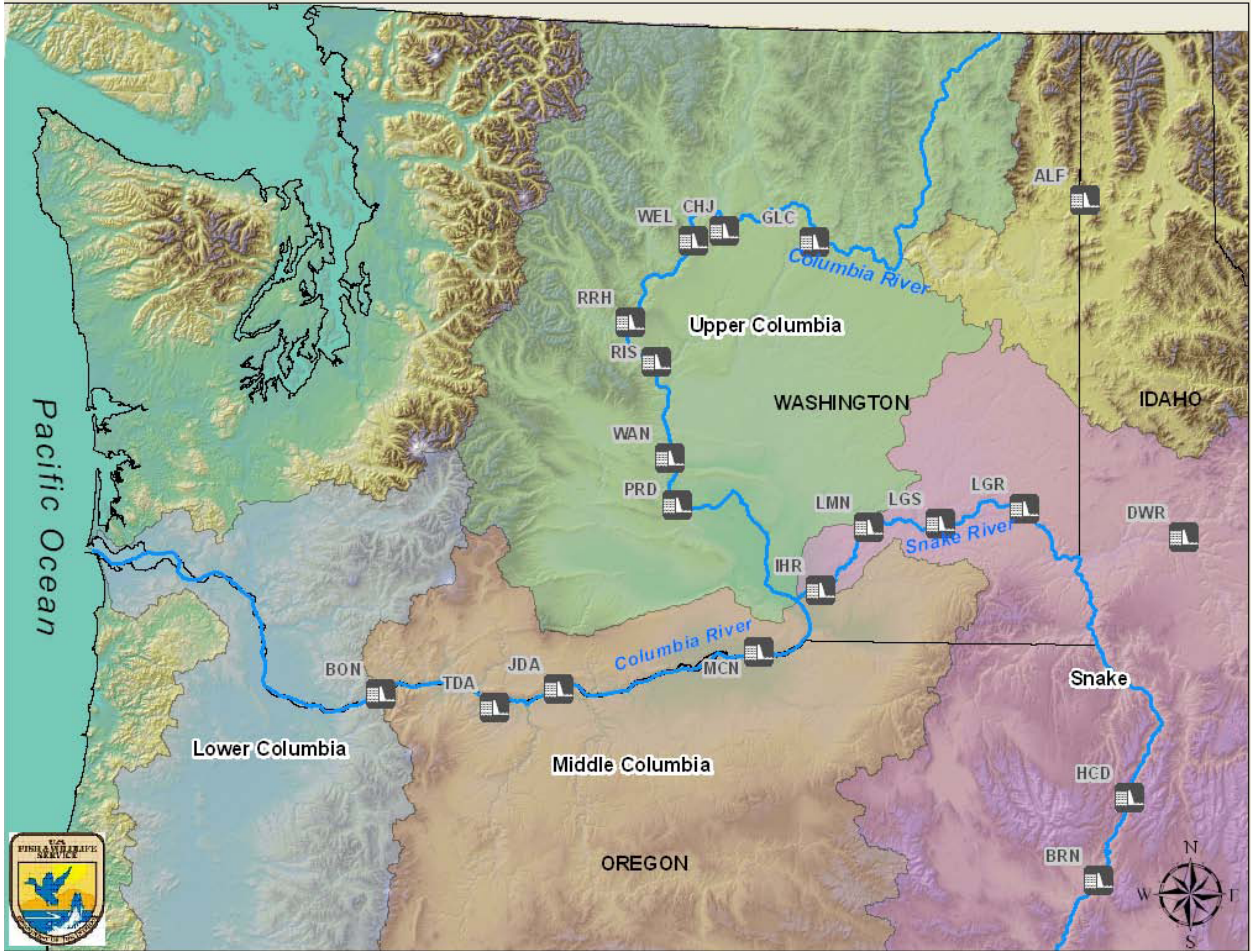


Figure 7-1. Map of four sub-regional areas of mainstem Columbia and Snake Rivers.

Ranked Population Status of Pacific Lamprey

The population status of Pacific Lamprey in the mainstem was not ranked because there is no obvious geographic separation of populations. There is evidence of rearing in the mainstem and some overwintering of larvae and juveniles, but it is unknown whether or not spawning occurs in mainstem habitats. The purpose of ranking the threats in the mainstem, by geographic sub-region, was to assess the risk for the various population groupings during their seaward migration as juveniles and the adult migration to the spawning grounds through the hydrosystem. Therefore, the scope and the severity of mainstem passage threats were ranked for each of the four Columbia River geographic sub-regions. These mainstem passage ranks were then integrated with the watershed threat rankings to calculate an overall threat ranking for each watershed unit for both scope and severity. These overall threat rankings were evaluated for each of the watershed comprising a geographic sub-region.

Threats and Limiting Factors to Pacific Lamprey

The information used to assess the mainstem threats and limiting factors were identified during the sub-regional mainstem meetings. In addition, this information was gathered from existing salmonid limiting factors analysis, Biological Opinions for Federal Columbia River Power System (NOAA 2008), independent scientific review assessing benefits of transportation and spill of smolts from four Snake River Evolutionary Significant Units (ISAB 2004) and recovery plans for salmonids of the Columbia River basin. The categories of threats and limiting factors include:

Passage

Passage in the mainstem is affected by nine Federal Columbia River Power System (FCRPS) dams and five Public Utility District dams. No passage is provided upstream of Chief Joseph Dam on the Columbia River or Hells Canyon Dam on the Snake River. The overall scope and severity of passage was ranked high in all three mainstem areas. Both upstream passage for adults and downstream passage for larvae and juveniles is affected. Adult lampreys have difficulty negotiating fish ladders designed for salmonids. Sharp corners, diffuser gratings, dead ends, high velocities, tailrace conditions, increased mortality from delays, count stations and fallback, orifices, lack of attachment points, trapping areas, transition zones, excessive energy use, temperature changes, lighting, unplanned maintenance and sound all have an impact on adult lamprey passage. Pacific Lamprey are less capable swimmers in high velocity flows when compared to salmon (Moser and Mesa 2009; Keefer et al. 2010). Nearly all salmon-based velocity criteria in the fish ladders may be too high for lamprey to navigate without repeated burst swimming, reattaching, and resting. The modifications that can be made to improve hydraulic conditions for lamprey are limited while keeping the fish ladder functional for ESA-listed salmon (USACE 2009). It was identified that removing impediments to anadromous lamprey passage was one of the two highest recovery objectives for Pacific Lamprey in the Columbia River Basin (CRBLTWG 2004, 2005).

Pacific Lamprey passage efficiency at Bonneville Dam was less than 50% in all years of radio-telemetry study (1997-2002) (Moser et al. 2002, 2005). Passage efficiencies at Bonneville, The Dalles, and John Day dams averaged 47%, 74% and 53%. The higher passage efficiencies at The Dalles Dam may be related to the natural rock structure inside much of the north ladder and no serpentine weir section in the exit (ACOE 2009). Studies have indicated that lamprey have difficulty at fishway entrances (Moser et al. 2005). Moser et al. (2005) found that less than 40% of lamprey that approached Bonneville entrance on the Washington shore successfully entered the fishway. High velocities (8 feet/second or greater) may be primarily constraining entrance of lamprey into fishways (ACOE 2009).

There are unknown threats for downstream migrating ammocoetes and macrophthalmia. The screening, bypass, and transportation facilities were designed to improve passage conditions at dams for juvenile salmonids during their seaward migration; and were not designed to facilitate the passage of lampreys (Mesa and Copeland 2009). However, it has been identified that juvenile lamprey move downstream primarily at night, but they are profoundly affected by flow (Dauble et al. 2006; Moser and Mesa 2009). With the development of suckorial discs during

metamorphosis, juvenile lampreys demonstrate protracted periods of attachment to the substrate (Dauble et al. 2006). Macrophthalmia may need attachment structure to rest between burst of swimming, similar to adult lamprey (Moser and Mesa 2009). Swimming endurance for macrophthalmia decreased rapidly as water velocities exceeded 0.46 m/s and swimming endurance of ammocoetes is likely lower, due to greater dependence on anaerobic metabolism (Dauble 2006). In addition, Dauble et al. (2006) found that the ability to avoid barrier screens by juveniles is greatly reduced when perpendicular velocities exceed 0.4 m/s (Dauble et al. 2006). Other research revealed that macrophthalmia can not swim faster than velocities found at the screen face of Columbia River mainstem dams (Moursund 2002; Moursund et al. 2003).

Pacific Lamprey macrophthalmia have been observed to be routinely impinged on screens located in front of turbine intakes for Columbia River dams (Moursund and Bleich 2006). More than 20% of juvenile lampreys that approach powerhouses and encounter turbine intake screens are vulnerable to impingement (USACE 2009). Impingement on the screens can result in mortalities under certain conditions, and that a gap reduction from 0.32 to 0.18 cm virtually eliminated impingement (Moursund et al. 2003; Moursund and Bleich 2006). The USAOE has changed screen spacing criteria to address lampreys; however, due to the expense of approximately \$1 million dollars for replacement per screen it will be many years before the passage screens are replaced to meet lamprey criteria at most of the facilities (USACE 2009). The juvenile bypass fish facilities have collected thousands of juvenile lampreys, some of which may clog the screens, causing lamprey injury and mortality. At the juvenile transportation collector facilities, lamprey held in raceways become impinged on tail screens (USACE 2009). Juvenile lampreys have shown high survival through the juvenile salmonid bypass system at mainstem dams (Moursund et al. 2002) but the lamprey are often inadvertently collected and transported downstream in barges or trucks with salmonid smolts. It is unknown whether this is detrimental to lamprey (Moser and Russon 2009). However, observations made by a fish technologist on the transportation barge included rapid dewatering and resulting stranding of ammocoetes and macrophthalmia, potential predation in the hold, and potential injuries similar to descaling of salmon smolts (M. Barrows, USFWS, personal communication).

Screen impingement, passage through turbines, pressure changes, the salmonid juvenile bypass system, transportation around the dams, passage through spillways, dead ends, tailrace conditions, bright lighting, loud sound, forebay hydraulic conditions, maintenance and cooling water screens were the potential threats identified for downstream migrants. These threats, either individually or in concert, can potentially cause delayed migration, injury and/or mortality.

Additionally, reservoirs have an impact on upstream and downstream passage. All stages of Pacific Lamprey are limited with respect to sustained burst speed through high velocity areas. The impact of overall hydrosystem management on water velocity is unknown but likely affects migration timing of adults and macrophthalmia. Reservoirs may alter distribution of fish in the basin causing a shortstopping effect in the Columbia and Snake rivers. Reservoirs are also implicated as a threat to rearing. Ammocoetes have been found in mainstem habitats of varying depths (Silver et al. 2007; Jolley et al. 2010). Pool level fluctuations and sediment management are potentially detrimental to rearing. Alternatively, juvenile lamprey do choose to occupy nearshore habitat that is frequently dewatered and it has been suggested that while reservoirs fluctuate, they provide relatively stable flow conditions and total amount of habitat as compared

to a natural system where flood events cause scouring and then dewater (B. Le, Longview Associates; B. Patterson, Douglas PUD; M. Clement, Grant PUD, personal communication).

Dewatering and Flow Management

The overall scope of this threat was ranked low; however, the severity was ranked moderate/high. General lack of screening criteria for lampreys, irrigation pumps (Ice Harbor and John Day pools), forebay and tail races (Ice Harbor), and fish attraction pumps (all dams) were identified as potential threats in this category. The construction of boat docks and marinas, and erosion control were identified as in-stream projects taking place in mainstem habitats that could affect lampreys.

Stream and Floodplain Degradation

The scope of stream and floodplain degradation in the mainstem Columbia River and Snake River Region was ranked high overall; and the severity was ranked high as dredging, channelization, loss of side channels and removal of vegetation has had major impacts where they have occurred. Dredging and channelization have occurred during dock, marina and road construction. Channel maintenance, water intakes, and disposal areas also threaten lampreys. Reservoirs have contributed to major losses of side channels throughout the mainstem Columbia River and Snake River Region. Vegetation has been inundated by reservoirs and the mainstem channel constrained by extensive levees and dikes, highway and railroad construction.

Water Quality

Water quality was ranked high for scope and unknown for severity. Record high temperatures are being recorded at dams and high temperatures are lasting longer (Quinn and Adams 1996, Bayer and Meeuwig). It is unknown what effect higher temperatures have on Pacific Lamprey regarding migration cues and timing in the mainstem.

Contaminants

Contaminants in sediments of the mainstem of these rivers potentially affect lampreys because of their long fresh water rearing period and increased exposure to toxics.

Predation

Predation was ranked high for both scope and severity primarily because of increased exposure due to reservoir operation, tailraces, delayed migration, and large numbers of warm water predators in reservoirs. Information from the ODFW pike minnow predation study (K. Kostow, ODFW, personal communication) and Cochnauer and Claire (2006) found that lamprey comprised a good proportion of Northern Pikeminnow diet. Lampreys are thought to serve as a predation buffer for salmonids and vice versa. Delay of adult lamprey below Bonneville Dam may subject them to increased predation pressure from sea lions and sturgeon (USACE 2009). Even though predation was ranked high for both scope and severity; there are many unknowns regarding this threat.

Translocation

Translocation was ranked as low scope and unknown severity but it is a potential threat primarily because the population structure of lamprey is unknown. Additionally, translocation could harm donor stocks if too many fish are taken. The risk of not translocating fish was identified as well.

Other

Radiotelemetry surgery is a credible threat to Pacific Lamprey because of the potential impact to fitness and mortality. The cumulative impact of research activities, such as tagging and handling, being performed on fish from a run is being studied by the USGS (M. Mesa, USGS, personal communication). Many fish are potentially being removed from the population, which could impact the number of adults available to spawn.

Historically there were more salmonids migrating through the mainstem Columbia River. Declining numbers of host fish could be affecting Pacific Lamprey numbers.

Prioritization of Limiting Factors and Threats

Number values, 1–4, were assigned to ranks, insignificant to high, respectively. An average was calculated to determine the priority order of threats. The highest priority threats in the mainstem Columbia River and Snake River Region is passage and predation, stream and floodplain degradation, followed by dewatering and flow management (Table 7-1). Water quality, translocation and disease all had unknown rankings and thus an overall numerical rank for scope and severity could not be calculated.

Again, these mainstem threat ranks were then integrated with the watershed threat rankings to calculate an overall threat ranking for each watershed unit for both scope and severity. These overall threat rankings were evaluated for each of the watershed comprising a geographic sub-region, and the results are summarized and contained in Chapters 8-11 of this plan.

Table 7-1. Threats to Pacific Lamprey and their habitats within the Mainstem Columbia River and Snake River Region.

Drainage/HUC	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	
Snake Basin	4	4	2	3.5		4		4	
Upper Columbia – Above Priest	4	4	2	3.5		4		4	
Mid Columbia – Bonneville to Priest	4	4	2	3.5		4		4	
	Mean Rank ^a	4 H	4 H	2 L	3.5 H		4 H		4 H
	Mean Scope and Severity Drainage Rank	4 H		2.75 M		H		H	

^a H (High) = 4, M/H (Moderate/High) = 3.5, M (Moderate) = 3, L/M (Low/Moderate) = 2.5, L (Low) = 2, I (Insignificant) = 1, U = No value

Table 7-1. Continued.

Drainage/HUC	Predation	
	Scope	Severity
Snake Basin	4	4
Upper Columbia – Above Priest	4	4
Mid Columbia – Bonneville to Priest	4	4
	Mean Rank	4 H
	Mean Scope and Severity Drainage Rank	4 H

Suites of Actions to Address Limiting Factors and Threats

Ongoing Conservation Measures

A comprehensive list of ongoing conservation measures and research/monitoring activities occurring in the Mainstem can be found in Appendix D.

1996-present Radiotagging Studies at Mainstem Dams.—Adult Pacific Lamprey were radio-tagged to evaluate upstream passage through various routes in mainstem dams, pinpoint areas that were problematic to passage, and determine travel time through reservoirs, fallback rates and number of adults that travelled to upstream reservoirs.

1994-Current Lamprey Passage Studies Research, Design Development, and Implementation.—Studies that examine adult and juvenile lamprey passage through mainstem dams; with existing conditions and modifications to enhance passage. Includes underwater and acoustic observations, laboratory swimming tests, fyke net sampling in turbine screen slots, development and testing of Lamprey Passage Systems, experimental fishways, velocity tests, orifice and diffuser modifications, pheromone tests, rounding corners and smoothing surfaces, passage behavior, attraction methods, dewatering protocols, translocation trapping, PIT tag methods and feasibility and screen impingement.

Development of Juvenile Separator in Juvenile Bypass System.—M. Moser and I. Russon, Development of a Separator for Juvenile Lamprey, 2007-2008. M. Moser and A. Vowles, Development of a Separator for Juvenile Lamprey, 2008-2009.

Annual Prioritization of Lamprey Research and Implementation Goals with MOA Participants.—Details of the Columbia River Fish Accords commitments and projects are contained in Appendix D, section C.

USACE Pacific Lamprey Passage Improvements Implementation Plan 2008 – 2018.—USACE in their 10 year passage plan believes deciding where to prioritize efforts to improve lamprey passage should be based on two simple but critical factors: (1) where passage efficiency is the poorest; and (2) where the affected numbers of Pacific Lamprey are the highest. This approach will maximize the improvements for both upper and lower Columbia Basin Pacific Lamprey. The USACE has identified the following plan based on these two factors and the current state of knowledge on dam passage, the preliminary prioritization at FCRPS dams would be:

1. Bonneville Dam - Cascade Island entrance modification that includes entrance weir, rock floor, PIT reader, and Lamprey Passage System (LPS) - Prototype 2009. March 2009-2010 evaluation/modification.
2. Washington Shore Ladder Entrance Modification - 2011 to 2012. Design development beginning in 2009.
3. John Day Dam - North Ladder exit section modification with lamprey improvements; winter 2009-2010 installation. North Ladder entrance modifications - 2010 to 2012. Design work ongoing.

4. McNary Dam - Oregon shore ladder entrance modifications - 2011 to 2013. Design development beginning in 2009.
5. Snake River Dams Ladder entrance modifications - 2014 to 2017.
6. The Dalles Dam - No activities planned until other dams are addressed because of existing high passage rates (74%) compared to other dams.

Nighttime Video Counts of Lamprey in Ladders.—Pacific Lamprey counting at most dams occurs only during daylight hours. Lampreys are more active at night and because there are numerous routes available for lamprey to pass dams and not be detected at the count windows (e.g., through picketed leads and trash racks, AWS channel, LPS, and others), existing counts are rough indexes of passage. The USACE is conducting research at several FCRPS dams using nighttime video counts, lamprey PIT detection, and Lamprey Passage System counts to develop a more accurate counting methodology. Night video based counting of lamprey passage at count windows now occurs at Bonneville, McNary, and Lower Granite dams as part of the O&M counting program. Additional video work is planned or ongoing as part of the RM&E at alternative routes that bypass the window at The Dalles and John Day dams. Nighttime counting is expected to continue at several of the FCRPS dams with a potential subsampling methodology being developed for counting at high volume ladders. Through the relicensing of several PUD owned hydroelectric projects, several PUDs now have 24-hour counting of adult lamprey within their adult fishways. Wanapum, Priest Rapids, Wells, Rocky Reach and Rock Island dams have 24-hour counting from approximately mid-April to mid-November. A better estimate of passage will improve evaluation of population status.

Mainstem Electrofishing Sampling.—The USFWS Columbia River Fisheries Program Office has developed and been using a boat-mounted, deepwater electrofisher (Jolley et al. 2010) to sample juvenile lamprey in the mainstem Willamette and Lower Columbia rivers. This study documented the first quantitative information on larval Pacific lamprey and *Lampetra* spp. occupancy in mainstem river habitats, and established the ability to effectively use the deepwater electrofishing technology and apply a statistically robust and rigorous sampling scheme to explore patterns of distribution, occupancy, and detection. This technique is being used specifically to: 1) Document presence lamprey ammocoetes throughout the Lower Columbia River in areas of varied salinity history; 2) Determine the probability of detecting larval lamprey in the Lower Columbia River with a deepwater electrofisher; 3) Describe the age (i.e., size) distribution of larval lamprey; 4) Describe the species composition of larval lamprey; and 5) Describe zones with different salinity histories that lamprey may/may not occupy. This research will greatly add to knowledge of lamprey rearing habitat, salinity tolerances and distribution in mainstem habitats.

Needed Actions for the Mainstem

Needed actions should proceed in an adaptive management context to offer improvements on adult passage in these systems on the best information available. Perfect information is not available, but needed actions are critical in the very near term.

The number one priority action needed is modification of ladder entrances and operations to improve adult passage. Other needed actions identified, but not prioritized, are:

- Implement methodologies used to improve the accuracy of adult lamprey upstream fishway counts.
- Information on fishway entrance approaching behavior would help modification of entrances for better adult passage efficiencies.
- Active and direct consideration of lamprey needs in all FCRPS.
- Overall assessment of mainstem spawning.
- Assessment of ammocoete mainstem rearing.
- Uniform process for quantifying juveniles on screens (Fish Passage Operations and Maintenance Coordination Team (FPOM)) and type and configuration of screens.
- Accelerate the schedule to replace screens with those that meet the minimum spacing criteria for lamprey; in a timely manner to effectively restore lamprey populations.
- Better understanding of transformation of ammocoetes to macrophthalmia to improve juvenile passage.
- Define the best method of current operation with existing information (transport, screens, etc.).
- Incorporate lamprey in dredging studies (e.g., Lower Granite) and apply proper study design.
- Implement USFWS/BLM/FS Best Management Practices for Minimizing impacts to Pacific Lamprey in mainstem restoration projects.

Research, Monitoring, and Evaluation Needs

The top two needed research actions for the mainstem are:

1. A systematic ladder and entranceway evaluation survey integrated with biological information and a stage-based model to evaluate lamprey passage at each Federal Columbia River Power System (FCRPS) project. The purpose is to provide an evaluation to inform priorities or the sequence of actions to be taken to improve adult passage, while not degrading adult salmon passage.
2. Development of a tag for juveniles for determination of a population estimate and passage routes being taken.

Additionally, a recommendation was made to consult the Columbia River Basin Lamprey Technical Workgroup for updated critical uncertainty prioritization. Currently, passage is ranked first for the threats that need to be addressed to restore lamprey populations to the Columbia River basin.

Other research needs that were identified but not prioritized are:

- Identification of ammocoetes.
- Monitor and evaluate the vertical distribution of juvenile lamprey approaching mainstem dams.

- Development of mark/recapture system: 1) population estimates; 2) location in the water column; 3) survival by passage route; and, 4) source of larvae needed for research.
- Tracking adults for movement in reservoirs.
- Determine scope of stream and floodplain degradation.
- Water quality studies.
- Research uncertainties related to translocation (see CBFWA white paper).
- Research techniques for the successful artificial propagation of Pacific Lamprey.
- Study diseases that affect lampreys in the mainstem.
- Evaluations and further refinement of surgical techniques.
- Development of a separate whole LPS so other modifications are not necessary, lampreys "bypass" ladder completely.
- Population estimates.
- Handling/holding fish, refining procedures to reduce disease, fungus.
- Numbers and effect of transportation system.
- Predation research (e.g., sea lion).
- Dredge spoil sampling.
- Impact of timing delays on survival to the ocean.
- Investigate the ocean life history phase (e.g. spatial & vertical distribution, host populations).
- Irrigation diversion impacts on juveniles and ammocoetes.
- Temperature tolerance for migration and survival.
- Translocation research and monitoring.

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8. SNAKE RIVER REGION

Geographic Description of the Region

The Snake River Region includes the Snake River and all waters draining into it downstream of Hells Canyon Dam to its confluence with the Columbia River. Major tributaries in this reach of the Snake River include the Imnaha, Salmon, Grande Ronde, Clearwater, and Tucannon.

More detailed descriptions of the geology, land use, hydrology and climate of the watersheds reviewed in this chapter can be found in the individual watershed templates and as follows:

- Clearwater Subbasin Assessment (Ecovista 2002)
- Salmon Subbasin Assessment (Servheen et al. 2004)
- Asotin Subbasin Management Plan (Asotin County Conservation District 2004)
- Grande Ronde Subbasin Plan (Nowak 2004)
- Imnaha Subbasin Assessment (Ecovista 2004)
- Snake Hells Canyon Subbasin Assessment (Nez Perce Tribe 2004)
- Tucannon Subbasin Plan (Columbia Conservation District 2004)

The Snake River Region supports a number of salmonids, including spring, summer and fall Chinook Salmon *O. tshawytscha*, Coho Salmon *O. kisutch*, summer Steelhead, Sockeye Salmon, Bull Trout *Salvelinus confluentus*, Redband Trout and Westslope Cutthroat Trout *O. clarkii*. Steelhead, Chinook Salmon, and Bull Trout are listed under the ESA as threatened, and Sockeye Salmon are listed as endangered.

The Snake River Region within the boundaries of the Pacific Lamprey Conservation Assessment is comprised of five Level III Ecoregions described by the Environmental Protection Agency (EPA) (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). Descriptions of each ecoregion (McGrath et al. 2002) can be found in Appendix A. The drainage open to Pacific Lamprey within the Snake River Region is approximately 64,149 km². Several historically occupied areas were not included in this assessment as they are now blocked by impassable dams. These include the Snake River from Hells Canyon Dam Complex to Shoshone Falls and several major tributaries (Gilbert and Evermann 1895), and the North Fork Clearwater, now blocked by Dworshak Dam. The Palouse River historically had Pacific Lamprey from the mouth upstream 9.7 km to Palouse Falls (P.Luke, Yakama Tribe, personal communication) but current status was not reviewed in this assessment. However, all of the Wallowa drainage was reviewed, although the dam on Wallowa Lake blocks access. The 23 HUCs still accessible to Pacific Lamprey and reviewed for the Conservation Assessment ranged in size from 552–6,242 km², and fall within 1–5 ecoregions. See Table 8-1 for how the HUC's fall within the ecoregions and Figure 8-1 on their distribution.

Table 8-1. Drainage Size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the Snake River Region.

Watershed	HUC Number	Drainage Size (km ²)	Level III Ecoregion(s)
Lower Clearwater	17060306	6,061	Columbia Plateau, Northern Rockies
Middle Fork Clearwater	17060304	552	Columbia Plateau, Northern Rockies, Idaho Batholith
South Fork Clearwater	17060305	3,030	Columbia Plateau
Lochsa	17060303	3,056	Northern Rockies, Idaho Batholith
Lower Selway	17060302	2,668	Idaho Batholith
Upper Selway	17060301	2,582	Idaho Batholith
Lower Salmon	17060209	3,212	Blue Mountains
Little Salmon	17060210	1,507	Blue Mountains
South Fork Salmon	17060208	3,393	Idaho Batholith
Middle Salmon-Chamberlain	17060207	4,403	Idaho Batholith
Lower Middle Fork Salmon	17060206	3,548	Idaho Batholith
Upper Middle Fork Salmon	17060205	3,859	Idaho Batholith
Middle Salmon-Panther	17060203	4,688	Idaho Batholith
Lemhi	17060204	3,289	Middle Rockies
Pahsimeroi	17060202	2,137	Middle Rockies
Upper Salmon	17060201	6,242	Idaho Batholith, Middle Rockies
Lower Snake-Asotin	17060103	1,841	Columbia Plateau
Lower Grande Ronde	17060105	3,963	Blue Mountains
Upper Grande Ronde	17060104	4,273	Blue Mountains
Imnaha	17060102	2,214	Blue Mountains
Wallowa	17060105	2,460	Blue Mountains
Mainstem Snake Hells Canyon	17060101	1,412	Blue Mountains
Lower Snake-Tucannon	17060107	3,833	Columbia Plateau, Blue Mountains

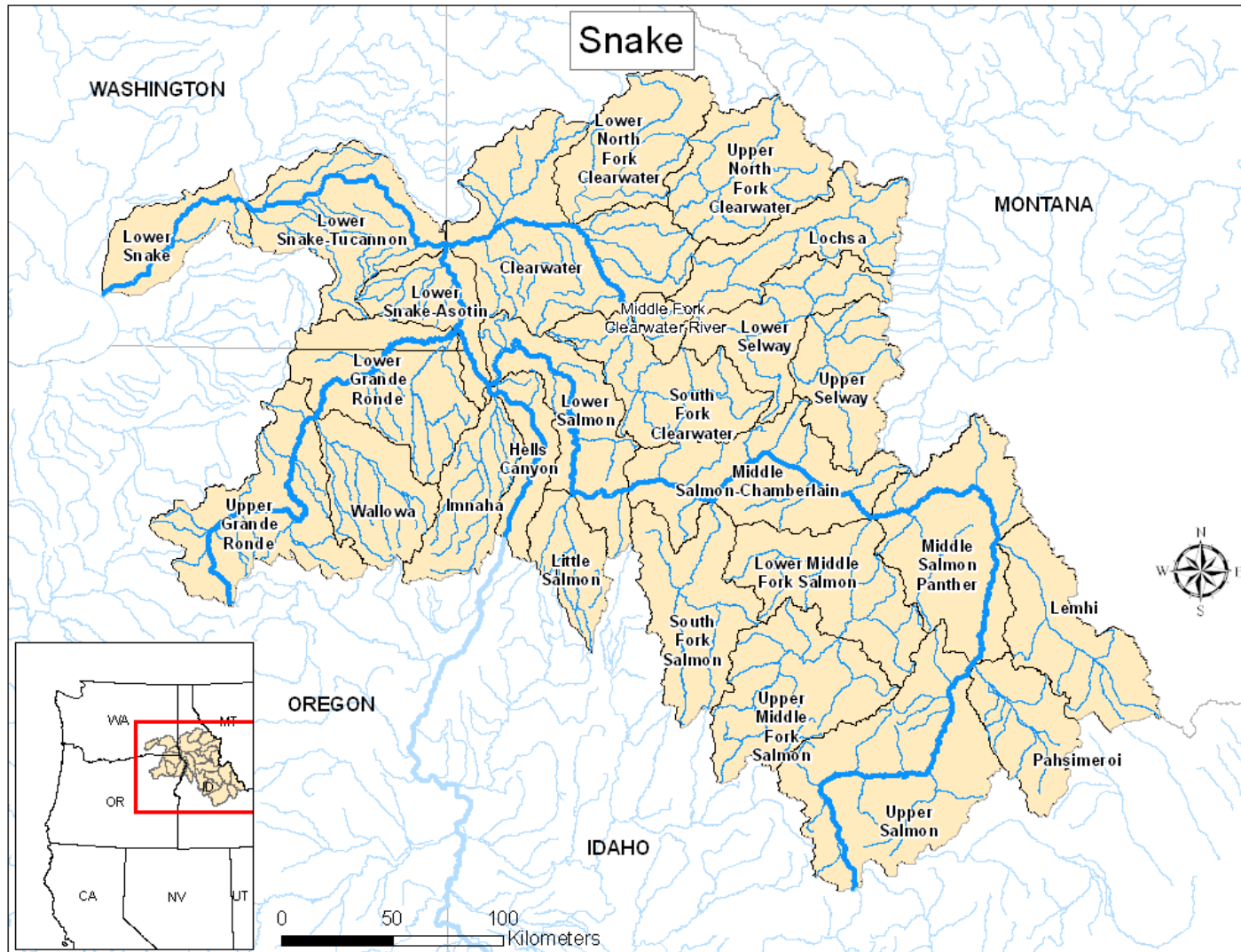


Figure 8-1. Map of Snake River Region watersheds and Level III Ecoregions.

Ranked Population Status of Pacific Lamprey in the Snake River Region

Population factors were difficult to rank in many watersheds. The uncertainty associated with determining them was high because of the paucity of fishing records, dam counts, and in particular targeted surveys for Pacific Lamprey. In most cases the uncertainty was categorized as best professional judgment based on expansion of data for other species (e.g., SIP) for historic distribution; and in the case of the category of current occupancy it was either largely undocumented (but based on extent of habitat, suspected barriers and/or anecdotal information) or based on partial surveys for less than one half of the watershed.

NatureServe status ranks were calculated for Pacific Lamprey populations in this Region based on input from participants in the regional meeting and professional judgment. Ranks for range extent and occupancy, current population size and trend for watersheds in the Snake River Region are in Table 8-2.

Threats and Limiting Factors to Pacific Lamprey in the Snake River Region

The Federal Columbia River Power System dams on the mainstem Snake and Columbia rivers were identified as the highest threat to the persistence of Pacific Lamprey in the Snake River watersheds. Based on this, the scope and severity of small effective population size was identified as a high threat in each of the watersheds reviewed (Table 8-3). Other documents that identify threats and actions that may affect Pacific Lamprey include the NWPCC/CBFWA Subbasin Planning documents, Bull Trout Assessments, Salmon Recovery Plans, Chinook and Steelhead Recovery Plans and Total Maximum Daily Load (TMDL) assessments.

Threats identified in the regional meetings, existing salmonid limiting factors analysis and recovery plans include:

Passage

In the Snake River watersheds, 19 out of 23 identified some passage issues, but passage overall was rated as low in scope and severity. Culverts in tributaries and scattered irrigation diversions throughout the area could be full or partial passage barriers. Weirs at two hatcheries, Kooskia Hatchery in the Middle Fork Clearwater watershed, and the Rapid River Hatchery in the Little Salmon watershed, could be barriers to Pacific Lamprey. The Wallowa Lake dam in the Wallowa watershed blocks passage for all aquatic organisms, and several irrigation dams in the Wallowa system, while passing adult salmonids, may be barriers to lamprey movement. The Hells Canyon dam on the Snake River is the uppermost point of current Pacific Lamprey distribution in the Snake River Region. Pacific Lamprey historically occurred in the watersheds above the Hells Canyon Dam Complex up to Shoshone Falls but have been extirpated since 1967 (Brownlee Dam 1958, Oxbow Dam 1961, Hells Canyon 1967). Pacific Lamprey also historically occurred in the North Fork Clearwater watershed but have been blocked from all but the lower three km of the river since 1972 when Dworshak Dam was completed. Headgate Dam on Asotin Creek may be a barrier to adult Pacific Lamprey passage (Schlosser and Peery 2010).

Adults were observed to pass over the structure from 1954-1960, but currently spawning occurs below Headgate Dam.

Table 8-2. Population status of the Pacific Lamprey in the Snake River, as ranked by participants at the regional meetings.

Watershed	Occupancy (km ²)		Current Population Size (Adults)	Short Term Trend
	Historic	Current		
Lower Clearwater	5000-20,000	20-100 to 100-500	1-50	>70% decline
Lower North Fork Clearwater	1000-5000	Extinct ^a	Extinct	
Upper North Fork Clearwater	1000-5000	Extinct	Extinct	
Middle Fork Clearwater	250-1000	4-20 to 20-100	1-50	>70% decline
South Fork Clearwater	1000-5000	4-20 to 20-100	1-50	>70% decline
Lochsa	1000-5000	4-20	1-50	>70% decline
Lower Selway	1000-5000	4-20	1-50	>70% decline
Upper Selway	1000-5000	4-20	1-50	>70% decline
Lower Salmon	1000-5000	4-20	1-50	>70% decline
Little Salmon	1000-5000	4-20	1-50	>70% decline
South Fork Salmon	1000-5000	0.4-4	1-50	>70% decline
Middle Salmon-Chamberlain	1000-5000	0.4-4	1-50	>70% decline
Lower Middle Fork Salmon	1000-5000	No rank	1-50	>70% decline
Upper Middle Fork Salmon	1000-5000	No rank	1-50	>70% decline
Middle Salmon-Panther	1000-5000	No rank	1-50	>70% decline
Lemhi	1000-5000	Zero, Extinct	1-50	>70% decline
Pahsimeroi	1000-5000	Zero, Extinct	1-50	>70% decline
Upper Salmon	5000-20,000	Zero, Extinct	1-50	>70% decline
Lower Snake-Asotin	1000-5000	4-20 to 20-100	1-50	>70% decline
Lower Grande Ronde	1000-5000	20-100 to 100-500	1-50	>70% decline
Upper Grande Ronde	1000-5000	<0.4 to 0.4-4	1-50	>70% decline
Imnaha	1000-5000	<0.4 to 0.4-4	1-50	>70% decline
Wallowa	1000-5000	<0.4 to 0.4-4	1-50	>70% decline
Mainstem Snake Hells Canyon	100-250 to 250-1000	<0.4 to 0.4-4	1-50	>70% decline
Lower Snake-Tucannon	1000-5000	No rank	1-50	>70% decline

^a The lower 3 km of the North Fork Clearwater River are still accessible to Pacific Lamprey. Current occupancy is 4-20 km², and current population is 1-50 adults.

Dewatering and Flow Management

While dewatering is widespread and can have localized impacts, this threat was considered to be low in scope and severity across the Snake River watersheds. Dewatering was identified as a threat in watersheds that have irrigated agriculture (Lower Snake tributaries, upper Salmon tributaries, upper Little Salmon), or in watersheds where either natural conditions or land management causes adverse flow regimes and hydrographs resulting in low base flows and/or subsurface flows (Lower Clearwater). Dams managed for irrigation (Wallowa Lake in the Wallowa watershed) or hydropower (Dworshak Dam on the North Fork Clearwater and Hells Canyon on the Snake River) have major impacts in hydrology, flow alteration, temperature alteration, stream alteration and sudden fluctuations causing stranding and isolation.

Stream and Floodplain Degradation

Across all watersheds, stream and floodplain degradation were rated low in scope and moderate in severity. Watersheds that are not managed as wilderness were generally rated at least a moderate in scope and severity for this threat factor. Channelization due to mining (Upper Grande Ronde, South Fork Clearwater, South Fork Salmon, Middle Salmon-Chamberlain, Middle Salmon-Panther and Upper Salmon) and road construction were the main causal factors, with grazing, timber harvest, agriculture, private development and recreation cited as secondary mechanisms impacting stream and floodplain integrity. Within a watershed scope could be rated as low or moderate but localized impacts could make the severity high.

Water Quality

Poor water quality was given a rating of low in scope and severity across all watersheds. However, several watersheds have issues with temperature, sediment and heavy metals (due to mining) so that individual watershed scores were rated as moderate or high. These watersheds included the Upper Grande Ronde, Lower Clearwater, South Fork Clearwater, Lower Snake-Asotin, Little Salmon and South Fork Salmon.

Other

Overall, , small effective population size was identified as highest threat for scope and severity across the Snake River Region because of upstream and downstream passage issues at the mainstem dams on the Snake and Columbia rivers.

Lack of Awareness was rated as moderate in scope and severity. Issues identified included unintentional adverse effects when conducting instream work (e.g. culvert installation, bridges, boat ramps, diversions) and habitat restoration activities for other aquatic species, not knowing where Pacific Lamprey occur, and lack of understanding on the role Pacific Lamprey play in the ecosystem. Related is the lack of knowledge we have about the distribution, status and general life history characteristics of Pacific Lamprey, which would help guide restoration of habitat and the species.

Climate change was also rated as moderate in scope and severity. In watersheds that occur in low elevations or are highly impacted by human activities, the rankings were moderate or high. It is in these areas where changes in climate would have the most adverse impact on Pacific Lamprey.

Predation by Smallmouth Bass and Northern Pikeminnow was rated as low in scope and severity, but in some localized areas it was rated as insignificant to moderate, depending on the residency of these species.

Harvest, translocation and disease were all rated as insignificant. Harvest does not occur, translocation is occurring in a few drainages from outside the Region, and the occurrence and prevalence of disease in Pacific Lamprey is uncertain.

Prioritization of Limiting Factors and Threats

Numeric values, 1–4, were assigned to ranks, insignificant to high, respectively. In cases where participants gave a combination ranking, such as M/H, the rank was assigned a value between the two ranks, e.g., 3.5.

An average for all watersheds was calculated for scope and severity, and the overall scope and severity values were averaged to obtain one value to determine the priority order of threats.

The highest priority threats in the Snake River watersheds are mainstem passage and small effective population size, followed by stream degradation, passage and water quality (Table 8-3). Climate change and lack of awareness are not highlighted in the regional analysis as they will be looked at across the range wide species scale.

Stream and floodplain degradation ranked as a medium/high threat in watersheds with human influences. Even though several HUCs are in wilderness areas within the Clearwater, Salmon and Lower Snake sub-watersheds, the degradation in non-wilderness areas highlighted the impact of human activities. Overall, stream and floodplain degradation ranked as medium throughout the Snake Region.

Table 8-3. Threats to Pacific Lamprey and their habitats within the Clearwater, Salmon, and Lower Snake River drainages, as identified and ranked by participants at regional meetings. H=4, M/H=3.5, M=3, L/M=2.5, L=2, I=1, U=No value

Watershed	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Clearwater Drainage												
<i>Lower Clearwater</i>	2.5	2.5	2.5	2.5	3	3.5	3	3.5	1	1	2	2.5
<i>Middle Fork Clearwater</i>	2	2	2	2	2.5	3	2	2.5	1	1	2	2
<i>South Fork Clearwater</i>	3	2.5	1.5	1.5	3.5	3.5	3	2.5	1	1	2	2.5
<i>Lochsa</i>	2	2	1	1	2	2	1	1	1	1	1	1
<i>Lower Selway</i>	1	1	1	1	2	2	1	1	1	1	1	1
<i>Upper Selway</i>	1	1	1	1	1	1	1	1	1	1	1	1
Mean Rank	1.92	1.83	1.5	1.5	2.33	2.5	1.83	1.92	1	1	1.5	1.67
	L	L	L	L	L	M	L	L	I	I	L	L
Mean Scope & Severity Drainage Rank	1.88		1.50		2.42		1.88		1.00		1.58	
	L		L		M		L		I		L	
Salmon Drainage												
<i>Lower Salmon</i>	2	2	2	2	2	2	2	2.5	1	1	2	2
<i>Little Salmon</i>	2	2.5	2.5	2.5	2.5	2.5	3	3	1	1	2	2
<i>South Fork Salmon</i>	2	2	1	1	2.5	2.5	2.5	2.5	1	1	2	2
<i>Mid. Salmon-Chamberlain</i>	1	1	1	1	2	2	2	2.5	1	1	2	2
<i>Low. Middle Fk. Salmon</i>	1	1	1	1	1	1	1	1	1	1	1	1
<i>Up. Middle Fk. Salmon</i>	1	1	1	1	1	1	1	1	1	1	1	1
<i>Middle Salmon-Panther</i>	3	3	3	4	3	3	3	2	1	1	2	1
<i>Lemhi</i>	3.5	4	4	4	3	3	3	2	1	1	2	1
<i>Pahsimeroi</i>	3.5	4	4	4	4	3	3	2	1	1	2	1
<i>Upper Salmon</i>	3	2	3	2	3	3	2	2	1	1	2	1
Mean Rank	2.2	2.25	2.25	2.25	2.4	2.3	2.25	2.05	1	1	1.8	1.4
	L	L	L	L	L	L	L	L	I	I	L	I
Mean Scope & Severity Drainage Rank	2.23		2.25		2.35		2.15		1.00		1.60	
	L		L		L		L		I		L	

Table 8-3. Continued.

Watershed	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Lower Snake												
<i>Lower Snake-Asotin</i>	2	1.5	1.5	1.5	3	3.5	2.5	2.5	1	1	3	3
<i>Lower Grande Ronde</i>	2	2	1	1	2	2	2	2.5	1	1	2	2.5
<i>Upper Grande Ronde</i>	2	3	3	3.5	3.5	3.5	3	3.5	1	1	2.5	3
<i>Innaha</i>	2	3.5	2	3	2	2.5	2	2	1	1	1	1
<i>Wallowa</i>	2	3.5	3	3.5	3	3.5	2	3.5	1	1	2.5	3
<i>Lower Snake-Hells Canyon</i>	2	4	4	4	2	3	1	1	1	1	1	2
<i>Lower Snake-Tucannon</i>	2	4	1	2	3	3	3	2	1	1	2	2
Mean Rank	2	3.07	2.21	2.64	2.64	3	2.21	2.43	1	1	2	2.36
	L	M	L	M	M	M	L	M	I	I	L	L
Mean Scope & Severity Drainage Rank		2.54		2.43		2.82		2.32		1.00		2.18
		M		L		M		L		I		L
Upper Snake Region												
Overall Rank	2.07	2.39	2.04	2.17	2.46	2.57	2.13	2.13	1.00	1.00	1.78	1.76
Mean Scope & Severity Overall Threat Rank		2.23		2.11		2.51		2.13		1.00		1.77
		L		L		M		L		I		L

Table 8-3. Continued.

Watershed	Translocation		Disease		Small Population Size		Lack of Awareness		Climate Change		Mainstem Passage	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Clearwater Drainage												
<i>Lower Clearwater</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
<i>Middle Fork Clearwater</i>	1	1	1	1	4	4	3	3	2.5	2.5	4	4
<i>South Fork Clearwater</i>	1	1	1	1	4	4	3	3	2.5	2.5	4	4
<i>Lochsa</i>	1	1	1	1	4	4	1	1	1	1	4	4
<i>Lower Selway</i>	1	1	1	1	4	4	1	1	1	1	4	4
<i>Upper Selway</i>	1	1	1	1	4	4	1	1	1	1	4	4
Mean Rank	I	I	I	I	H	H	L	L	L	L	H	H
Mean Scope & Severity Drainage Rank	1.00 I		1.08 I		4 H		2.00 L		1.88 L		4 H	
Salmon Drainage												
<i>Lower Salmon</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
<i>Little Salmon</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
<i>South Fork Salmon</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
<i>Mid. Salmon-Chamberlain</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
<i>Low. Middle Fk. Salmon</i>	1	1	1	2	4	4	1	1	2	2	4	4
<i>Up. Middle Fk. Salmon</i>	1	1	1	2	4	4	1	1	2	2	4	4
<i>Middle Salmon-Panther</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
<i>Lemhi</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
<i>Pahsimeroi</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
<i>Upper Salmon</i>	1	1	1	2	4	4	3	3	3	3.5	4	4
Mean Rank	I	I	I	L	H	H	M	M	M	M	H	H
Mean Scope & Severity Drainage Rank	1.00 I		1.50 L		4.00 H		2.60 M		3.00 M		4.00 H	

Table 8-3. Continued.

Watershed	Translocation		Disease		Small Population Size		Lack of Awareness		Climate Change		Mainstem Passage	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Lower Snake												
<i>Lower Snake-Asotin</i>	1	1	1	1	4	4	3.5	3.5	2.5	2.5	4	4
<i>Lower Grande Ronde</i>	1	1	1	1	4	4	4	4	4	4	4	4
<i>Upper Grande Ronde</i>	1	1	1	1	4	4	4	4	3	3	4	4
<i>Imnaha</i>	1	1	1	1	4	4	4	4	3	3	4	4
<i>Wallowa</i>	1	1	1	1	4	4	4	4	4	4	4	4
<i>Lower Snake-Hells Canyon</i>	1	1	1	1	4	4	4	4	3	3	4	4
<i>Lower Snake-Tucannon</i>	1	1	1	1	4	4	3	3	U	U	4	4
Mean	1	1	1	1	4	4	3.79	3.79	3.25	3.25	4	4
Rank	I	I	I	I	H	H	H	H	M	M	H	H
Mean Scope & Severity Drainage Rank	1.00		1.00		4.00		3.79		3.25		4.00	
	I		I		H		H		M		H	
Upper Snake Region												
Overall Rank	1.00	1.00	1.00	1.48	4.00	4.00	2.80	2.80	2.66	2.86	4.00	4.00
Mean Scope & Severity Overall Threat Rank	1.00		1.24		4.00		2.80		2.76		4.00	
	I		I		H		M		M		H	

Suites of Actions to Address Limiting Factors and Threats

Ongoing Conservation Measures

Distribution and Habitat Use Surveys – past and ongoing (IDFG, NPT, USFWS).—The Idaho Department of Fish and Game began surveys in 2000 to document presence and distribution of Pacific Lamprey within the state. Focused initially in the South Fork Clearwater drainage, where Pacific Lamprey were known to occur at the time, the surveys expanded to other waters where Pacific Lamprey could still access habitat, and some surveys in historically occupied, but not currently accessible. Formal surveys ended in 2006, but some surveys are conducted annually on a small scale, primarily in conjunction with trend surveys for salmonids in wilderness areas. Results of distribution and habitat where ammocoetes were found are documented in reports that can be found on the Bonneville Power website, and IDFG maintains a GIS based database with sites where Pacific Lamprey have been surveyed, found and not sampled. There is also a draft Management Plan for Pacific Lamprey (Cochner and Claire 2009) that summarizes this information and has suggestions for habitat restoration and management needs. The Nez Perce Tribe and USFWS are monitoring juvenile production, distribution and habitat use for progeny resulting from adult translocation studies (see below). Schlossler and Peery (2010) modeled available spawning and rearing habitat for Pacific Lamprey in Asotin Creek, identifying several suitable areas within the mainstem Asotin Creek, but not in George Creek, a tributary. They also identified Headgate Dam as a passage barrier that should either be removed or modified to allow passage.

NPT Adult Pacific Lamprey Translocation Initiative (Summary from LTWG Translocation Paper 2010).—Since 2006, biologists with the Nez Perce Tribe have conducted a trial translocation program to augment natural lamprey production in the Snake River. Adult lamprey salvaged from John Day Dam adult fishways during the annual winter dewatering period are held through the winter at the Nez Perce Tribal Hatchery on the Clearwater River. In May they are released into four Snake River tributaries: Asotin Creek in Washington, and Lolo, Newsome, and Orofino creeks in Idaho. A sub-sample are radio-tagged to track movements and spawning locations. Electrofishing surveys are employed to document juvenile production, distribution and habitat use.

Snake River Salmon Recovery Plan.—The Snake River Salmon Recovery Plan (SRSRB 2007) outlines activities that have occurred, are currently being implemented, and are planned, to address habitat threats in the Southeast Washington watersheds, including the Tucannon and Asotin. While targeted towards anadromous salmonids, several of the activities will benefit lamprey species. An example is the removal of the Headgate Dam in Asotin Creek.

Barrier Removals and Road Decommissioning on USFS lands in the Clearwater, Salmon, Payette, Boise, Wallowa-Whitman Forests.—Since the early 1990s, National Forests have been replacing barrier culverts with structures that pass aquatic organisms, or removing them completely when roads are decommissioned. In the Clearwater National Forest, a minimum of 74 culverts have been improved or removed in current Pacific Lamprey habitat since 2000.

Data from other forests has not been obtained. Road decommissioning not only removes barriers, but minimizes road failures and resultant sediment inputs into watersheds.

Barrier Removals and Road Decommissioning on BLM lands in Idaho.—Primarily during the 2000s the BLM has been active in removing barrier culverts or re-connecting some streams that have had barriers created by historic mining (e.g. dredge mining) in streams that may provide potential Pacific Lamprey habitat. Road decommissioning is also occurring but at a limited amount.

USFS and BLM Biological Assessments for Anadromous Salmonids and Bull Trout.—Biological assessments have been completed that address federal land management actions in most watersheds with Pacific Lamprey. These were done primarily for bull trout and anadromous salmonid species, but several factors in the analyses are applicable to Pacific Lamprey. These assessments provide a description of baseline habitat and population conditions as required to assess Federal actions during Endangered Species Act Section 7 consultation. These consultations have taken place in accordance with streamlining procedures required under a 1999 Memorandum of Understanding between the U.S. Fish and Wildlife Service, U.S. Forest Service, Bureau of Land Management, and National Marine Fisheries Service. Of the completed formal consultations, none of the Federal actions were determined to jeopardize the continued existence of the Columbia River Basin distinct population segment for bull trout, and many actions were modified to minimize the impacts to bull trout. The corresponding biological opinions include conservation recommendations to suggest additional actions that the consulting agencies may take which would be beneficial to listed species. Habitat remediation activities are ongoing.

Completed TMDLs for several HUCs identify measures to provide management direction for addressing TMDLs, specifically temperature and sediment.—

- Cottonwood Creek Total Daily Maximum Load (TMDL) (IDEQ 2000).
- Draft Hatwai Creek Subbasin Assessment and TMDLs (IDEQ 2010).
- Lower Grande Ronde Subbasins TMDLs (includes Wallowa, Imnaha and Lower Grande Ronde) (ODEQ 2010).
- Jim Ford Creek Total Daily Maximum Load Watershed Management Plan (IDEQ 2000a).
- Lindsay Creek Watershed Assessment and Total Maximum Daily Loads (IDEQ 2007).
- Little Salmon River Subbasin Assessment and TMDL (IDEQ 2006).
- Lochsa River Subbasin Assessment (Bugosh 1999).
- Lower Salmon River and Hells Canyon Tributaries Assessments and TMDLs (IDEQ 2010a).
- Lower Selway River Subbasin Assessment (Bugosh 2002).
- Middle Fork Salmon River Subbasin Assessment and Total Maximum Daily Loads (Herron and Freeman 2008).
- Middle Salmon River-Chamberlain Creek Subbasin Assessment and Crooked Creek Total Maximum Daily Load (Shumar 2002).

- Middle Salmon River-Panther Creek Subbasin Assessment and TMDL (IDEQ 2001).
- Pahsimeroi River Subbasin Assessment and Total Maximum Daily Load (Shumar et al. 2003).
- Potlatch River Subbasin Assessment and TMDLs (IDEQ 2008).
- South Fork Clearwater River Subbasin Assessment and Total Maximum Daily Loads (Dechert and Woodruff 2003).
- South Fork Salmon River Subbasin Assessment (IDEQ 2002).
- Tammany Creek Sediment TMDL (IDEQ 2001a).
- Tucannon River and Pataha Creek Temperature Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan (WDE 2010).
- Upper Grande Ronde Subbasin Total Maximum Daily Load (ODEQ 2000).
- Upper Salmon River Subbasin Assessment and TMDL (IDEQ 2003).

Fish Passage and Fish Screen installations at water diversions in the Salmon Basin.—Management agencies in Idaho, particularly the Idaho Department of Fish and Game, have been installing fish screens at irrigation diversions in the Salmon River watershed since the 1950’s. Currently most of the screens installed conform to NOAA criteria. The screens are in anadromous salmonid waters. Diversions that pose as fish passage barriers are remediated to allow fish passage at most flows. As opportunity arises, water diversions are consolidated and water delivery is improved so that more water can be left instream.

Water Transactions in the Upper Salmon Basin that keep water in the stream.—The Columbia Basin Water Transactions Program (CBWTP) has been instrumental in water savings in several tributaries in the Upper Salmon, Grande Ronde, and Lower Snake watersheds and elsewhere in the Columbia Basin. Using permanent acquisitions, leases, investments in efficiency and other incentive-based approaches, the CBWTP supports program partners in Oregon, Washington, Idaho and Montana to assist landowners who wish to restore flows to existing habitat (<http://www.cbwtp.org/jsp/cbwtp/program.jsp>). Leaving water in the stream improves instream flows, temperature and provides more in-channel habitat during critical times.

Tribal Pacific Lamprey Restoration Plan Implementation.—TBD

Needed Actions

Columbia Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lampreys (2005) (In Appendix C).—Meeting attendees think that critical uncertainties apply.

Actions Identified in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Snake River Region (Table 8-4).

Table 8-4. Actions identified (depicted by X) in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia Basin (2008) for the Snake River Region.

Category/Task	Grande Ronde	Tucannon	Clearwater	Salmon	Asotin	Imnaha	Snake Hells Canyon	Palouse	Snake River Subbasins
Status									
Document current adult abundance and distribution	X	X							
Document historic adult and juvenile abundance and distribution; collect anecdotal information; interview biologists, tribal elders and landowners with knowledge of lamprey	X	X							
Establish and monitor ammocoete index sites for changes in distribution and abundance; presence/absence surveys. Identify species	X	X	X	X	X	X	X	X	X
Monitor general Snake River status and trends via adult and macrophthmia counts statistics at dams	X	X	X	X	X	X	X	X	X
Monitor juvenile outmigration; describe outmigration timing and abundance	X	X							
Biology/Life History									
Determine adult and juvenile migration timing, size, age and condition	X	X							
Identify/describe/determine adult and juvenile tributary habitat use: timing, duration and age	X	X							
Limiting Factors									
Identify habitat limiting factors for adult migration	X	X							
Identify habitat limiting factors for adult spawning	X	X							
Identify habitat limiting factors for juvenile rearing	X	X							
Identify habitat limiting factors for juvenile outmigration	X	X							

Table 8-4. Continued.

Category/Task	Grande Ronde	Tucannon	Clearwater	Salmon	Asotin	Imnaha	Snake Hells Canyon	Palouse	Snake River Subbasins
Research									
Collect lamprey tissue samples for genetic archives/analyses. Develop and maintain a genetic library/database. Supplement existing genetic libraries of genetic markers.	X	X	X	X	X	X	X	X	X
Pursue additional research questions as knowledge of lampreys progress and as needed to restore lamprey populations	X	X							
Restoration									
Develop, employ, and monitor lamprey-specific restoration projects that augment lamprey habitat and directly address limiting factors	X	X				X	X	X	X
Enhance summer stream flows for adult migration	X	X							
Supplement natural production by out-planting adults. Implement translocation of adults from mainstem dams to upstream watersheds	X	X	X	X	X	X	X	X	X
Monitor spawning at target translocation streams	X	X	X	X	X	X	X	X	X
Monitoring									
Monitor ammocoete production at target translocation streams	X	X	X	X	X	X	X	X	X
Monitor macrophthalmia emigration at selected target translocation streams	X	X	X	X	X	X	X	X	X
Monitor adult abundance at target translocation streams	X	X	X	X	X	X	X	X	X
Monitor habitat conditions	X	X				X	X	X	X
Identify passage constraints and address critical impediments by developing and implementing structural passage aids	X	X				X	X	X	X

Research, Monitoring, and Evaluation Needs

Ongoing RM&E

NPT Adult Pacific Lamprey Translocation Initiative.—(see description above).

NPT/USFWS Habitat Use.—The Nez Perce Tribe and USFWS are monitoring juvenile production, distribution and habitat use for progeny resulting from adult translocation studies.

Completed Adult Telemetry study.—A recently completed study conducted by the University of Idaho documented movement of adult Pacific Lamprey captured at Little Goose Dam or Lower Monumental Dam, outfitted with radio transmitters and released above Lower Granite Dam. Movements were tracked until the transmitters failed. Final distribution, rate of movement and associated environmental factors were documented.

RM&E Needs Identified but not Prioritized

Columbia Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lampreys (2005) (In Appendix C).—Meeting attendees think that critical uncertainties apply.

Actions Identified in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Snake River Region (Table 8-4.)

Conduct additional population surveys, population estimates and map distribution.

Investigate factors limiting Pacific Lamprey occurrence in the mainstem Snake River below Hells Canyon Dam.

NPCC Fish and Wildlife Program

- Restore lamprey passage and habitat in the mainstem and in tributaries that historically supported spawning lamprey populations.
- Attain self-sustaining and harvestable populations of lamprey throughout their historical range.
- Mitigate for lost lamprey production in areas where restoration of habitat or passage is not feasible.

Subbasin Plans.—

Clearwater Subbasin (Ecovista 2003)

- Assess population status, limiting factors, and rehabilitation potential for Pacific Lamprey in the Clearwater subbasin and accessible anadromous waters.
- Collection of life history, distribution, abundance by life stage.
- Genetic and homing behavior attributes of Pacific Lamprey ammocoetes and macrophthalmia in the Clearwater subbasin.

- Habitat assessments and population surveys to identify potential restoration opportunities.

Salmon Subbasin (IDFG 2001)

- Collect life history, distribution, abundance by life stage, genetic and homing behavior attributes.
- Inventory work to determine its present range, distribution and population status.
- Determine habitat requirements and limiting factors for Pacific Lamprey production in the subbasin and assess the rehabilitation potential and process in the subbasin.
- Develop techniques for collection and estimating population size.
- Describe habitat utilization and limiting factors in the subbasin.
- Develop and implement strategies to protect, improve and restore habitat.
- Develop plans to mitigate for ongoing activities.
- Coordinate with the Columbia Basin Lamprey Workgroup to exchange information that will enhance knowledge of the species and help develop recovery actions.
- Restore and maintain healthy, viable populations of Pacific Lamprey populations in the subbasin.

Asotin Subbasin Plan (Asotin County Conservation District 2004)

- Assess population status, limiting factors, habitat availability and rehabilitation potential for Pacific Lamprey. In the Asotin and Tucannon subbasins.
- Collection of life history, distribution, abundance by life stage.
- Genetic and homing behavior attributes of Pacific Lamprey ammocoetes and macrophthalmia in the Asotin and Tucannon subbasins. Habitat assessments and population surveys to identify potential restoration opportunities.

Snake Hells Canyon Subbasin Plan (Ecovista 2004a)

- Conduct research on Pacific Lamprey life history, abundance/distribution, and productivity within the subbasin.

Imnaha Inventory and Subbasin Plan (Ecovista 2004b)

- Collection of information critical to improve our understanding of Pacific Lamprey in the subbasin, including population distribution, population abundance/density estimates, capture efficiencies, population monitoring, basic ecological information, including habitat use, and within species biodiversity.
 - Lamprey Status
 - Basic Biology/Ecology, including but not limited to species and gender, migration, aging, reproduction, growth, feeding,
 - Genetic Structure
 - Adult/Juvenile Passage
 - Survival Estimates

- Limiting factors, including environmental stressors, habitat requirement/availability for life history stages, host availability
- Restoration Actions
- Education and Outreach

Tucannon Subbasin Plan (Columbia Conservation District 2004)

- Assess population status, limiting factors, habitat availability and rehabilitation potential for Pacific Lamprey. In the Asotin and Tucannon subbasins.
- Collection of life history, distribution, abundance by life stage.
- Genetic and homing behavior attributes of Pacific Lamprey ammocoetes and macrophthalmia in the Asotin and Tucannon subbasins.
- Habitat assessments and population surveys to identify potential restoration opportunities.

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9. UPPER COLUMBIA RIVER REGION

Geographic Description of the Region

Most of the Columbia River Basin (258,000 square miles (670,000 km²)) lies roughly between the Rocky Mountains on the east and the Cascade Mountains on the west. Within the watershed are diverse landforms including mountains, arid plateaus, river valleys, rolling uplands, and deep gorges. Vegetation varies widely, ranging from western hemlock and western red cedar in the moist regions to sagebrush in the arid regions. Many different land uses exist within the region including cattle grazing, crop production, mining, and timber harvest.

The Upper Columbia River Region within the boundaries of the Pacific Lamprey Conservation Assessment includes the tributaries of the Columbia River Basin upstream, including, the Yakima River. The largest tributaries, in terms of discharge, include the Yakima River, Wenatchee, and Okanogan rivers (Figure 9-1). The drainage open to Pacific Lamprey within the Upper Columbia River Region is approximately 50,669 km². This region is comprised of five Level III Ecoregions described by the Environmental Protection Agency EPA (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). Descriptions of each ecoregion (McGrath et al. 2002) can be found in Appendix A. The 11 watersheds (4th field HUCs), still accessible to Pacific Lamprey and reviewed for the Conservation Assessment, ranged in size from 1,735 – 11,318 km², and fall within 1 – 4 ecoregions. See Table 9-1 for how the HUC's fall within the ecoregions and Figure 9-1 on their distribution.

More detailed descriptions of the geology, land use, hydrology and climate of the watersheds reviewed in this chapter can be found in the individual watershed templates and as follows:

Entiat Subbasin Plan (Peven et al. 2004).

Methow Subbasin Plan (Moore et al., editors, 2004).

Wenatchee Subbasin Plan (Johnsen J., editor, 2004).

Okanagan Subbasin Plan (Moore D. et al., editors, 2004).

Crab Creek Subbasin Plan (KWA Ecological Services, Inc. 2004).

Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2004).

Table 9-1. Drainage Size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the Upper Columbia River Region.

Watershed	HUC Number	Drainage Size (km ²)	Level III Ecoregion(s)
Crab Creek	17020013, 17020015	11,318	Columbia Plateau
Upper Columbia Smaller Tributaries		2,512	Columbia Plateau, Eastern Cascades Slopes and Foothills
Wenatchee	17020011	3,648	Northern Cascades, Columbia Plateau, Eastern Cascades Slopes and Foothills
Entiat	17020010	3,937	Northern Cascades, Columbia Plateau, Eastern Cascades Slopes and Foothills
Chelan	17020009	2,473	Northern Cascades, Columbia Plateau
Methow	17020008	4,714	Northern Cascades, Columbia Plateau
Okanogan	17020006	4,248	Northern Cascades, Columbia Plateau, Northern Rockies
Similkameen	17020007	1,735	Northern Cascades, Columbia Plateau
Upper Yakima	17030001	5,517	Northern Cascades, Columbia Plateau, Cascades, Eastern Cascades Slopes and Foothills
Naches	17030002	2,927	Columbia Plateau, Cascades, Eastern Cascades Slopes and Foothills
Lower Yakima	17030003	7,640	Columbia Plateau, Eastern Cascades Slopes and Foothills

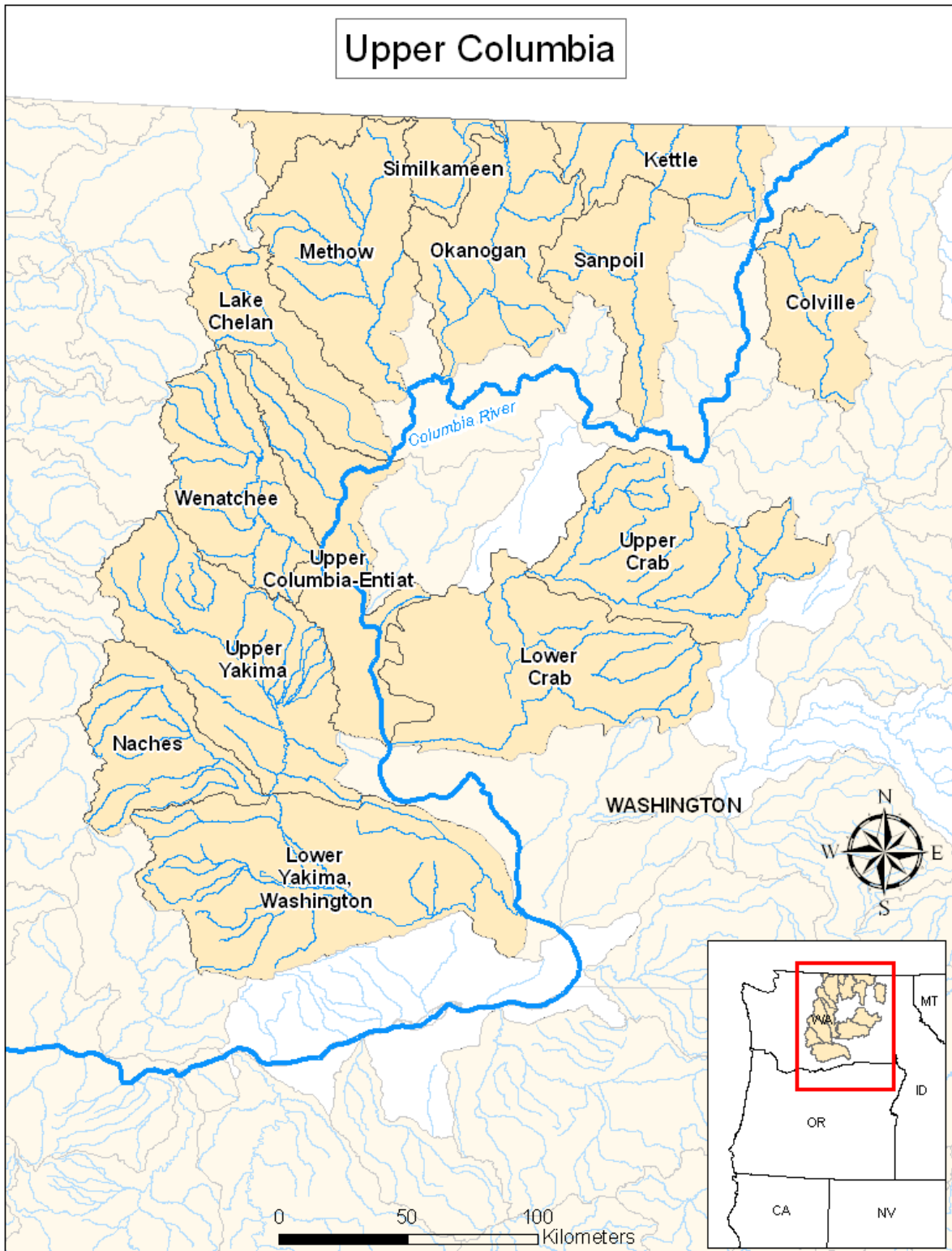


Figure 9-1. Map of Upper Columbia River Region watersheds and Level III Ecoregions.

Ranked Population Status of Pacific Lamprey in the Upper Columbia River Region

Population factors were difficult to rank in many watersheds. The uncertainty associated with determining them was high because of the paucity of fishing records, dam counts, and in particular targeted surveys for Pacific Lamprey. In most cases the uncertainty was categorized as best professional judgment based on expansion of data for other species (e.g., SIP) for historic distribution; and in the case of the category of current occupancy it was either largely undocumented (but based on extent of habitat, suspected barriers and/or anecdotal information) or based on partial surveys for less than one half of the watershed. NatureServe status ranks were calculated for Pacific Lamprey populations in this Region based on input from participants in the regional meeting and professional judgment. The area upstream of Chief Joseph Dam including the tributaries Kettle, Colville and Sanpoil rivers are not accessible to anadromous fish. Pacific lamprey are considered extirpated from these areas and not included in this assessment. Ranks for range extent and occupancy, current population size and trend for watersheds in the Upper Columbia Region are in Table 9-2.

Table 9-2. Population Status of Pacific Lamprey in the Upper Columbia as ranked by participants at the Regional Meetings. Intrinsic Steelhead Potential was used for historic distribution.

Watershed	Occupancy (km ²)		Current Population Size (Adults)	Current Trend (past 27 years or 3 generations)
	Historic	Current		
Crab Creek	Unknown	Unknown	Zero	Unknown, unchanged or within +/- 10%
Upper Columbia Smaller Tributaries	Unknown	Unknown	Zero	Unknown, unchanged or within +/- 10%
Wenatchee	1000-5000	100-500	250 – 1000	Unchanged or within +/- 10%
Entiat	1000-5000	500-2000	250 – 1000	Unchanged or within +/- 10%
Chelan	Unknown	Unknown	Unknown	Unknown
Methow	1000-5000	500	1 – 50	Unchanged or within +/- 10% fluctuation
Okanogan	1000-5000	500	1 – 50	Unchanged or within +/- 10% fluctuation
Similkameen	<100	20-100	1 – 50	Unchanged or within +/- 10% fluctuation
Upper Yakima	250-1000 to 1000-5000	Zero	Zero or unknown	50-70% decline to >70% decline
Naches	100-250 to 250-1000	Zero to <0.4	1-50 to 50-250	50-70% decline to >70% decline
Lower Yakima	100-250 to 250-1000	<0.4 to 0.4-4	1-50 or unknown	50-70% decline to >70% decline

Threats and Limiting Factors to Pacific Lamprey in the Upper Columbia River Region

Passage

The Federal Columbia River Power System dams on the Columbia River were identified as the highest threat to the persistence of Pacific Lamprey in the Upper Columbia River watersheds. Based on this, the scope and severity of small effective population size was identified as a high threat in the Yakima drainage (Table 9-3). Several larger irrigation and power dams in the Upper Columbia River tributaries are either complete impediments to upstream passage (Roza Dam, Tieton Dam) or may be barriers that need to be evaluated (Nelson, Selah, Wapatox, Horn Rapids, Prosser, Sunnyside, Wapato). In the Wenatchee River, Dryden Dam (Rkm 27) and Tumwater Dam (Rkm 50) are two main river dams that may pose problems for migrating adult lampreys.. Dryden Dam is an 2.4 m low head irrigation dam that has a ladder to improve salmonid passage, however how well lamprey pass this dam is unknown. Juvenile Pacific lamprey have been collected upstream of Dryden Dam. Passage at Tumwater Dam is uncertain. Chelan County PUD electrofishing surveys conducted in 1981 (Hays 1981) found juvenile lampreys upstream of Tumwater Dam. Recent electrofishing surveys conducted by USFWS in 2010 did not located juvenile lampreys upstream of Tumwater Dam (RD Nelle, USFWS, personal communication). The Tumwater Dam fish passageladder was modified and rebuilt in the mid-1980s to facilitate salmonid passage however may now pose a problem for adult lampreys passage. There is 0.6 km of habitat above the Lake Chelan Hydroelectric Project powerhouse available to anadromous fish. In the Icicle Creek a dam near the Leavenworth National Fish Hatchery may present an impediment to adult passage. On the Okanogan, it is unknown whether the Pacific lamprey use the fishway at Zozel Dam. Small irrigation diversions are present in many of the tributaries and may be a barrier for adults based on salmonid criteria. Irrigation diversions are a probable but unknown threat in terms of entrainment and impingement. Screening may not be adequate for juvenile lamprey. Recent changes in screens may be effective, but we do not know the impact of these structures on juvenile lamprey. The changes made for salmonids has likely helped lamprey.. Impacts depend on screen size, and orientation to the streamflow. Dewatering and stranding effects can also occur. Temperature barriers do occur in this basin and migrants may be blocked by high temperatures.

Dewatering and Flow Management

To meet water needs during the dry summer period, most Upper Columbia tributaries experience some form of dewatering and flow management due to mainstem dams and irrigation diversions. In the Upper Yakima, water diversion dewatering is common, and ramping rates may negatively impact lampreys by rapid dewatering. There are low flow issues in the Naches and Methow rivers and their tributaries where irrigation diversions are common. In the Wenatchee, Methow, Entiat, and Okanogan river basins, irrigation diversions are present and contribute to reduced flow conditions. Dams on the Yakima and Okanogan rivers hold back water during some times of the year, increasing water temperatures (Lower Yakima) and winter flows (Zozel). Many smaller tributaries are regularly dewatered. When the mainstem Columbia water flows are lowered and drop, several of the tributaries are inaccessible due to the deltas that have formed. In some basins surface irrigation is being converted to wells and groundwater pumping, so more water is remaining instream (Entiat River). Historically the Chelan River Dam was operated to keep the Chelan River dry most of the year. Beginning in 2008, changes in water management

now provide flow to the river. In the Methow, diversions dewater the margins of the river, decreasing the amount of area useable by lamprey. Historically lower sections of Crab Creek would run dry during the summer, however now due to irrigation returns Crab Creek remains watered throughout the year. Subbasin plans and county databases highlight how many irrigation diversions there are in the Upper Columbia.

Stream and Floodplain Degradation

Within the Upper Columbia Basin habitat degradations has been identified as a factor limiting recovery of salmonids and could play a role in conserving Pacific lamprey as well. Loss of floodplain habitat in the Upper Columbia Basin is one component of habitat degradation that limits conservation of Pacific lamprey. Additionally, there been stream modifications due to agriculture, rural and urban development, and roads. Streams have been straightened, the number of side-channels reduced, riparian vegetation reduced resulting in the loss of natural stream functions. In the Upper Yakima and Naches rivers, the main source of scouring may be due to reservoir management at Tieton Dam. In the Wenatchee and Entiat rivers there has been a loss of side channels, but current restoration projects are restoring them. Channelization and riprap placement is a problem in the Wenatchee River. Habitat conditions are well documented in the Methow River (USBR Report).

Water Quality

Water quality varies across the Upper Columbia. In the Upper Yakima River, water quality is considered good with the exception of Wilson Creek. In the Naches River, the Cowiche Creek negatively impacts the lower mainstem. Temperature is an issue in the Cowiche, lower mainstem Naches and the Lower Yakima, resulting in impacts to salmonid rearing and blocking movement of migrants in the watershed. There have been 303(d) listings for water temperature throughout the tributaries of the Upper Columbia Region. Chemicals, pollutants, dissolved oxygen, pH, sediment and agricultural runoff have been identified as issues in the Lower Yakima, some smaller tributaries, Wenatchee, Entiat, Methow and Okanogan rivers and some smaller tributaries. TMDL's for some parameters are being developed for several waterbodies and stream reaches that have been put on the 303(d) list. Non-point source pollution from roads, agriculture, and urban development may contribute to reduced water quality.

Other

Small effective population size was ranked high throughout the Yakima Basin but was not ranked as a threat outside the Yakima Basin. Although small effective population size was not ranked high throughout the rest of the Upper Columbia Region tributaries, declining numbers of returning adults to the upper tributaries would suggest this threat may need to be elevated to a higher rank..

Lack of awareness was ranked as a medium threat in the Yakima Basin but was not ranked in other watersheds.

Climate change was ranked as a high threat in the Yakima Basin, but was not ranked for other watersheds. In the Upper Yakima, localized impacts are uncertain. Water temperatures are cooler now than in the recent past, so it is not as great an issue. In the Naches, localized impacts

are uncertain. Unregulated warmer summer temperatures could not be cooled with agriculture compensation flows.

Predation is considered to be a low threat in the Yakima Basin, and insignificant elsewhere in the Upper Columbia. Primary predation in the Yakima Basin is by Smallmouth Bass, Catfish, Northern Pikeminnow and gulls, with Rainbow Trout in the Naches. Predation in the Upper Yakima is not expected to be significantly shifted from historic. Predation could be much larger at certain times of the year but has not been studied.

Harvest is ranked as insignificant throughout the Upper Columbia.

Translocation and disease were not ranked for all watersheds within the Upper Columbia. Where it was it is considered an insignificant threat. The threat of disease is uncertain for life stages other than adults.

Prioritization of Limiting Factors and Threats

Numeric values, 1 to 4, were assigned to ranks, insignificant to high, respectively. In cases where participants gave a combination ranking, such as M/H, the rank was assigned a value between the two ranks, e.g., 3.5. An average for all watersheds was calculated for scope and severity, and the overall scope and severity values were averaged to obtain one value to determine the priority order of threats.

There were two meetings held to assess threats in the Upper Columbia. The first meeting was for the Yakima Basin, the second meeting included Crab Creek, smaller tributary streams, the Entiat, Methow, Okanogan and Wenatchee river basins. Threat templates were not filled in completely for waters outside the Yakima Basin, so it is difficult to identify the highest priority threat for the entire Upper Columbia. For threat factors that were identified at both meetings, the highest priority threats were mainstem passage, dewatering and flow management, followed by stream and floodplain degradation and passage (Table 9-3). In the Yakima Basin, passage, dewatering and flow management and small effective population size all ranked as high threats. In drainages other than the Yakima, stream and floodplain degradation and water quality were identified as the most serious threats, with a moderate ranking.

Table 9-3. Threats to Pacific Lamprey and their habitats in the Upper Columbia River Region, as identified and ranked by participants in regional meetings. H=4, M/H=3.5, M=3, L/M=2.5, L=2, I=1, U=No value

Watershed	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Upper Columbia												
<i>Crab Creek</i>			2	2	3	3	4	4	1	1	1	1
<i>Smaller Tributaries</i>	1	1	3	2	1	2	1	2	1	1	1	1
<i>Wenatchee</i>	3	2	3	2	3	3	1	2	1	1	1	1
<i>Entiat</i>	1	1	2	2	3	3	1	1	1	1	1	1
<i>Chelan</i>				1	1	1	1	1	1	1	1	1
<i>Methow</i>	1	1	2.5	1	3	3	1	1	1	1	1	1
<i>Okanogan</i>	1	1	3	3	3	3	3	3	1	1	1	1
Mean Rank	1.4	1.2	2.66	1.86	2.43	2.57	1.714	2	1	1	1	1
	I	I	M	L	L	M	L	L	I	I	I	I
Mean Scope & Severity Drainage Rank	1.30		2.22		2.50		1.86		1.00		1.00	
	I		L		M		M		I		I	
Yakima Drainage												
<i>Upper Yakima</i>	4	4	4	4	2	2	1	1	1	1	1	1
<i>Naches</i>	3	3	3	3	2	2	2	2	1	1	1	1
<i>Lower Yakima</i>	3	4	4	4	2	2	4	4	1	1	2	4
Mean Rank	3.33	3.67	3.67	3.67	2	2	2.33	2.33	1	1	1.33	2
	M	H	H	H	L	L	L	L	I	I	I	L
Mean Scope & Severity Drainage Rank	3.50		3.67		2.00		2.33		1.00		1.67	
	H		H		L		L		I		L	
Upper Columbia Region												
Overall Rank	2.13	2.13	2.94	2.40	2.30	2.40	1.90	2.10	1.00	1.00	1.10	1.30
Mean Scope & Severity	2.13		2.67		2.35		2.00		1.00		1.20	
Overall Threat Rank	L		M		L		L		I		I	

Table 9-3. Continued.

Watershed	Translocation		Disease		Small Population Size		Mainstem Passage		Climate Change	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Upper Columbia	1	1	1	1			4	4		
<i>Crab Creek</i>	1	1					4	4		
<i>Smaller Tributaries</i>							4	4		
<i>Wenatchee</i>							4	4		
<i>Entiat</i>							4	4		
<i>Chelan</i>							4	4		
<i>Methow</i>							4	4		
<i>Okanogan</i>							4	4		
Mean	1	1	1	1			4	4		
Rank	I	I	I	I			H	H		
Mean Scope & Severity	1.00		1.00				4.00			
Drainage Rank	I		I				H			
Yakima Drainage										
<i>Upper Yakima</i>	1	1	1	1	4	4	4	4		
<i>Naches</i>	1	1	1	1	4	4	4	4	3	4
<i>Lower Yakima</i>	1	1	1	1	4	4	4	4	3	4
Mean	1	1	1	1	4	4	4	4	3	4
Rank	I	I	I	I	H	H	H	H	M	H
Mean Scope & Severity	1.00		1.00		4.00		4.00		3.50	
Drainage Rank	I		I		H		H		H	
Upper Columbia Region										
Overall Rank	1.00	1.00	1.00	1.00	4.00	4.00	4.00	4.00	3.00	4.00
Mean Scope & Severity	1.00		1.00		4.00		4.00		3.50	
Overall Threat Rank	I		I		H		H		H	

Suites of Actions to address Threats

Ongoing Conservation Measures

Improved passage at PUD facilities.

Kittitas County diversion database and other data collection on status.

Habitat restoration actions in conjunction with salmon and Steelhead activities.—Habitat restorations in Upper Columbia Basin directed at restoring listed salmon stocked is thought to help Pacific lamprey by increasing complexity to many systems. However awareness of the habitat needs of Pacific lamprey should be included in habitat proposals, designs, and monitoring, thus furthering the understanding of how lampreys benefit from habitat restoration efforts.

Completed TMDLs for several HUCS identify measures to provide management direction for addressing TMDLs, specifically temperature and sediment.

Fish Passage and Fish Screen installations at water diversions in the Upper Columbia.—Management agencies in Washington, particularly the Washington Department of Fish and Wildlife and Bureau of Reclamation, have been installing fish screens at irrigation diversions in the Upper Columbia watershed since the 1950's. Currently most of the screens installed conform to NOAA criteria. The screens are in anadromous salmonid waters. Diversions that pose as fish passage barriers are remediated to allow fish passage at most flows. As opportunities arise, water diversions are consolidated and water delivery is improved leaving more water in stream.

Water Transactions in the Upper Columbia Basin.—The Columbia Basin Water Transactions Program (CBWTP) has been instrumental in water savings in several tributaries in the Upper Columbia Region. Using permanent acquisitions, leases, investments in efficiency and other incentive-based approaches, the CBWTP supports program partners in Oregon, Washington, Idaho and Montana to assist landowners who wish to restore flows to existing habitat (<http://www.cbwtp.org/jsp/cbwtp/program.jsp>). Leaving water in the stream improves instream flows, temperature and provides more in-channel habitat during critical times.

Tribal Pacific Lamprey Restoration Plan Implementation.—The Yakama Nation is working with other agencies to implement habitat improvement actions to benefit aquatic resources

Columbia Basin Fish Accords.—Under the Columbia Basin Fish Accords, the Bureau of Reclamation is identifying all BOR projects that may affect lamprey in the Yakima Basin, investigating potential effects, and making recommendations for either further study or actions that may be taken to reduce effects. The BOR and the Tribes are working together to develop a lamprey plan for BOR projects.

Needed Actions

Crab- water issues, habitat issues

- Identify presence/absence and distribution of Pacific Lamprey.
- Habitat modification.
- Evaluate temperature regimes in Crab Creek in relation to Pacific lamprey.
- Lab study for temperature tolerance.

Entiat

- Support habitat restoration projects.
- Evaluate contaminants in juvenile lampreys.
- Evaluate lamprey rearing water diversions and provide recommendations to prevent dewater.
- Identify spawning areas and assess distribution.

Methow

- Protection of existing habitat and instream flow.
- Restoration of existing habitat.
- Screening.
- LWD complexity.
- Outreach/education.

Okanongan

- Improve water temperature.
- Reestablish flow.
- Purchasing land to restore stream meander.
- Creating meanders and riparian replanting in Canada to lower water temps in U.S.
- Creating side channel habitat using wells with colder water to create local refugia.

Wenatchee

- Passage evaluation at Tumwater Dam and on Icicle Creek.
- Fix passage issues.
- Define and assess all passage barriers and obstacles such as culverts and diversion dams.
- Outreach/education.
- Assess distribution post barrier removal.

Lower Yakima

- Conduct rapid assessment of adult passage at Wanawish/Horn Rapids, Chandler/Prosser (ladders and over dam-assess likely accuracy of counts), Wapato, and Parker using a panel of lamprey experts.

- Conduct rapid assessment of juvenile passage and screening criteria at Wanawish/Horn Rapids, Chandler/Prosser (ladders and over dam-assess likely accuracy of counts), Wapato, Parker plus phase II sites using a panel of lamprey experts.
- Continue assessment of adult passage issues and juvenile passage and entrainment and impingement issues.
- Use the information from the assessments to identify, explore and prioritize alternative actions to address and improve adult and juvenile passage, entrainment or impingement issues as appropriate.

Naches

- Conduct rapid assessment of adult passage at Nelson, Wapatox, Naches Selah using a panel of experts.
- Conduct a rapid assessment of juvenile passage and screening criteria at Nelson, Wapatox, Naches, and Selah using a panel of lamprey experts.
- Use the information from the assessments to identify, explore, and prioritize alternative actions to address and improve adult and juvenile passage, entrainment, or impingement issues as appropriate.

Upper Yakima

- Conduct a rapid assessment of adult passage at Roza Dam using a panel of lamprey experts.
- Conduct a rapid assessment of juvenile passage and screening criteria at Roza Dam using a panel of lamprey experts.
- Use the information from the assessments to identify, explore, and prioritize alternative actions to address and improve adult and juvenile passage, entrainment, or impingement issues as appropriate.

All Yakima Basin

- Evaluate ramping rates on lamprey in three reaches: mainstem areas would be Roza through Parker, Tieton to lower Naches, Parker to Zillah.
- Evaluate mainstem water temperatures – where and when temperatures exceed levels that may adversely impact Pacific Lamprey.
- Accelerate studies to determine temperature tolerance levels for adults, ammocoetes, and macrophthalmia.
- Identify areas that are temperature limiting after temperature tolerance levels have been identified.
- Explore actions to address the temperature limiting areas for lamprey that are in additions to temperature actions already being explored through salmon restoration.
- Get lamprey Best Management Practices for instream work/salvage to project managers in the basin.
- Explore with predator control/evaluation biologists how we can determine the impact on juvenile lamprey by piscivorous predators in the lower Yakima River. Assess if

the impacts are high enough to warrant additional actions above those for salmon and Steelhead restoration.

- Improve collaboration and coordination between the diverse range of parties with an interest in lamprey in the Yakima Basin, including fisheries managers such as the Yakama Nation, WDFW, and USFWS as well as facility managers such as USBR, BPA, the USACE, irrigation districts, PUDs, municipalities, and other water users.
- Develop a Yakima Basin Pacific Lamprey distribution list for interested parties.
- Conduct meetings every two years to assess progress on tasks related to Pacific Lamprey recovery.
- Determine schedule of needed actions for passage, screening, flow management, predator management, habitat restoration, water temperature management and other needs identified from assessments.

Columbia Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lampreys (2005) (In Appendix C).—Meeting attendees think that critical uncertainties apply.

Actions Identified in the CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Upper Columbia Region (Table 9-4).

Research, Monitoring, and Evaluation Needs – Critical Uncertainties

Ongoing RM&E

RM&E needs identified but not prioritized

Upper Columbia River Tributaries

- Evaluate historic distribution and abundance through a thorough assessment of historic reports, Tribal interviews, and anecdotal accounts.
- Survey upstream and downstream of potential barriers to describe present distribution and identify passage obstacles and barriers.
- Evaluate habitat restoration projects for presence of juvenile Pacific lamprey. Use information to develop recommendations for future habitat restoration efforts with recommendations to enhance lamprey habitat.
- Evaluate rotary screwtrap data to characterize outmigration in respect to water temperature, time of year, and discharge.
- Use radio telemetry and PIT methods to assess movement patterns and habitat use.
- Identify risk factors such as screens, diversions and seasonally dewatered irrigation ditches that may affect lamprey movements and survival.
- Evaluate counts of adult Pacific lamprey at the mid-Columbia River PUD dams to apportion counts to respective tributaries.

Yakima Basin

- Identification workshop for field crews – Yuki R. point of contact.
- Compile information on lamprey identification methods and results- Yuki R. point of contact.
- Workshop to develop methods and sampling design to determine distribution of lamprey in the Yakima Basin – these methods should be standardized across basins in the Columbia River.
- Evaluate the adult lamprey counts at Prosser Dam.
- Potentially do experimental work on passage route/efficiency at Chandler. Conduct night surveys.
- Review of screening issues to id areas where impacts are likely....WDFW/USBR.
- Identify a contact person to compile data/anecdotal information on lamprey occurrences.
- Evaluate mainstem water temperatures for adult and macrophthalmia run timing and temperature tolerances.
- Sampling in major screen forebays, and if found, behind screens.
- Possible efforts to sample in likely habitat.
- Evaluate the risks and benefits of translocation as tool to recover Pacific lamprey in the Yakima Basin.
- Identify temperature tolerances of ammocoetes to identify areas in Topp/Satus and Wapato floodplain to sample.
- Review gradient maps, etc. to identify sampling areas in the Naches basin.

- Sample for juvenile lamprey in the Gap to Gap floodplain.

Okanogan Basin

Needs identified in Table 9-4.

Columbia Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lampreys (2005) (In Appendix C).—Meeting attendees think that critical uncertainties apply.

Actions Identified in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Upper Columbia Region (Table 9-4).

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Upper Columbia Meeting in Chelan, Washington October 29, 2009

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James White	Upper Columbia Salmon Recovery Board, Wenatchee, WA
Charlie Snow	WDFW
Bob Rose	Yakama Nation Toppenish, WA
Steve Lewis	USFWS Wenatchee Field Office
Chuck Peven	BioAnalysts, Inc, Wenatchee, WA

Upper Columbia Meeting in Yakima, Washington July 22, 2009

Gabe Temple	WDFW Yakima, WA
Alex Conley	Yakima Basin Fish and Wildlife Recovery Board Yakima, WA
Patrick Luke	Yakama Nation, Goldendale, WA
Bob Rose	Yakama Nation, Toppenish, WA
Pat Schille	WDFW Yakima, WA
Jennifer Scott	WDFW Yakima, WA
Jim Cummins	WDFW Yakima, WA
Yuki Reiss	Yakima Basin Fish and Wildlife Recovery Board Yakima, WA
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Eric Anderson	WDFW Yakima, WA
Pat Monk	USFWS Yakima, WA
Steve Lewis	USFWS Wenatchee Field Office

On phone:

Molly Hallock	WDFW Olympia, WA,
Mike Clement	Grant County Public Utility District, Ephrata, WA

Table 9-4. Actions identified (depicted by X) in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia Basin (2008) for the Upper Columbia Region.

Category/Task	Methow	Yakima	Wenatchee	Entiat	Crab Creek
Status					
Document current adult abundance and distribution	X	X	X	X	X
Document historic adult and juvenile abundance and distribution; collect anecdotal information; interview biologists, tribal elders and landowners with knowledge of lamprey	X	X	X	X	X
Establish and monitor ammocoete index sites for changes in distribution and abundance; presence/absence surveys. Identify species	X	X	X	X	X
Monitor juvenile outmigration; describe outmigration timing and abundance	X	X	X	X	X
Biology/Life History					
Describe key predators and conditions where lamprey are most vulnerable		X	X	X	
Identify key areas where adults hold and /or spawn. Provide description of the amount of suitable adult holding and spawning habitat; Describe time of adult entrance, over-wintering and spawning time	X	X	X	X	X
Determine adult and juvenile migration timing, size, age and condition	X	X	X	X	X
Identify/describe/determine adult and juvenile tributary habitat use: timing, duration and age	X	X	X	X	X
Identify current strongholds and relative densities in ammocoete rearing areas	X	X	X	X	X
Identify extent lamprey are subject to disease		X	X	X	
Identify environmental/physiological conditions that trigger spawning and migration to occur	X	X	X	X	X

Table 9-4. Continued.

Category/Task	Methow	Yakima	Wenatchee	Entiat	Crab Creek
Limiting Factors					
Investigate presence of contaminants and toxins such as pesticides, herbicides, and fertilizers in lamprey habitats and tissues.		X	X	X	
Identify habitat limiting factors for adult migration	X	X	X	X	X
Identify habitat limiting factors for adult spawning	X	X	X	X	X
Identify habitat limiting factors for juvenile rearing	X	X	X	X	X
Identify habitat limiting factors for juvenile outmigration	X	X	X	X	X
Research					
Collect lamprey tissue samples for genetic archives/analyses. Develop and maintain a genetic library/database. Supplement existing genetic libraries of genetic markers.	X	X	X	X	X
Identify body weight of adults entering subbasin and compare with time of spawning. Identify factors contributing to inadequate energy reserves to successfully spawn		X	X	X	
Evaluate if artificial production can be used to “jump-start” ammocoete production in appropriate watersheds where productivity is currently lacking		X	X	X	
Identify existing facilities potentially available – or needed facilities to successfully rear ammocoetes to desired age classes		X	X	X	
Continue evaluating physical and / or biologic cues that may influence and / or guide adult migration and spawning		X	X	X	
Assess trophic relationships of both juvenile and adult lamprey		X	X	X	

Table 9-4. Continued.

Category/Task	Methow	Yakima	Wenatchee	Entiat	Crab Creek
Restoration					
Supplement natural production by out-planting adults. Implement translocation of adults from mainstem dams to upstream watersheds	X	X	X	X	
Monitor spawning at target translocation streams	X	X	X	X	
Monitor ammocoete production at target translocation streams	X	X	X	X	
Monitor macrophthalmia emigration at selected target translocation streams	X	X	X	X	
Monitor adult abundance at target translocation streams	X	X	X	X	
Develop subbasin restoration strategies	X	X	X	X	X
Implement and evaluate restoration projects with respect to changes in habitat characteristics, habitat use and productivity	X	X	X	X	X
Describe if eggs/ammocoetes distributed in degraded habitat may be at significantly greater risk relative to those in healthy or properly functioning environmental conditions. Provide strategy for habitat restoration		X	X	X	

10. MID-COLUMBIA RIVER REGION

Geographic Description of the Region

The Mid-Columbia River Region within the boundaries of the Pacific Lamprey Conservation Assessment includes the Walla Walla, Umatilla, Willow, Middle Columbia-Hood, Klickitat, Upper John Day, North Fork John Day, Middle Fork John Day, Lower John Day, Upper Deschutes, Little Deschutes, Beaver-South Fork, Upper Crooked, Lower Crooked, Lower Deschutes and Trout watersheds. The region is comprised of five Level III Ecoregions described by the Environmental Protection Agency (EPA) (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). Descriptions of each ecoregion (McGrath et al. 2002) can be found in Appendix A. The watersheds ranged in size from 772–3,600 km² for the 16 HUCs. They were contained by 1–4 ecoregions. See Table 10-1 for how the HUCs fall within the ecoregions and Figure 10-1 on their distribution. More detailed descriptions of the geology, land use, hydrology and climate of the watersheds evaluated in this chapter can be found in the individual watershed templates.

Table 10-1. Drainage size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the Mid-Columbia Region.

Watershed	HUC Number	Drainage Size (km ²)	Level III Ecoregion(s)
Walla Walla	17060102	4,533	Columbia Plateau, Blue Mountains
Umatilla	17060103	6,579	Columbia Plateau, Blue Mountains
Willow	17060104	2,282	Columbia Plateau, Blue Mountains
Mid-Columbia – Hood	17060105	5,620	Cascades, Eastern Cascade Slopes, Columbia Plateau
Klickitat	17060106	3,445	Cascades, Eastern Cascade Slopes, Columbia Plateau
Upper John Day	17070201	5,517	Blue Mountains
North Fork John Day	17070202	4,740	Blue Mountains
Middle Fork John Day	17070203	2,033	Blue Mountains
Lower John Day	17070204	8,184	Columbia Plateau, Blue Mountains
Upper Deschutes	17070301	5,543	Cascades, Eastern Cascade Slopes, Blue Mountains
Little Deschutes	17070302	2,642	Cascades, Eastern Cascade Slopes
Beaver-South Fork	17070303	3,963	Blue Mountains, Northern Basin
Upper Crooked	17070304	2,979	Blue Mountains, Northern Basin
Lower Crooked	17070305	4,766	Cascades, Eastern Cascade Slopes, Blue Mountains, Northern Basin
Lower Deschutes	17070306	5,957	Cascades, Eastern Cascade Slopes, Columbia Plateau, Blue Mountains
Trout	17070307	1,800	Columbia Plateau, Blue Mountains

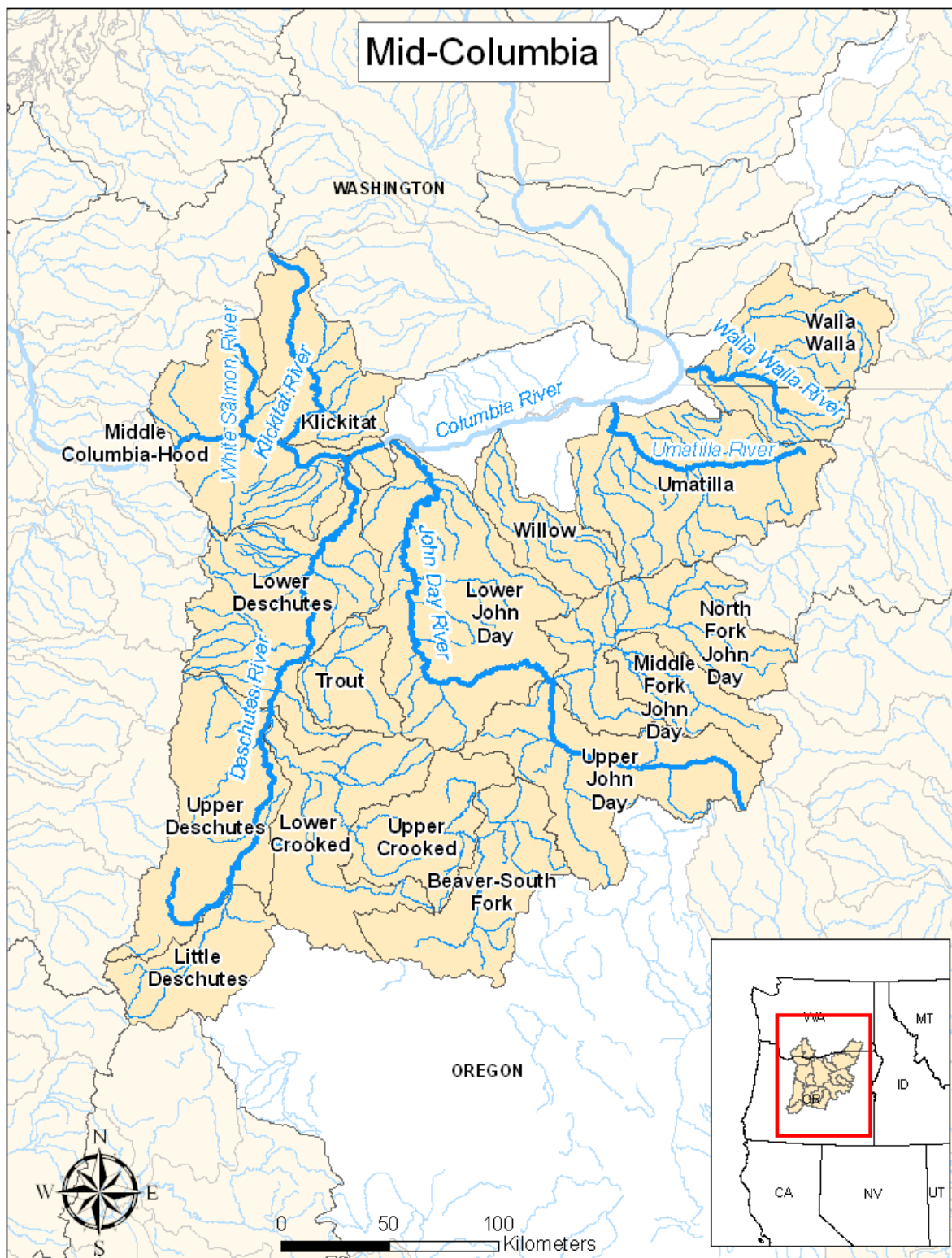


Figure 10-1. Map of Mid-Columbia River Region watersheds and Level III Ecoregions.

Ranked Population Status of Pacific Lamprey in the Mid-Columbia River Region

Population factors were difficult to rank in many watersheds. The uncertainty associated with determining them was high because of the paucity of fishing records, dam counts, and in particular targeted surveys for Pacific Lamprey. In most cases the uncertainty was categorized as “best professional judgment” based on expansion of data for other species (e.g., SIP) for historic distribution; Current occupancy was either largely undocumented (but based on extent of habitat, suspected barriers and/or anecdotal information) or based on partial surveys for less than one half of the watershed. NatureServe status ranks were calculated for Pacific Lamprey populations in this region based on input from participants in the regional meeting and professional judgment. Ranks for range extent and occupancy, current population size and trend for watersheds in the Mid-Columbia River Region are in Table 10-2.

Table 10-2. Population status of Pacific Lamprey in the Mid-Columbia River Region, as ranked by participants at the regional meetings.

Watershed	Occupancy (km ²)		Current Population Size (Adults)	Current Trend
	Historic	Current		
Upper Deschutes	Not ranked	Not ranked	Not ranked	Not ranked
Little Deschutes	Not ranked	Not ranked	Not ranked	Not ranked
Beaver-South Fork	Not ranked	Not ranked	Not ranked	Not ranked
Upper Crooked	Not ranked	Not ranked	Not ranked	Not ranked
Lower Crooked	Not ranked	Not ranked	Not ranked	Not ranked
Lower Deschutes	1,000-5,000	100-500	2,500 - 10,000	Decline of 30-50% to decline of 10-30%
Trout	Unknown	Zero	Zero	Unknown
Walla Walla	1000-5000	Extinct	Zero to 1-50	Decline of >70%
Umatilla	250-1000	4-20	1-50 pre supplementation, 250-1,000 post supplementation	Decline of >70% pre-supplementation, decline of 10-30% post-supplementation
Willow	Not ranked	Not ranked	Not ranked	Not ranked

Threats and Limiting Factors to Pacific Lamprey in the Mid-Columbia River Region

Passage

Passage in the Mid-Columbia Region is impeded by four Federal Columbia River Power System dams (Bonneville, The Dalles, John Day, and McNary). It is also affected by smaller dams such as Condit Dam on the White Salmon River, Powerdale and Lawrence Lake Dam on the Hood River and Hemlock Dam on Wind River. In addition there are many low elevation diversion dams in the Hood, John Day and Umatilla basins (operated by the Bureau of Reclamation). Hundreds of smaller water diversions throughout the Mid-Columbia Region, and in particular in the Walla Walla and Umatilla basins, have inadequate screening especially for ammocoetes.

Tributary passage for lampreys was ranked as a moderate threat overall, but mainstem passage in this region was ranked high.

Dewatering and Flow Management

The overall scope and severity of this threat were ranked moderate. Flow is altered from reservoirs of the above mentioned dams. McKay Reservoir in the Umatilla does provide cool water in the summer but restricts passage of summer adults. Specifically, water diversion for irrigation purposes was ranked high in the Walla Walla, Umatilla and John Day basins. Annual maintenance of push up dams in this basin add to the moderate threat level.

Stream and Floodplain Degradation

Stream and floodplain degradation was ranked moderate overall in the Mid-Columbia River Region; however, channelization, loss of side channels and scouring has occurred in the Walla Walla, Umatilla, Middle Fork John Day, Lower John Day and Hood basins. Historically there was extensive mining throughout the John Day Basin with some legacy effects. Currently there is dredging associated with diversion maintenance throughout the region.

Water Quality

Water quality was ranked moderate overall for scope and severity in the Mid-Columbia River Region. Temperature is the main water quality issue in the region. High summer temperatures result primarily from water diversions. Chemical run-off from agricultural practices and some legacy effects from rotenone treatments also contribute to the moderate ranking.

Other

Of the smaller category threats climate change was ranked highest with a moderate/high ranking for scope and severity throughout the Mid-Columbia watersheds. Lack of awareness was the next most serious smaller threat with a moderate ranking for scope and severity. Small population size and predation were ranked low. Northern Pikeminnow and Smallmouth Bass were cited as the most common predators on lampreys. The effects of disease are unknown in the Mid-Columbia and translocation and harvest is not occurring.

Prioritization of Limiting Factors and Threats

Numeric values, 1 to 4, were assigned to ranks, insignificant to high, respectively. An average for all watersheds was calculated for scope and severity of threats, and the overall scope and severity values were averaged to obtain one value to determine the priority order of threats. The highest priority threat in the Mid-Columbia watersheds is mainstem passage followed by climate change, stream and floodplain degradation, water quality, dewatering and flow management, tributary passage and lack of awareness (Table 10-3).

Small population size and predation were both ranked low; harvest/overutilization and translocation were ranked insignificant; and disease was ranked unknown for both scope and severity.

Table 10-3. Threats to Pacific Lamprey and their habitats within the Mid-Columbia River Region, as identified and ranked at regional meetings. H=4, M/H=3.5, M=3, L/M=2.5, L=2, I=1, U=No value

Watershed	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Walla Walla	3	3	3.5	3.5	3	2.5	3	3	1	1	2	2
Umatilla	4	3.5	3	3.5	4	4	3.5	3	1	1	2	2
Willow												
Mid. Columbia-Hood	3	3	4	4	4	4	4	3.5	U	U	1	1
Klickitat	1	1	1	1	2	2	2	3	2	2	2	2
Upper John Day	3.5	3.5	3.5	3.5	3.5	4	4	4	1	1	2	2
North Fork John Day	2	2	2.5	2.5	2.5	2.5	2	2.5	1	1	2	2.5
Mid. Fork John Day	2	2	2.5	2.5	3.5	3.5	3	3	1	1	1.5	1.5
Lower John Day	3	3	4	4	3.5	3.5	4	4	1.5	1.5	3	3
Upper Deschutes												
Little Deschutes												
Beaver-South Fork												
Upper Crooked												
Lower Crooked												
Lower Deschutes	2	2.5	2	2	2.5	2.5	2.5	2.5	2.5	2.5	1	1
Trout												
Mean Rank	2.61	2.61	2.89	2.94	3.17	3.17	3.11	3.17	1.38	1.38	1.83	1.89
	M	M	M	M	M	M	M	M	I	I	L	L
Mean Scope & Severity	2.61		2.92		3.17		3.14		1.38		1.86	
Drainage Rank	M		M		M		M		I		L	

Table 10-3. Continued.

Watershed	Translocation		Disease		Small Population Size		Lack of Awareness		Climate Change		Mainstem Passage	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Walla Walla	1	1	U	U	4	4	3	3	3.5	3.5	4	4
Umatilla	1	1	U	U	3	3	2	2	3.5	3.5	4	4
Willow												
Mid. Columbia-Hood	1	1	U	U	2.5	2.5	3.5	3	4	4	4	4
Klickitat	1	1	U	U			3	3	3	3	4	4
Upper John Day	1	1	U	U	2	2	3	3	3.5	3.5	4	4
North Fork John Day	1	1	U	U	2	2	2	2	3.5	3.5	4	4
Mid. Fork John Day	1	1	U	U	2	2	2.5	2.5	3.5	3.5	4	4
Lower John Day	1	1	U	U	1	1	2.5	2.5	3.5	3.5	4	4
Upper Deschutes												
Little Deschutes												
Beaver-South Fork												
Upper Crooked												
Lower Crooked												
Lower Deschutes	1	1	U	U	2	2	2	2	3.5	3.5	4	4
Trout												
Mean Rank	1	1			2.31	2.31	2.61	2.56	3.5	3.5	4	4
	I	I			L	L	M	M	H	H	H	H
Mean Scope & Severity		1			2.31		2.58		3.5		4	
Drainage Rank		I			L		M		H		H	

Suites of Actions to Address Limiting Factors and Threats

Ongoing Conservation Measures

Walla Walla

- A number of habitat restoration projects.
- Steelhead recovery plan – for habitat actions.
- Passage improvements for salmonids.
- Nursery Bridge passage improvements.
- Mill Creek –Goes Street.
- Ditch consolidation.
- Umatilla Tribe purchased irrigation rights.
- Rainwater Wildlife area NF Touchet – runoff goes into Touchet.

Umatilla

- A number of habitat restoration projects since 1984.
- Salmon and Steelhead recovery plan – for habitat actions.
- Numerous passage improvements for salmonids.
 - Three Mile Dam
 - Maxwell Diversion
 - Dillon Diversion
 - Westland Diversion
 - Feed Diversion – Newly installed adult lamprey ramp
 - Stanfield Diversion
 - New lamprey ladder at Three Mile dam
- Umatilla Tribe purchased irrigation rights.
- Umatilla lamprey recovery plan.
- CRITFC Restoration Plan.
- Phase 1 flow exchange from Three Mile to the mouth July 1 – Aug 15.
- Umatilla Basin plan.
- Continued evaluation of passage structures.
- Long term monitoring for outplanting adults.
- Under the Accords, BOR is identifying all BOR projects in the basin that may affect lamprey, investigating potential effects, and where appropriate, making recommendations for either further study or actions that may be taken to reduce effects. The BOR and the tribes are working together to develop a lamprey plan for BOR projects.

Water Transactions in the Mid-Columbia Basin.—The Columbia Basin Water Transactions Program (CBWTP) has been instrumental in water savings in several tributaries in the Mid-Columbia Region. Using permanent acquisitions, leases, investments in efficiency and other incentive-based approaches, the CBWTP supports program partners in Oregon, Washington,

Idaho and Montana to assist landowners who wish to restore flows to existing habitat (<http://www.cbwtp.org/jsp/cbwtp/program.jsp>). Leaving water in the stream improves instream flows, temperature and provides more in-channel habitat during critical times.

Needed Conservation Actions

Walla Walla

Near Term

- More surveys for Pacific Lamprey.
- Radio telemetry studies to evaluate adult movement in the Walla Walla Basin.
- Evaluating adult and juvenile passage structures for lamprey passage effectiveness at dams and water diversion structures.
- Education of state agencies, private entities and the public about instream water work and appropriate salvage operations for lamprey juveniles and adults.
- Continue to work on water quality improvements and identify specific lamprey concerns. Work on identifying specific studies to evaluate adult and juvenile temperature tolerance criteria.

Long term

- From the above assessments determine schedule of actions for passage, screening, and flow management, etc.
- Umatilla Tribe wants to develop a Pacific Lamprey restoration plan for the Walla Walla basin.

Umatilla

Near Term

- Recharging aquifer.
- Continue assessment of adult passage issues and juvenile passage and entrainment/impingement issues at water diversions. Use the information from the assessments to identify, explore, and prioritize alternative actions to address identified issues as appropriate.
- Education of state agencies, private entities and the public about conduct of instream water work and appropriate salvage operations for lamprey juveniles and adults. Drain stamps.
- Continue to work on water quality improvements and identify specific lamprey concerns. Work on identifying specific studies to evaluate adult and juvenile temperature tolerance criteria.

Long term

- From the above assessments determine schedule of actions for passage, screening, and flow management, etc.

NPCC Fish and Wildlife Program

- Restore lamprey passage and habitat in the mainstem and in tributaries that historically supported spawning lamprey populations.

- Attain self-sustaining and harvestable populations of lamprey throughout their historical range.
- Mitigate for lost lamprey production in areas where restoration of habitat or passage is not feasible.

Actions Identified in the CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Mid-Columbia Region (Table 10-4)

Table 10-4. Actions identified (depicted by X) in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia Basin (2008) for the Mid-Columbia Region.

Category/Task	Hood	Fifteenmile Creek	Deschutes	John Day	Umatilla	Walla Walla	Smaller Tributaries
Status							
Characterize use of Fifteenmile Creek by lamprey that fail to pass The Dalles Dam		X					
Document current adult abundance and distribution				X	X	X	X
Document historic adult and juvenile abundance and distribution; collect anecdotal information; interview biologists, tribal elders and landowners with knowledge of lamprey	X	X	X			X	X
Establish and monitor ammocoete index sites for changes in distribution and abundance; presence/absence surveys. Identify species	X	X	X		X	X	X
Estimate tribal harvest and/or spawning escapement	X	X	X				
Implement standardized electrofishing surveys	X	X	X				
Monitor juvenile outmigration; describe outmigration timing and abundance				X	X	X	X
Utilize existing technology to monitor annual abundance	X	X	X	X			
Biology/Life History							
Characterize maturation level of adults entering the basin at various times.	X	X	X	X			
Collect outmigrant timing information and determine relationships with habitat parameters (i.e., discharge, water temperature, water quality)	X	X	X	X			

Table 10-4. Continued.

Category/Task	Hood	Fifteenmile Creek	Deschutes	John Day	Umatilla	Walla Walla	Smaller Tributaries
Biology/Life History (Cont.)							
Describe preferred habitat and environmental conditions throughout the life cycle	X	X	X	X			
Describe sex ratio and length at times of entry and spawning	X	X	X	X			
Identify key areas where adults hold and /or spawn. Provide description of the amount of suitable adult holding and spawning habitat; Describe time of adult entrance, over-wintering and spawning time	X	X	X	X			X
Determine adult and juvenile migration timing, size, age and condition				X	X	X	X
Identify/describe/determine adult and juvenile tributary habitat use: timing, duration and age				X	X	X	X
Improve knowledge of lamprey habitats in the basin. Identify and map spawning, rearing and overwintering habitats; Map key ammocoete rearing areas for preservation	X	X	X	X			
Identify current strongholds and relative densities in ammocoete rearing areas							X
Identify environmental or physiological conditions that trigger spawning and migration to occur							X
Investigate genetic basis for run time	X	X	X	X			
Limiting Factors							
Investigate presence of contaminants and toxins such as pesticides, herbicides, and fertilizers in lamprey habitats and tissues.	X	X	X	X			
Monitor water temperature, quality, and stream flow.	X	X	X	X			

Table 10-4. Continued.

Category/Task	Hood	Fifteenmile Creek	Deschutes	John Day	Umatilla	Walla Walla	Smaller Tributaries
Limiting Factors (Cont.)							
Locate and evaluate barriers to adult and juvenile passage (e.g., dams, flow, temperature, water withdrawal structures, culverts).	X	X	X	X			
Investigate and quantify screen impingement and entrainment associated with water withdrawal.	X	X	X	X			
Identify and address further limiting factors.	X	X	X	X			
Describe predation, parasites, and disease and their prevalence by location for all life stages	X	X	X	X			
Assess habitat limitation associated with sedimentation of spawning areas, channelization and scouring of rearing areas, lack of shade and riparian cover, and large wood removal	X	X	X	X			
Identify habitat limiting factors for adult migration				X	X	X	X
Identify habitat limiting factors for adult spawning				X	X	X	X
Identify habitat limiting factors for juvenile rearing				X	X	X	X
Identify habitat limiting factors for juvenile outmigration				X	X	X	X
Research							
Use molecular techniques to investigate population structure, species composition, and life histories as part of larger study in the CRB.	X	X	X	X			
Analyze ammocoete length data to describe age-structure, investigate year-class success, and detect years with failed spawning/larval recruitment	X	X	X	X			

Table10-4. Continued.

Category/Task	Hood	Fifteenmile Creek	Deschutes	John Day	Umatilla	Walla Walla	Smaller Tributaries
Research (Cont.)							
Describe relationships between various life stages (i.e., stock-recruitment indices) to help understand which are most important for determining year-class success	X	X	X	X			
Develop tributary spawner escapement estimates	X	X	X	X			
Collect lamprey tissue samples for genetic archives/analyses. Develop and maintain a genetic library/database. Supplement existing genetic libraries of genetic markers.	X	X	X	X	X	X	X
Investigate use of pheromones emitted by ammocoetes (or synthetic derivatives) as means for attracting spawning adults	X	X	X	X	X		
Develop new capture methodologies for all life phases	X	X	X	X			
Develop or improve methods for estimating annual abundance for all life stages	X	X	X	X			
Estimate fecundity, larval production and early life survivorship	X	X	X	X			
Pursue additional research questions as knowledge of lampreys progress and as needed to restore lamprey populations	X	X	X	X		X	
Investigate long-term juvenile tagging technology and protocol					X		
Identify disease concerns					X		

Table 10-4. Continued.

Category/Task	Hood	Fifteenmile Creek	Deschutes	John Day	Umatilla	Walla Walla	Smaller Tributaries
Restoration							
Develop, employ, and monitor lamprey-specific restoration projects that augment lamprey habitat and directly address limiting factors				X	X	X	
Evaluate ongoing restoration projects aimed at salmonids in terms of effects on lamprey	X	X	X	X			
Increase instream flows using water conservation measures	X	X	X	X			
Plant native vegetation in and/or fence riparian areas to stabilize banks, contribute leaves and woody debris, and add shade	X	X	X	X			
Promote responsible grazing practices through collaborative efforts	X	X	X	X			
Develop, evaluate, implement methods for introducing adults and/or ammocoetes into areas where suitable habitat exists, but populations have been extirpated or are low	X	X		X			
Assess habitat availability above PRB			X				
Assess upstream and downstream lamprey passage after completion of the Selective Water Withdrawal Structure in Lake Billy Chinook			X				
If passage is feasible, implement reintroduction of Pacific Lamprey			X				
Enhance summer stream flows for adult migration				X	X	X	
Supplement natural production by outplanting adults. Implement translocation of adults from mainstem dams to upstream watersheds				X	X	X	
Identify passage constraints and address critical impediments by developing and implementing structural passage aids	X	X	X	X	X	X	

Table 10-4. Continued.

Category/Task	Hood	Fifteenmile Creek	Deschutes	John Day	Umatilla	Walla Walla	Smaller Tributaries
Restoration (Cont.)							
Develop subbasin restoration strategies							X
Implement and evaluate restoration projects with respect to changes in habitat characteristics, habitat use and productivity							X
Education							
Coordinate with on-going efforts in the basin (e.g., FERC relicensing, Superfund, ACOE)							
Collaborate with tribal, state, and federal government, and non-governmental organizations to achieve objectives.	X	X	X	X			
Guide fisheries managers to make lamprey friendly improvements as information becomes available.	X	X	X	X			
Make genetic and other relevant data available in a centralized database.	X	X	X	X			
Actively participate in multi-agency working groups which aid in lamprey recovery.	X	X	X	X			
Coordinate with entities within the basin to include lamprey in their data collection activities such as rotary screw trap operations and Steelhead redd counting	X	X	X	X			
Work with landowners and public to improve knowledge and importance of lamprey to a healthy ecosystem	X	X	X	X			
Collaborate in the development of standardized data collection methods and determine efficiencies of sampling gear	X	X	X	X			

Research, Monitoring, and Evaluation Needs

Walla Walla

- Identification (ID) workshop for field crews.
- Compile information on lamprey identification methods and results.
- Workshop to develop methods and sampling design to determine distribution of lamprey in the Walla Walla Basin – these methods should be standardized across basins in the Columbia River.
- Evaluate the adult lamprey counts at McNary Dam (24 hour counts).
- Potentially do experimental work on passage route/efficiency at review of screening issues to identify areas where impacts are likely (Umatilla Tribes, WDFW/BOR).
- Access compiled data/anecdotal information on lamprey occurrences from the Tribes.
- Evaluate mainstem water temps and adult & macrophthalmia run timing and temperature tolerances.
- Sampling in major screen forebays, and if found, behind screens.
- Possible efforts to sample in likely habitat.
- Identify temperature tolerances of ammocoetes to identify areas of presence.
- Look at gradient maps, etc. to identify sampling areas in Walla Walla basin.
- Evaluate effectiveness of ongoing habitat restoration for salmonids - evaluate for lamprey as well.
- Long term monitoring of lamprey restoration – outplanting.
- Effectiveness of screens (when developed).

Umatilla

- Identification (ID) workshop for field crews.
- Compile information on lamprey identification methods and results.
- Workshop to develop methods and sampling design to determine distribution of lamprey in the Umatilla Basin – these methods should be standardized across basins in the Columbia River.
- Evaluate the adult lamprey counts at mainstem dams (24 hour counts).
- Potentially do experimental work on passage route/efficiency at review of screening issues to identify areas where impacts are likely....Umatilla Tribes, WDFW/USBR/USGS/USFWS.
- Maintain compiled data/anecdotal information on lamprey occurrences from the Tribes.
- Evaluate mainstem water temperatures and adult & macrophthalmia run timing and temp tolerances as part of ongoing long term monitoring.
- Sampling in major screen forebays, and if found, behind screens as part of USBR's work.
- Evaluate criteria for culvert passage and make recommendations.
- Evaluate criteria for adult lamprey ramps and make recommendations.
- Evaluate habitat requirements for overwintering.
- Evaluate effectiveness of ongoing habitat restoration for salmonids - evaluate for lamprey as well.
- Long term monitoring of lamprey restoration – outplanting.

- Effectiveness of screens (when developed).

Columbia Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lampreys (2005) (In Appendix C).—Meeting attendees think that critical uncertainties apply.

Actions Identified in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Mid-Columbia Region (Table 10-4).

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11. Lower Columbia River/Willamette Region

Geographic Description of the Region

Lower Columbia Sub-Region

The Lower Columbia River Sub-Region within the boundaries of the Pacific Lamprey Conservation Assessment includes the Sandy, Lewis, Upper and Lower Cowlitz, Clatskanie, and Lower Columbia watersheds. It is comprised of four Level III Ecoregions described by the Environmental Protection Agency (EPA)

(http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). Descriptions of each ecoregion (McGrath et al. 2002) can be found in Appendix A. The watersheds within this sub-region range in size from 1,740 to 3,781 km² for the 6 HUCs. See Table 11-1 for how the HUCs fall within the ecoregions and Figure 11-1 on their distribution.

Willamette Sub-Region

The Willamette River Sub-Region within the boundaries of the Pacific Lamprey Conservation Assessment includes the McKenzie, Santiam, Yamhill, and Willamette River watersheds. It is comprised of twelve 4th field HUCs and three Level III Ecoregions described by the Environmental Protection Agency (EPA)

(http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). Descriptions of each ecoregion (McGrath et al. 2002) can be found in Appendix A. The watersheds within this sub-region range in size from 655 to 2,945 km² for the 12 HUCs. See Table 11-1 for how the HUCs fall within the ecoregions and Figure 11-1 on their distribution.

More detailed descriptions of the geology, land use, hydrology and climate of the Watersheds evaluated in this chapter can be found in the individual watershed templates and in the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan.

Table 11-1. Drainage Size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the Lower Columbia/Willamette Region.

Watershed	HUC Number	Drainage Size (km ²)	Level III Ecoregion(s)
Lower Columbia-Sandy	17080001	2,875	Willamette Valley, Cascades
Lewis	17080002	2,797	Puget Lowland, Willamette Valley, Cascades
Upper Cowlitz	17080004	2,668	Puget Lowland
Lower Cowlitz	17080005	3,781	Puget Lowland, Cascades
Lower Columbia-Clatskanie	17080003	2,321	Coast Range, Willamette Valley
Lower Columbia	17080006	1,740	Coast Range
Middle Fork	17090001	2,172	Willamette Valley
Coast Fork Willamette	17090002	1,069	Coast Range
Upper Willamette	17090003	2,945	Willamette Valley
McKenzie	17090004	2,188	Willamette Valley, Cascades
North Santiam	17090005	1,240	Willamette Valley, Cascades
South Santiam	17090006	1,689	Willamette Valley, Cascades
Middle Willamette	17090007	1,126	Willamette Valley
Yamhill	17090008	1,239	Coast Range
Molalla-Pudding	17090009	1,421	Willamette Valley, Cascades
Tualatin	17090010	1,156	Coast Range, Willamette Valley
Clackamas	17090011	1,505	Willamette Valley, Cascades
Lower Willamette	17090012	655	Willamette Valley



Figure 11-1. Map of watersheds within the Lower Columbia River/Willamette Region.

Ranked Population Status of Pacific Lamprey

Population factors were difficult to rank in many watersheds. The uncertainty associated with determining them was high because of the paucity of fishing records, dam counts, and in particular targeted surveys for Pacific Lamprey. In most cases the uncertainty was categorized as best professional judgment based on expansion of data for other species (e.g., SIP) for historic distribution; and in the case of the category of current occupancy it was either largely undocumented (but based on extent of habitat, suspected barriers and/or anecdotal information) or based on partial surveys for less than one half of the watershed.

Lower Columbia Sub-Region

NatureServe status ranks were calculated for Pacific Lamprey populations in this Region based on input from participants in the regional meeting and professional judgment. Ranks for range extent and occupancy, current population size and trend for watersheds in the Lower Columbia River Region are in Table 11-2.

Table 11-2. Population status of the Pacific Lamprey in the Lower Columbia River/Willamette Region, as ranked by participants at the regional meetings.

Watershed	Occupancy (km ²)		Current Population Size (Adults)	Current Trend
	Historic	Current		
Lower Columbia-Sandy Lewis	1000-5000	500-2000	Unknown	decline of 30-50%
Lower Columbia-Clatskanie	1000-5000	500-2000	Unknown	decline of 10-30%
Upper Cowlitz	1000-5000	Zero	Unknown	NA
Lower Cowlitz	1000-5000	500-2000	Unknown	decline of 10-30%
Lower Columbia	1000-5000	500-2000	Unknown	decline of 10-30%
Middle Fork Willamette	1000-5000	100-500	Unknown	decline of 50-70%
Coast Fork Willamette	1000-5000	100-500	Unknown	decline of 50-70%
Upper Willamette	1000-5000	2000-20,000	Unknown	decline of 50-70%
Mckenzie	1000-5000	500-2000	Unknown	decline of 50-70%
North Santiam	250-1000	100-500	Unknown	decline of 50-70%
South Santiam	1000-5000	500-2000	Unknown	decline of 50-70%
Middle Willamette	1000-5000	500-2000	Unknown	decline of 50-70%
Yamhill	1000-5000	500-2000	Unknown	decline of 50-70%
Molalla-Pudding	1000-5000	2000-20,000	Unknown	decline of 50-70%
Tualatin	1000-5000	500-2000	Unknown	decline of 50-70%
Clackamas	1000-5000	100-500	Unknown	decline of 50-70%
Lower Willamette	250-1000	100-500	Unknown	decline of 50-70%

Willamette Sub-Region

NatureServe status ranks were calculated for Pacific Lamprey populations in this Region based on input from participants in the regional meeting and professional judgment. Ranks for range

extent and occupancy, current population size and trend for watersheds in the Willamette River Region are in Table 11-2.

Threats and Limiting Factors to Pacific Lamprey

Lower Columbia Sub-Region

Passage.—Passage in the Lower Columbia Sub-Region is not impeded by dams of the Federal Columbia River Power System. It is, however, affected by other dams including Swift, Yale, and Merwin (none of which have fish passage) in the Lewis Basin, and Barrier, Mayfield, Mossy Rock and Cowlitz Falls in the Upper and Lower Cowlitz Basins. Culverts and private hobby and push up dams are widespread throughout the watersheds of the Lower Columbia.

Dewatering and Flow Management.—Flow is altered from reservoirs of the above mentioned dams (Swift Reservoir RKM 77.1 (RM 47.9), Yale Lake RKM 55 (RM 34.2), Lake Merwin RKM 31.4 (RM 19.5), Mayfield Lake, Riffe Lake and Lake Scanewa). The scope and severity of this threat was ranked high. Though there are numerous private water control structures, such as hobby and push up dams, in this basin the threat of dewatering from them was ranked low to moderate.

Stream and Floodplain Degradation.—Dredging and mining was ranked insignificant to low in the Lower Columbia basin. Channelization and scouring were also ranked low. The most serious threat in this category for the Lower Columbia is loss of side channels and vegetation removal. Both were ranked moderate in scope and severity throughout the watersheds of the Lower Columbia.

Water Quality.—Threats to water quality including elevated temperature, chemical, physical and biological factors were generally ranked low in the Lower Columbia. Some exceptions are elevated temperatures in the Sandy (high/moderate) and Lewis (moderate/moderate) watersheds. Urbanization, agriculture and logging were some of the activities that contribute to poorer water quality when applicable in the Lower Columbia. Lack of marine derived nutrients is considered widespread in the Lower Columbia, and ranked high in scope and unknown in severity throughout.

Other.—Of the smaller category threats predation, lack of awareness and climate change were ranked high for scope and unknown for severity throughout the Lower Columbia watersheds. Northern Pikeminnow, non-native fish and birds were cited as the most common predators on lampreys. The effects of disease and small population size are unknown in the Lower Columbia and translocation and harvest are not occurring.

Willamette Sub-Region

Passage.—Passage in the Willamette region is not impeded by dams of the Federal Columbia River Power System. It is however affected by other dams including Dexter, Fall Creek, Fernridge, Stayton, Bennett, Big Cliff, Detroit, Minto, Lebanon, Foster, Faraday, North Fork, and Kellogg. Culverts and diversion dams for agriculture and municipal water sources are widespread throughout the watersheds of the Willamette.

Dewatering and Flow Management.—Flow is altered from reservoirs of the above mentioned dams and from flow fluctuation below the dams. There is heavy agricultural and municipal water use which causes flow disruptions in the mainstem and tributaries. The scope and severity of this threat was ranked high and moderate throughout the watersheds.

Stream and Floodplain Degradation.—Overall this threat was ranked high for scope and severity in most watersheds of the Willamette. Agriculture and urbanization have caused extensive channelization and loss of side channels and vegetation.

Water Quality.—Threats to water quality including elevated temperature, chemical, and sedimentation were generally ranked high or moderate in the Willamette. The McKenzie watershed was the only one to be ranked low. Temperature problems arise from flow fluctuations from water diversions. Urbanization and agricultural run-off are the main activities that contribute to poor water quality.

Other.—Of the smaller category threats lack of awareness was low in some watersheds and high in others for both scope and severity. Climate change was generally ranked high for scope throughout the Willamette but unknown for scope. Non-native fish and cormorants were cited as the most common predators on lampreys. The effects of disease and small population size are unknown in the Willamette. Harvest of adult lamprey in the lower Willamette has an unknown effect on the overall population in the Willamette.

Prioritization of Limiting Factors and Threats

Lower Columbia Sub-Region

Numeric values, 1 to 4, were assigned to ranks, insignificant to high, respectively. An average for all watersheds was calculated for scope and severity of threats, and the overall scope and severity values were averaged to obtain one value to determine the priority order of threats. The highest priority threat in the Lower Columbia watersheds is passage followed by dewatering and flow management, stream degradation and water quality (Table 11-3).

Predation, lack of awareness, and climate change were designated high for scope but unknown for severity and therefore did not receive an overall average rank or prioritization. Disease and small population effects were ranked unknown for both scope and severity. Harvest/overutilization and translocation were both ranked not applicable. None of these threats were given an overall average rank or prioritization.

Willamette Sub-Region

Number values, 1 to 4, were assigned to ranks, insignificant to high, respectively. An average was calculated to determine the priority order of threats. The highest priority threat in the Willamette watersheds is stream and floodplain degradation (Table 11-3). Passage, dewatering and flow management, water quality and predation all ranked moderate for both scope and severity.

Lack of awareness was ranked high for scope and severity for several watersheds and low in others depending on the type and amount of research or in-stream work that is being conducted. Disease and small population effects were ranked unknown for both scope and severity in all watersheds except for the lower Willamette in which they were ranked low. Climate change was ranked high in scope for some watersheds and unknown in both scope and severity for all other watersheds. Harvest/overutilization was ranked insignificant in some watersheds and unknown in others. Translocation was ranked not applicable. None of these threats were given an overall average rank or prioritization even though the lower Willamette watershed did have ranks assigned for them.

Table 11-3. Threats to Pacific Lamprey and their habitats within the Lower Columbia River, as identified and ranked by participants at regional meetings. H=4, M/H=3.5, M=3, L/M=2.5, L=2, I=1, U=No value

Watershed	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Lower Columbia River												
<i>Sandy</i>	4	4	2	3	3	3	3	3	1	1	4	U
<i>Lewis</i>	3	3	4	4	3	3	3	3	1	1	4	U
<i>Clatskanie</i>	4	4	2	3	3	3	2	U	1	1	4	U
<i>Upper Cowlitz</i>	3	4	4	4	3	3	1	1	1	1	U	U
<i>Lower Cowlitz</i>	3	3	3	4	3	3	1	2	1	1	4	U
<i>Lower Columbia</i>	2	4	2	2	3	3	2	U	1	1	4	U
Mean	3.17	3.67	2.83	3.33	3.00	3.00	2.00	2.25	1	1	4	
Rank	M	H	M	M	M	M	L	L	I	I	H	
Mean Scope & Severity	3.42		3.08		3.00		2.13		1			
Drainage Rank	M		M		M		L		I			

Table 11-3. Continued.

Watershed	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Willamette River Basin												
<i>Middle Fork Willamette</i>	4	4	4	4	4	4	4	4	1	1	2	2
<i>Coast Fork Willamette</i>	4	3	3	3	4	3	3	3	1	1	U	U
<i>Upper Willamette</i>	3	3	3.5	3	4	4	4	3.5	U	U	3	3
<i>Mckenzie</i>	3	3	3	3	4	3	2	2	1	1	2	2
<i>North Santiam</i>	4	4	3	3	3.5	3	3	3	1	1	2	2
<i>South Santiam</i>	4	4	3	3	3.5	3	3	3	1	1	2	2
<i>Middle Willamette</i>	2	2	4	4	4	4	3	3	U	U	3	3
<i>Yamhill</i>	3	3	3	3	4	4	4	4	1	1	3	3
<i>Molalla-Pudding</i>	2.5	2.2	4	4	4	4	3	3	1	1	3	3
<i>Tualatin</i>	2.5	2.5	2.5	2.5	4	4	4	4	1	1	3	3
<i>Clackamas</i>	4	3	3	3	4	3	3	3	1	1	3	3
<i>Lower Willamette</i>	4	3	3	3	4	4	4	4	U	U	4	4
Mean Rank	3.33	3.08	3.25	3.21	3.92	3.58	3.33	3.29	1/U	1/U	2.73	2.73
	M	M	M	M	H	H	M	M	U	U	M	M
Mean Scope & Severity Drainage Rank	3.21		3.23		3.75		3.1		1/U		2.73	
	M		M		H		M		U		M	
Lower Columbia/Willamette Region												
Overall Rank												
Mean Scope/Severity	3.31		3.16		3.38		2.62		1.0		3.3U	
Overall Threat Rank	M		M		M		M		I		M/U	

Table 11-3. Continued.

Watershed	Translocation		Disease		Small Population Size		Lack of Awareness		Climate Change	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Lower Columbia River										
<i>Sandy</i>	NA	NA	U	U	U	U	4	U	4	U
<i>Lewis</i>	NA	NA	U	U	U	U	4	U	4	U
<i>Clatskanie</i>	NA	NA	U	U	U	U	4	U	4	U
<i>Upper Cowlitz</i>	NA	NA	U	U	4	U	4	U	4	U
<i>Lower Cowlitz</i>	NA	NA	U	U	U	U	4	U	4	U
<i>Lower Columbia</i>	NA	NA	U	U	U	U	4	U	4	U
	Mean				4		4		4	
	Rank				H		H		H	
Mean Scope & Severity Drainage Rank										

Table 11-3. Continued.

Watershed	Translocation		Disease		Small Population Size		Lack of Awareness		Climate Change	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Willamette River Basin										
<i>Middle Fork Willamette</i>	1	1	U	U	U	U	2	2	4	U
<i>Coast Fork Willamette</i>	NA	NA	U	U	U	U	2	2	U	U
<i>Upper Willamette</i>	NA	NA	U	U	U	U	4	4	U	U
<i>Mckenzie</i>	1	1	U	U	U	U	2	2	4	U
<i>North Santiam</i>	1	1	U	U	U	U	2	2	4	U
<i>South Santiam</i>	1	1	U	U	U	U	2	2	4	U
<i>Middle Willamette</i>	NA	NA	U	U	U	U	4	4	U	U
<i>Yamhill</i>	NA	NA	U	U	U	U	4	4	U	U
<i>Molalla-Pudding</i>	NA	NA	U	U	U	U	4	4	U	U
<i>Tualatin</i>	NA	NA	U	U	U	U	4	4	U	U
<i>Clackamas</i>	1.5	2	U	U	U	U	2	2	4	U
<i>Lower Willamette</i>	1	1	2	2	2	2	3	3	4	U
Mean Rank	NA	NA	U	U	U	U	2.92	2.92	4	U
Mean Scope & Severity Drainage Rank	NA		U		U		M		4/U	
Lower Columbia/Willamette Region										
Overall Rank										
Mean Scope/Severity	NA		U		U		3.46/U		4/U	
Overall Threat Rank	NA		U		U		M/U		H/U	

Suites of Actions to Address Limiting Factors and Threats

Ongoing Conservation Measures

Lower Columbia Sub-Region.—For general conservation measures see the Lower Columbia Subbasin Plan: www.nwcouncil.org/fw/subbasinplanning/lowercolumbia/plan/

Willamette Sub-Region.—Ongoing conservation measures specific to lamprey have not yet been identified for the Willamette Region. For general conservation measures see the Lower Columbia Subbasin Plan: <http://www.nwcouncil.org/fw/subbasinplanning/willamette/plan/>

Clackamas

E1. Ongoing Actions

- A number of habitat restoration projects- PGE tree planting; large wood placement projects in Clear Creek and Deep Creek; gravel replacement; Forest Service decommissioning roads
- Steelhead and Coho recovery plan – for recovery actions
- Passage improvements – dam passage, culvert replacement - ODFW culvert replacement priority list; Forest Service and ODOT and State Forest, counties are using this list; States developing water budgets; PGE making lamprey specific improvements
- Watershed Councils - watershed assessment limiting factors analysis.
- Water quality standards, and plans to meet aquatic criteria
- ODFW putting together Chinook, coho, and steelhead conservation plans and actions.
- County and state roadway infrastructure maintenance and construction improved
- DEQ water quality monitoring program – turbidity and temps

E2. Develop new actions

- Identify areas where potential passage problems exist for adult lamprey in each basin relative to the potential distribution of lamprey in a basin.
- Provide passage criteria for culvert replacement that will also benefit lamprey
- Develop and provide guidance for ramping rates or salvage operations for protecting ammocoetes for instream projects, channel and dam maintenance.
- Develop guidance for suction dredging operations and for gravel mining operations for protecting ammocoetes
- Screening criteria for juvenile lamprey for water diversions and municipal pumps
- Improve side channel and floodplain connectivity
- 99 bridge slough potential tree removal

Long Term Needs:

F1 Research, monitoring, and evaluation needs – critical uncertainties

- Potential for fire
- Research on ocean phase desperately needed
- Water quantity – evaluating flow needs by life stage, future water withdrawals
- Disease, parasites
- More survey for Pacific Lamprey abundance and distribution
- Evaluate water quality impacts to areas for ammocoete rearing habitats and hibernation habitat
- Continue to work on water quality improvements and identify specific lamprey concerns.
- Work on identifying additional studies to evaluate specific adult, egg/incubation, and juvenile life stage temperature tolerance criteria/guidelines.
- Identification workshop for field crews –
- Compile information on lamprey ID methods and results-
- Develop methodologies to enumerate adult lamprey through various approaches: weirs, M/R, redd surveys.
- Develop methods and sampling design to determine distribution of lamprey in Basin – these methods should be standardized across basins.
- Use life-cycle monitoring to tag macrophthalmia for evaluating run timing.
- Develop tags for juvenile lamprey that can be detected through adult phase.
- Potentially do experimental work on passage route/efficiency at review of screening issues to id areas where impacts are likely
- Access compiled data/anecdotal information on lamprey occurrences from the Tribes
- Evaluate mainstem water temps/adult & macrothalia run timing and temp tolerances....
- Downstream passage of juveniles
- Possible efforts to sample in likely habitat...
 - Identify temperature tolerances of ammocoetes to id areas
 - Look at gradient maps, etc to id sampling areas in basin
 - Monitor habitat quality for juveniles and adults for spawning and rearing – mapping rearing potential.
 - ID habitat preferences by life stage
 - Map distribution of preferred habitats
 - Determine seeding levels of preferred habitats by life stage
- Evaluate Pacific Lamprey population structure analysis using polymorphic microsatellite loci
 - Develop and optimize markers for polymorphic microsatellite loci
 - Evaluate Pacific lamprey population structure using these microsatellite markers

F2. Effectiveness monitoring

- Monitoring of Clackamas translocation
- Evaluate effectiveness of passage criteria for lamprey passage through culvert modification
- Evaluate ramping rates for protecting ammocoetes during dewatering maintenance periods

- Develop and implement an approach to track lamprey population status and associated monitoring needs.

Needed Actions

Lower Columbia and Willamette Sub-Regions

NPCC Fish and Wildlife Program.—

- Restore lamprey passage and habitat in the mainstem and in tributaries that historically supported spawning lamprey populations.
- Attain self-sustaining and harvestable populations of lamprey throughout their historical range.
- Mitigate for lost lamprey production in areas where restoration of habitat or passage is not feasible.
- The federal and state agencies also should evaluate the extent of pinniped predation on Pacific Lamprey in the lower Columbia River from below Bonneville Dam to the mouth of the river.
- Halt declining trends in Columbia River Basin salmon and Steelhead populations, especially those that originate above Bonneville Dam. Significantly improve the smolt-to-adult return rates (SARs) for Columbia River Basin salmon and Steelhead, resulting in productivity well into the range of positive population replacement. Continue restoration of lamprey populations.

Lower Columbia Subbasin Plan.—For general non-lamprey specific conservation measures see the Lower Columbia and Willamette Subbasin Plans:

www.nwcouncil.org/fw/subbasinplanning/lowercolumbia/plan/

<http://www.nwcouncil.org/fw/subbasinplanning/willamette/plan/>

Columbia Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lampreys (2005) (In Appendix C). — Meeting attendees think that critical uncertainties apply.

Actions Identified in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Lower Columbia and Willamette Regions (Table 11-4).

Table 11-4. Actions Identified (depicted by X) in the Draft CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Lower Columbia Region.

Category/Task	Wind River	White Salmon	Klickitat	Willamette
Status				
Document current adult abundance and distribution	X	X	X	
Document historic adult and juvenile abundance and distribution; collect anecdotal information; interview biologists, tribal elders and landowners with knowledge of lamprey	X	X	X	X
Establish and monitor ammocoete index sites for changes in distribution and abundance; presence/absence surveys. Identify species	X	X	X	X
Monitor juvenile outmigration; describe outmigration timing and abundance	X	X	X	X
Estimate tribal harvest and/or spawning escapement				X
Biology/Life History				
Describe key predators and conditions where lamprey are most vulnerable			X	
Identify key areas where adults hold and /or spawn. Provide description of the amount of suitable adult holding and spawning habitat; Describe time of adult entrance, over-wintering and spawning time	X	X	X	X
Determine adult and juvenile migration timing, size, age and condition	X	X	X	
Identify/describe/determine adult and juvenile tributary habitat use: timing, duration and age	X	X	X	
Identify current strongholds and relative densities in ammocoete rearing areas	X	X	X	
Identify extent lamprey are subject to disease			X	
Identify environmental/physiological conditions that trigger spawning and migration to occur	X	X	X	
Broaden understanding of population dynamics				X
Document and describe life history types and/or run times				X
Improve knowledge of lamprey habitats in the basin. Identify and map spawning, rearing and overwintering habitats; Map key ammocoete rearing areas for preservation				X
Limiting Factors				
Investigate presence of contaminants and toxins such as pesticides, herbicides, and fertilizers in lamprey habitats and tissues.			X	X

Table 11-4. Continued.

Category/Task	Wind River	White Salmon	Klickitat	Willamette
Limiting Factors (Cont.)				
Monitor water temperature, quality, and stream flow.				X
Locate and evaluate barriers to adult and juvenile passage (e.g., dams, flow, temperature, water withdrawal structures, culverts).				X
Investigate and quantify screen impingement and entrainment associated with water withdrawal.				X
Identify habitat limiting factors for adult migration	X	X	X	
Identify habitat limiting factors for adult spawning	X	X	X	
Identify habitat limiting factors for juvenile rearing	X	X	X	
Identify habitat limiting factors for juvenile outmigration	X	X	X	
Research				
Collect lamprey tissue samples for genetic archives/analyses. Develop and maintain a genetic library/database. Supplement existing genetic libraries of genetic markers.	X	X	X	
Identify body weight of adults entering subbasin and compare with time of spawning. Identify factors contributing to inadequate energy reserves to successfully spawn			X	
Evaluate if artificial production can be used to “jump-start” ammocoete production in appropriate watersheds where productivity is currently lacking			X	
Identify existing facilities potentially available – or needed facilities to successfully rear ammocoetes to desired age classes			X	
Continue evaluating physical and / or biologic cues that may influence and / or guide adult migration and spawning			X	
Assess trophic relationships of both juvenile and adult lamprey			X	
Use molecular techniques to investigate population structure, species composition, and life histories as part of larger study in the CRB				X
Pursue additional research questions as knowledge of lampreys progress and as needed to restore lamprey populations				X

Table 11-4. Continued.

Category/Task	Wind River	White Salmon	Klickitat	Willamette
Restoration				
Supplement natural production by outplanting adults. Implement translocation of adults from mainstem dams to upstream watersheds	X	X	X	
Monitor spawning at target translocation streams	X	X	X	
Monitor ammocoete production at target translocation streams	X	X	X	
Monitor macrophthalmia emigration at selected target translocation streams	X	X	X	
Monitor adult abundance at target translocation streams	X	X	X	
Develop subbasin restoration strategies	X	X	X	
Implement and evaluate restoration projects with respect to changes in habitat characteristics, habitat use and productivity	X	X	X	
Describe if eggs/ammocoetes distributed in degraded habitat may be at significantly greater risk relative to those in healthy or properly functioning environmental conditions. Provide strategy for habitat restoration			X	
Develop, employ, and monitor lamprey-specific restoration projects that augment lamprey habitat and directly address limiting factors				X
Education				
Coordinate with on-going efforts in the basin (e.g., FERC relicensing, Superfund, USACE)				X
Collaborate with tribal, state, and federal government, and non-governmental organizations to achieve objectives.				X
Guide fisheries managers to make lamprey friendly improvements as information becomes available.				X
Make genetic and other relevant data available in a centralized database.				X

Research, Monitoring, and Evaluation Needs

Better understand the level of predation that is occurring on returning adult lamprey by Stellar sea lions.

Columbia Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lampreys (2005) (In Appendix C).—Meeting attendees think that critical uncertainties apply.

Actions Identified in the CRITFC Pacific Lamprey Restoration Plan for the Columbia River Basin, specific to the Lower Columbia Region (Table 11-4).

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12. OREGON COAST REGION

Geographic Description of the Oregon Coast

North Oregon Coast Sub-Region

The North Oregon Coast Sub-Region within the boundaries of the Pacific Lamprey Conservation Assessment is comprised of two Level III Ecoregions described by the Environmental Protection Agency (EPA) (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). Descriptions of each ecoregion can be found in Appendix A. The North Oregon Coast Sub-Region for this plan is equivalent to the USGS hydrologic unit accounting unit 171002 (Northern Oregon Coastal), which are the rivers that drain into the Pacific Ocean from the Columbia River Basin boundary to the Umpqua River boundary and is a total area of 4,310 square miles. This sub-region consists of two EPA level III ecoregions: the Coast Range, and the Willamette Valley. The drainages range in size from 334 to 2,520 km² for the 7 HUCs. The HUCs of this sub-region are primarily contained within the Coast Range Ecoregion. See Table 12-1 for how the HUCs fall within the ecoregions and Figure 12-1 on their distribution.

More detailed descriptions of the geology, land use, hydrology and climate of the watersheds evaluated in this chapter can be found in the individual watershed templates. Descriptions of each ecoregion (Pater et al. 1998) and the 4th Field Hydrologic Unit Code (HUC) Watersheds within them can be found in Appendix A.

Table 12-1. Drainage size and level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the North Coast Oregon Sub-Region.

Watershed	HUC Number	Drainage Size (km ²)	Level III Ecoregion(s)
Necanicum	17100201	334	Coast Range
Nehalem	17100202	1,728	Coast Range
Wilson-Trask-Nestucca	17100203	2,520	Coast Range
Siletz-Yaquina	17100204	1,950	Coast Range
Alsea	17100205	1,805	Coast Range
Siuslaw	17100206	1,992	Coast Range, Willamette Valley
Siltcoos	17100207	334	Coast Range

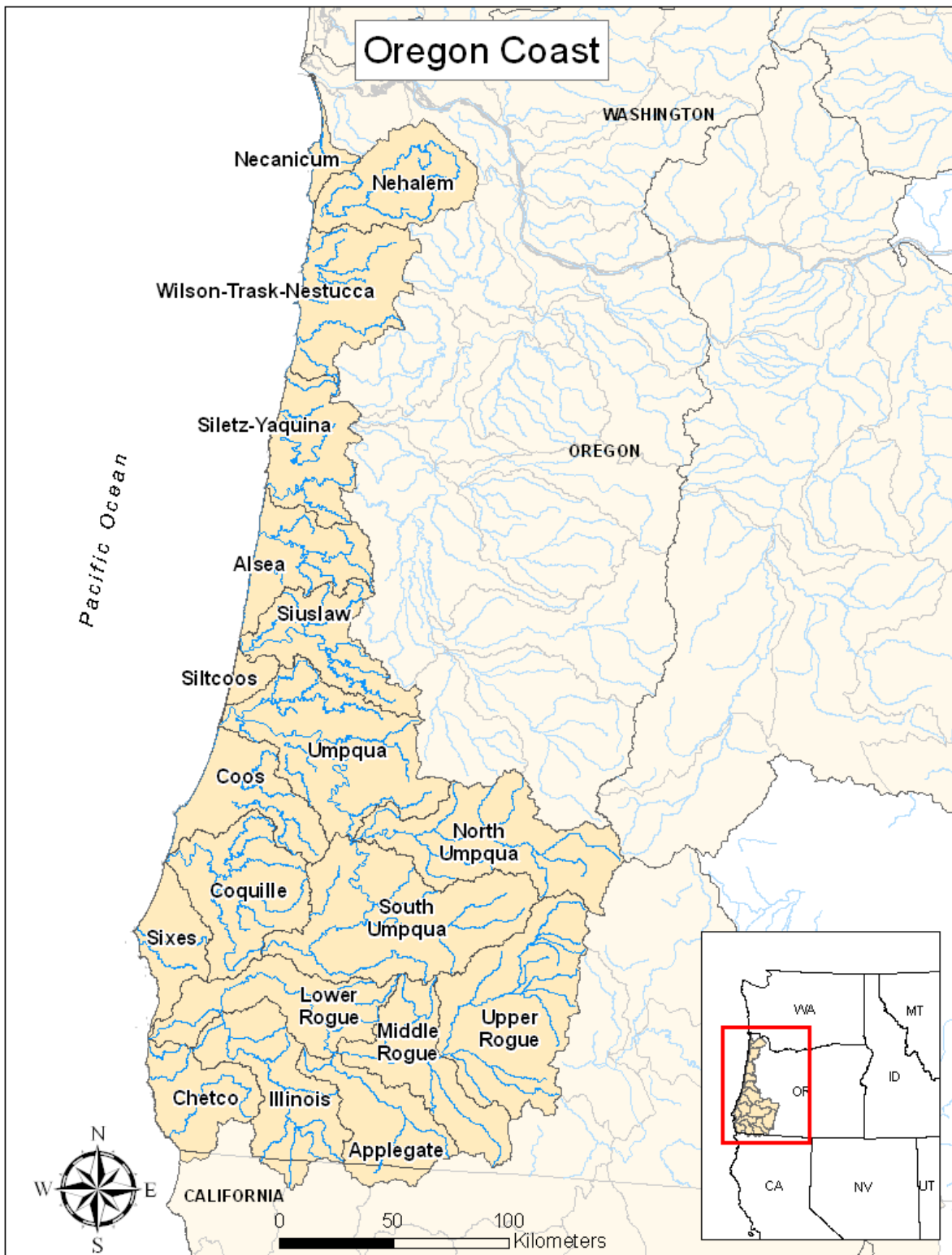


Figure 12-1. Map of the watersheds within the North and South Coast Oregon Region.

South Oregon Coast Sub-Region

The South Oregon Coast Sub-Region within the boundaries of the Pacific Lamprey Conservation Assessment is comprised of five Level III Ecoregions described by the Environmental Protection Agency (EPA) (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). Descriptions of each ecoregion and the 4th Field Hydrologic Unit Code (HUC) Watersheds within them are described below. The South Oregon Coast Sub-Region for this plan is equivalent to the USGS hydrologic unit accounting unit 171003 (Southern Oregon Coastal), which are the rivers that drain into the Pacific Ocean from the Umpqua River basin to the Smith River boundary in California and is a total area of 12,600 square miles. This sub-region consists of five EPA Level III Ecoregions: the Coast Range, Klamath Mountains, Cascades, Eastern Cascades Slopes and Foothills, and the Willamette Valley. The drainages range in size from 1,210 to 4,636 km² for the 12 HUCs. The HUCs of this Sub-Region are primarily contained within the Coast Range Ecoregion. See Table 12-2 for how the HUCs fall within the ecoregions and Figure 12-1 on their distribution.

More detailed descriptions of the geology, land use, hydrology and climate of the watersheds evaluated in this chapter can be found in the individual watershed templates. Descriptions of each ecoregion (McGrath et al. 2002) and the 4th Field Hydrologic Unit Code (HUC) Watersheds within them can be found in Appendix A.

Table 12-2. Drainage size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the South Coast Oregon Region.

Watershed	HUC Number	Drainage Size (km ²)	Level III Ecoregion(s)
North Umpqua	17100301	3,497	Cascades, Klamath Mountains
South Umpqua	17100302	4,636	Coast Range, Cascades, Klamath Mountains
Umpqua	17100303	3,885	Coast Range, Cascades, Willamette Valley, Klamath Mountains
Coos	17100304	1,914	Coast Range
Coquille	17100305	2,668	Coast Range, Klamath Mountains
Sixes	17100306	1,210	Coast Range
Upper Rogue	17100307	4,170	Cascades, Klamath Mountains, Eastern Cascades Slopes and Foothills
Middle Rogue	17100308	2,292	Cascades, Klamath Mountains
Applegate	17100309	1,966	Klamath Mountains
Lower Rogue	17100310	2,326	Coast Range, Klamath Mountains
Illinois	17100311	2,541	Klamath Mountains
Chetco	17100312	1,632	Coast Range, Klamath Mountains

Ranked Population Status of Pacific Lamprey in the Oregon Coast Region

Population factors were difficult to rank in many watersheds. The uncertainty associated with determining them was high because of the paucity of fishing records, dam counts, and in particular targeted surveys for Pacific Lamprey. In most cases the uncertainty was categorized as “best professional judgment” based on expansion of data for other species (e.g., SIP) for historic distribution; and in the case of the category of current occupancy it was either largely undocumented (but based on extent of habitat, suspected barriers and/or anecdotal information) or based on partial surveys for less than one half of the watershed. NatureServe status ranks were calculated for Pacific Lamprey populations in this Region based on input from participants in the regional meeting and professional judgment. Ranks for range extent and occupancy, current population size and population trend for watersheds in the Oregon Coast Region are in Table 12-3.

Table 12-3. Population status of the Pacific Lamprey in the Oregon Coast Region, as ranked by participants at the regional meetings.

Watershed	Occupancy (km ²)		Current Population Size (Adults)	Current Trend
	Historic	Current		
North Coast				
Necanicum	100-250 to 250-1000	20-100	250-2500	50 to >70% decline
Nehalem	1000-5000	100-500 to 500-2000	250-10,000+	50 to >70% decline
Wilson-Trask-Nestucca	1000-5000	100-500 to 500-2000	250-10,000+	50 to >70% decline
Siletz-Yaquina	250-1000 to 1000-5000	100-500 to 500-2000	2500-10,000	>70% decline
Alsea	250-1000 to 1000-5000	100-500 to 500-2000	2500-10,000	>70% decline
Siuslaw	250-1000 to 1000-5000	100-500 to 500-2000	2500-10,000	50 to >70% decline
Siltcoos	100-250 to 250-1000	100-500	1000-2500	50 to >70% decline
South Coast				
North Umpqua	1000-5000	500-2000	250-2500	>70% decline
South Umpqua	1000-5000	500-2000	250-2500	50-70% decline
Umpqua	1000-5000	500-2000	1000-10,000	50-70% decline
Coos	250-1000 to 1000-5000	500-2000	1000-10,000	10-30% decline
Coquille	1000-5000	500-2000	2500-10,000	30-50% decline
Sixes	250-1000 to 1000-5000	500-2000	2500-10,000	10-30% decline
Upper Rogue	1000-5000	500-2000	2500-10,000	10-30% decline
Middle Rogue	1000-5000	100-500	Unknown	30-50% decline
Applegate	1000-5000	500-2000	Unknown	Unknown
Lower Rogue	250-1000 to 1000-5000	500-2000	Unknown	Unknown
Illinois	1000-5000	500-2000	Unknown	Unknown
Chetco	1000-5000	500-2000	2500-10,000	Unknown

Threats and Limiting Factors to Pacific Lamprey

North Coast Oregon

Within this region, all of the HUCs exhibited stream and flood plain degradation that ranked moderate for scope and severity. All other categories of threats ranked either low or insignificant for scope and severity within this region.

Passage.—Passage in the Oregon North Coast Sub-Region is not impeded by large hydroelectric or storage dams. In the majority of watersheds that were assessed, the scope and severity of threats from passage are low. Culverts and tidegates in low lying areas are widespread throughout the watersheds of the North Coast. There are dams at the outflow of lakes in the Siltcoos HUC that may impede passage from low head.

Dewatering and Flow Management.—There are few major water diversions in the rivers of the north Oregon Coast. On average the scope and severity of threats from water diversions was low for the north Oregon Coast. However, there are municipal water diversions in the Necanicum, Siletz and Siuslaw HUCs, which have moderate impacts during portions of the year. Though there are numerous residential water diversions in a number of the HUCs in this Sub-Region, the threat of dewatering from them was ranked low.

Stream and Floodplain Degradation.—The most serious threat in this category for the north Oregon Coast is from loss of side channels, scouring and vegetation removal. These impacts are related to historic timber and agricultural practices. Many current impacts are related to urbanization. Both were ranked moderate in scope and severity throughout the watersheds of the north Oregon Coast.

Water Quality.—Threats to water quality including elevated temperature, chemical, physical and biological factors were generally ranked low in the north Oregon Coast HUCs. Some exceptions are chemical inputs from commercial forestry and agricultural practices in the Wilson, Siletz, Alesia Siuslaw, and Siltcoos HUCs, where the scope and severity were moderate. Urbanization, agriculture and logging were some of the activities that contribute to poorer water quality in the north Oregon Coast. Some of the dissolved oxygen values were observed to be below the rearing and incubation ODEQ criteria for juvenile salmonids in 6th order and smaller systems for a number of north Oregon Coast HUCs.

Other.—Of the smaller category threats predation, lack of awareness and climate change were ranked low for scope and low for severity throughout the north Oregon Coast HUCs. Northern Pikeminnow, non-native fish, and birds were cited as the most common predators on lampreys. The effects of disease and small population size are unknown in the north Oregon Coast and translocation and harvest are not occurring.

South Coast Oregon

Within this Sub-Region, all of the HUCs exhibited stream and flood plain degradation that ranked moderate for scope and severity. The HUCs of this Sub-Region exhibited water quality

conditions that predominately ranked moderate for scope and severity. All other categories of threats ranked either low or insignificant for scope and severity within this region.

Passage.—Passage in the Oregon South coast region is generally not impeded by large hydroelectric or storage dams. In the majority of watersheds that were assessed, the scope and severity of threats from passage are low. However, the north Umpqua, Coos, and upper Rogue HUCs exhibited high to moderate threats from passage. Culverts and tidegates in low lying areas are widespread throughout the watersheds of the South Coast.

Dewatering and Flow Management.—Few major water diversions exist in the rivers of the south Oregon Coast. On average, the scope and severity of threats from water diversions was low for the south Oregon Coast. However, there are municipal water diversions in the Umpqua, Coquille, and Rogue HUCs, which have moderate impacts during portions of the year. Though there are numerous agricultural and residential water diversions in a number of the HUCs in this Sub-Region, the threat of dewatering from them was ranked on average low.

Stream and Floodplain Degradation.—The most serious threat in this category for the south Oregon Coast is from channelization, loss of side channels, and scouring. These impacts are related to historic timber and agricultural practices. Many current impacts are related to urbanization. Both were ranked moderate in scope and severity throughout the watersheds of the south Oregon Coast

Water Quality.—Threats to water quality including elevated temperature, chemical, physical and biological factors were generally ranked the most significant threat in the south Oregon Coast HUCs. Some exceptions were in the lower Rogue and Chetco HUCs, where the scope and severity were insignificant. Urbanization, agriculture and logging were some of the activities that contribute to poorer water quality in the south Oregon Coast. Some of the dissolved oxygen values were observed to be below the ODEQ rearing and incubation criteria for juvenile salmonids in 6th order and smaller systems for a number of south Oregon Coast HUCs.

Other.—Of the smaller category threats predation, lack of awareness and climate change were ranked moderate to low for scope and low for severity throughout the south Oregon Coast HUCs. Northern Pikeminnow, non-native fish and birds were cited as the most common predators on lampreys. The effects of disease and small population size are unknown in the south Oregon Coast and translocation and harvest are not occurring.

Prioritization of Limiting Factors and Threats

North Coast Oregon

Numeric values, 1 to 4, were assigned to ranks, insignificant to high, respectively. An average for all watersheds was calculated for scope and severity of threats, and the overall scope and severity values were averaged to obtain one value to determine the priority order of threats. The highest priority threat in the north Oregon Coast watersheds is stream and flood plain degradation followed by dewatering and flow management, passage and water quality (Table 12-4).

South Coast Oregon

Numeric values, 1 to 4, were assigned to ranks, insignificant to high, respectively. An average for all watersheds was calculated for scope and severity of threats, and the overall scope and severity values were averaged to obtain one value to determine the priority order of threats. The highest priority threat in the south Oregon Coast watersheds is water quality followed by stream and flood plain degradation, dewatering and flow management, and passage (Table 12-5).

Table 12-4. Threats to Pacific Lamprey in the North Coast of Oregon, as identified and ranked by participants at the regional meetings.

Watershed	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Necanicum	2	2	2	2	3	3	2	2	1	1	2	2
Nehalem	2	2	2	2	3	3	3	2	1	1	2	2
Wilson-Trask-Nestucca	2	2	2	2	3	3	2	2	1	1	2	2
Siletz-Yaquina	2	2	3	3	3	3	2	2	1	1	2	2
Alsea	2	2	2	2	3	3	2	2	1	1	2	2
Siuslaw	2	2	2	3	3	3	2	2	1	1	2	2
Siltcoos	3	2	3	2	3	3	2	2	1	1	3	2
Mean Rank	2.14	2.00	2.29	2.29	3.00	3.00	2.14	2.00	1.00	1.00	2.14	2.00
	L	L	L	L	M	M	L	L	I	I	L	L
Mean Scope & Severity Drainage Rank	2.07		2.29		3.00		2.07		1.00		2.07	
	L		L		M		L		I		L	

Table 12-4. Continued.

Watershed	Translocation		Disease		Small Population Size		Lack of Awareness		Climate Change	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Necanicum	1	1	2	2	2	2	2	2	2	2
Nehalem	1	1	2	2	2	2	2	2	2	2
Wilson-Trask-Nestucca	1	1	2	2	2	2	2	2	2	2
Siletz-Yaquina	1	1	2	2	2	2	2	2	2	2
Alsea	1	1	2	2	2	2	2	2	2	2
Siuslaw	1	1	2	2	2	2	2	2	2	2
Siltcoos	1	1	2	2	2	2	2	2	2	2
Mean Rank	1	1	2	2	2	2	2	2	2	2
	I	I	L	L	L	L	L	L	L	L
Mean Scope & Severity Drainage Rank	1.00		2.00		2.00		2.00		2.00	
	I		L		L		L		L	

Table 12-5. Threats to Pacific Lamprey in the South Coast of Oregon, as identified and ranked by participants at the regional meetings.

Watershed	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
North Umpqua	4	3	4	3	2.5	3	3	2.5	2	2	1	1
South Umpqua	2	2	2.5	2.5	3	3	3	2.5	2	2	2	3
Umpqua	2	2	2	2	2.5	3	3	3			4	3
Coos	3	2	2	2.5	3	3	3.5	3	1	1	3	2
Coquille	2.5	2	2.5	2	3	3	3.5	2.5	1	1	3	2
Sixes	2	2	2	2	3	3	2.5	2.5	1	1	1	1
Upper Rogue	3	3	2.5	3	3	3	3	3	1	1	1	1
Middle Rogue	2.5	2.5	3	3	3.5	3.5	3	3	1	1	1	1
Applegate	1	1	3	3.5	3	3	3	3	1	1	1	1
Lower Rogue	1	1	1	1	1	1	1	1	1	1	1	1
Illinois	1	1	3	3.5	2	3	3	3	1	1	1	1
Mean Rank	2.08	1.88	2.42	2.42	2.58	2.79	2.71	2.50	1.20	1.20	1.73	1.55
	L	L	L	L	M	M	M	M	I	I	L	L
Mean Scope & Severity Drainage Rank	1.98		2.42		2.69		2.61		1.20		1.64	
	L		L		M		M		I		L	

Table 12-5. Continued.

Watershed	Translocation		Disease		Small Population Size		Lack of Awareness		Climate Change	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
North Umpqua	1	1	U	U	U	U	4	2	3	2
South Umpqua	1	1	U	U	U	U	4	2	3	2
Umpqua	1	1	U	U	U	U	4	2	3	2
Coos	1	1	U	U	U	U	4	2	3	2
Coquille	1	1	U	U	U	U	4	2	3	2
Sixes	1	1	U	U	U	U	4	2	3	2
Upper Rogue	1	1	U	U	U	U	4	2	3	2
Middle Rogue	1	1	U	U	U	U	4	2	3	2
Applegate	1	1	U	U	U	U	4	2	3	2
Lower Rogue	1	1	U	U	U	U	4	2	3	2
Illinois	1	1	U	U	U	U	4	2	3	2
Mean Rank	1.00	1.00					4.00	2.00	3.00	2.00
	I	I					H	L	M	L
Mean Scope & Severity	1.00						3.00		2.5	
Drainage Rank	I						M		M	

Suites of Actions to Address Limiting Factors and Threats

Ongoing Conservation Measures

- A number of habitat restoration projects.
- Coastal Coho recovery plan – for recovery actions.
- Passage improvements for salmonids – culvert replacement.
- Watershed Councils - watershed assessment limiting factors analysis.
- Water quality standards, and plans to meet aquatic criteria.
- ODFW putting together Chinook Salmon and Steelhead conservation plans and actions.

Needed Actions

- More survey for Pacific Lamprey abundance and distribution.
- Evaluate water quality impacts to areas for ammocoete rearing habitats.
- Continue to work on water quality improvements and identify specific lamprey concerns.
- Work on identifying additional studies to evaluate specific adult, egg/incubation, and juvenile life stage temperature tolerance criteria/guidelines.
- Identify areas where potential passage problems exist for adult lamprey in each basin relative to the potential distribution of lamprey in a basin.
- Provide passage criteria for culvert replacement that will also benefit lamprey.
- Develop and provide guidance for ramping rates or salvage operations for protecting ammocoetes for instream projects, channel and dam maintenance.
- Develop guidance for suction dredging and gravel mining operations for protecting ammocoetes.

Research, Monitoring and Evaluation Needs

Critical Uncertainties

- Identification (ID) workshop for field crews.
- Compile information on lamprey ID methods and results.
- Develop methodologies to enumerate adult lamprey through various approaches, such as weirs, mark-recapture, redd surveys.
- Develop methods and sampling design to determine distribution of lamprey in basin – these methods should be standardized across basins on the Oregon coast.
- Evaluate ocean phase of Pacific Lamprey: estuary transition, migration, host preferences (dedicated effort to document lamprey scars in fish catch sampling), and survival rates.
- Trawl sampling program to determine macrophthalmia/early adult timing in estuary and near shore environment.
- Use life-cycle monitoring to tag macrophthalmia for evaluating run timing.
- Develop tags for juvenile lamprey that can be detected through adult phase.
- Potentially do experimental work on passage route/efficiency at review of screening issues to identify areas where impacts are likely.
- Access compiled data/anecdotal information on lamprey occurrences from the tribes.

- Evaluate mainstem water temperatures, adult and macrophthalmia run timing and temperature tolerances.
- Possible efforts to sample in likely habitat
 - Identify temperature tolerances of ammocoetes to identify areas to sample
 - Look at gradient maps to identify sampling areas in basin
- Evaluate Pacific Lamprey population structure analysis using polymorphic microsatellite loci
 - Develop and optimize markers for polymorphic microsatellite loci
 - Evaluate Pacific Lamprey population structure using these microsatellite markers

Effectiveness Monitoring

- Evaluate effectiveness of passage criteria for lamprey passage through culvert modification.
- Evaluate ramping rates for protecting ammocoetes during dewatering maintenance periods.
- Develop and implement an approach to track lamprey population status and associated monitoring needs.

Many of the recommendations of the Columbia River Basin Lamprey Technical Workgroup apply to Coastal Oregon – Columbia Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lamprey (2005) See Appendix C.

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13. CALIFORNIA REGION

The information collected in California is incomplete at the 4th field HUC and future work will be focused on completing this section. We attempted to summarize the initial draft risk assessment results for the California Region. We believe it is instructive to include the initial results of the NatureServe risk assessment at the approximately 3rd field HUC level to help guide the future data collection and risk assessments, although this information is subject to change before it is finalized. Citation of this information should be postponed to the release of the completed section anticipated to be in winter 2012.

The California Region is comprised of the Northern California and the Southern California/Sacramento/San Joaquin Sub-Regions (Figures 13-1 and 13-2).

Results

Historic Range Extent.—Most HUCs in the California Region were categorized as having a historical range extent of 2,500 –10,000 km². However, the scale at which the information was collected was at a larger order HUC (3rd) than in other regions (4th). The uncertainty associated with determining historic range extent was high in most HUCs because of the paucity of surveys, fishing records, and dam counts for Pacific Lamprey. In most cases, the uncertainty was categorized as “best professional judgment” based on expansion of data for other species (e.g., anadromous salmonids).

Current Occupancy.—Current occupancy, or distribution, primarily ranged from 0-51,000 km². Current occupancy in the North Coast was primarily 500-51,000 km², Central and South of Pt. Conception, Sacramento, and San Joaquin watersheds had a similar range of occupancy 0-51,800 km². Regarding uncertainty, the current occupancy data was most often categorized as largely undocumented but based on population genetic surveys (Goodman et al. 2008), extent of habitat, lamprey nests encountered during salmonid redd surveys, suspected barriers and/or anecdotal information.

Ratio of Current Occupancy to Historic Range Extent.—The ratio of current occupancy to historic range extent was between 0.05-0.5 in most watersheds in the California Region. Overall current occupancy ranged from >1% to 99% of historic range extent. The North Coast of California exhibited generally a much higher ratio (0.25– 0.5) than in the South of Pt. Conception, Sacramento, and San Joaquin watersheds (0.001-0.05).

Population Size.—Population size, defined as the number of adults, ranged from 0 to a range of 2,500-10,000. The North Coast had the highest population levels between 1,000-10,000 adult lampreys. The South of Pt. Conception, Sacramento, and San Joaquin watersheds abundance range was much lower, between 0 – 1,000. Uncertainty for population size is considerably greater for a larger number of watersheds than in other regions, primarily ranging from best professional judgment based on expansion of data for other species to unknown.

Short Term Trend.—Short term trend was defined as the percentage of decline in the population over the last three generations or approximately 27 years. The California Region decline ranged from >70% to as low as 10-30%. On average the South of Pt. Conception, Sacramento, and San Joaquin watersheds exhibited steeper declines between <70% to 50%. The uncertainty associated with short term trend is the same as current occupancy and population size.

Threats.—The threats that were identified most often in the California region watersheds are stream and floodplain degradation, water quality, dewatering and flow management, and tributary passage. Each HUC along the California Coast had a threat that was ranked moderate in scope and severity, with the exception of the Smith that exhibited lower levels of threats. The threats in the South of Pt. Conception, Sacramento, and San Joaquin watersheds were consistently ranked high in both scope and severity. The ranks in this Southern portion of the region are primarily related to threats from urbanization and agricultural impacts.

Risk Assessment.—For the California Region lamprey populations that inhabit approximately 3rd order HUC watersheds, calculated risk from the sub national NatureServe procedure (Master et al. 2009) primarily exhibited a narrow range. The California region risk categories ranged from SH to S4 for the 10 HUCs inhabited by Pacific lamprey. The majority of the HUCs were estimated to be at a S1 & S2 risk level (8 out of 10). This means that a majority of the HUCs fall into a relatively high risk category, which is because of rarity due to very restricted range, few occurrences, steep declines, or other factors making it vulnerable to extirpation from the HUCs. The highest risk level for the California region was South of Pt. Conception watershed (at SH) and the lowest risk was in the Smith (18010101) HUC at S4. In the northern portion of the California region the risk categories were estimated in a range between S4 and S1. The southern portion of the California Region showed narrower range of risk.

Several critical steps are needed to complete this section of the Conservation Assessment. Stakeholder input is the primary source for drainage-specific information and risk assessment analyses that form the core of this project. Promotion of communication and collaboration among stakeholders is also a primary objective of the PLCI. We plan to review and update the current stakeholder database to be as inclusive as possible.

In addition, we will collect additional current and historical distributional information in California. Distributional information, both historical and current, is essential for assessing the status of Pacific Lamprey, extent of historic range loss and potential for range expansion into currently unoccupied drainages or habitat. The development of a rangewide map of historical and current distribution is a primary objective of the Pacific Lamprey Conservation Assessment. We will accomplish this objective with a review of the appropriate regional and national museum collections for vouchered locality data. We will also identify the lowest impassable barriers (natural or artificial) in each HUC in order to identify the maximum upstream extent of potential habitat (historic and current). This information will then be processed into ArcGIS shapefile format suitable for incorporation into the rangewide Conservation Initiative dataset.

Standardized questionnaires and risk assessment spreadsheets form the basis for the NatureServe status assessment (see Methods) to be used in the California regional and rangewide plan sections. This data is not yet completed for California and is necessary to meet the objectives of

the Conservation Initiative. We will review available stakeholder questionnaires and information developed in 2009 stakeholder work sessions to identify missing or incomplete information fields. We will contact stakeholders for drainages with missing information and complete. We will produce the initial draft of questionnaire and risk assessment spreadsheet for each HUC and which will be provided to stakeholders for review. Stakeholder comments will then be incorporated into the analyses and local work sessions will be held if necessary to resolve substantial disagreement. This process will result in a revised questionnaire and risk assessment for each drainage grouping.

This dataset will be summarized and processed into the California chapter of the Conservation Initiative. In addition, the range wide section of the Conservation Initiative will be updated with the additional California information. This document will then be sent out for review by stakeholders. Stakeholder comments will be incorporated into the document and the Conservation Assessment finalized in winter 2012 with the California Region.

However, despite the shortcomings of the initial NatureServe assessment (described above) for the California Region, we have summarized the findings to date. Historic distribution for Pacific Lamprey was difficult to determine in many areas. There is a lack of fishing records, except from historical tribal fisheries, and count data at dams are mostly unavailable historically. As a surrogate for historical range extent Coho Salmon and Steelhead distribution was used in many HUCs in the California Region. Because Coho salmon and Steelhead use similar habitat for spawning it was determined that Pacific Lamprey probably occurred in these areas historically as well. The range extent of Pacific Lamprey may be even larger than Coho Salmon and Steelhead distribution as they are able to scale some natural barriers therefore this may be a conservative estimate. In watersheds where Coho Salmon and Steelhead distribution was considered a viable surrogate the uncertainty of the historic range extent is still high.

Current occupancy was also difficult to determine because very few lamprey targeted surveys have been completed. Often lamprey occurrence data is collected incidentally during salmonid surveys and as such identification by species is not made or is made by untrained surveyors. Furthermore, ammocoetes under 60 mm are nearly unidentifiable to species (Goodman 2009). Few watersheds have had thorough lamprey surveys and in those areas the certainty of the current occupancy data is much higher

Because the uncertainty remains high for both historic and current distribution in many of the California Region watersheds, the ratio of current to historic was added to the NatureServe risk assessment as an equally weighted factor. The percentage of historic range extent was low in most watersheds and decreases as you move from north to south watersheds. Additionally, population size decreases and short term trend declines increase as you move south, but the uncertainty for these categories is greater in the Southern portion of the California Region. It is in the southern watersheds that the threats combine with population attributes to create serious impacts, which yield the predominantly critically imperiled status for Pacific Lamprey. The threats in the South of Pt. Conception, Sacramento, and San Joaquin watersheds were consistently ranked high in both scope and severity. The ranks in this Southern portion of the region are primarily related to threats from urbanization and agricultural impacts.

Based on this preliminary assessment for the larger geographic groupings, Pacific Lamprey are at risk throughout the California Region. Summarizing the risk level for the California Region watersheds, it appears that the majority are at relatively high risk with only one HUC showing a lower risk level at Secure. Given that the predominant expression of risk is high and with little opportunity for healthy watersheds to provide a rescue effect, the risk status for this region should be viewed with concern. In terms of connectivity among watersheds, it is typical that the lower portions of these watersheds are impacted by urbanization or agricultural practices and, in addition there are considerable ocean distances between river mouths and to the spawning grounds. Lastly, the scope or severity of threats is either high or moderate for all the watersheds in the California Region except the Smith River.

Approach for Completing California Chapter

Conservation planning has been initiated in California using similar methods applied in Washington, Oregon and Idaho. The conservation planning process is not yet completed in California and this section is a status update of conservation planning in the state. The objectives of this section include:

- 1) A summary of conservation planning applied in California to date,
- 2) A description of additional information and work needed to complete the plan for California,
- 3) A plan for completion of the California component of the Pacific Lamprey Conservation Initiative (Conservation Initiative).

Conservation planning in California was tailored to maximize efficiency of information collection while accomplishing the goals of the PLCI. To accomplish this, we collected information on a more coarse resolution than other areas. Rather than HUC specific sections, we created drainage groupings to conduct conservation analyses. To create the drainage groupings, first we identified HUCs that have potential for current or historical Pacific lamprey populations. We then combined HUCs within larger drainages such as the Klamath, Eel, Sacramento/San Joaquin, etc. We separated several major tributaries within these drainages such as the Sacramento River from the San Joaquin River and the Trinity River from the Klamath River to facilitate more detailed data collection in these areas. Smaller coastal drainages were combined into coastal groupings. Separation between coastal drainage groupings was created by a variety of factors including major geographical features (Cape Mendocino and Point Conception) and major drainages (Klamath and Eel River drainages). The resulting 10 drainage groupings created the foundation for the subsequent conservation analyses.

Due to time constraints at the regional meetings, we were unable to collect a complete set of information for the Assessment, with information missing for all drainages and no information collected for the Humboldt Bay, Mad River, Redwood Creek, and Smith River drainages. Participants in the meeting that covered Cape Mendocino to Baja California, Mexico recommended revising the regional drainage groupings for a higher resolution analysis.

Based on the results from the regional meetings, it was recognized that supplementation of information collected at the regional meetings was necessary to meet the objectives of the Conservation Initiative in California. Additional data collection is needed to review and update

stakeholder lists, assemble available data for historical and current distribution, complete regional drainage grouping questionnaires, and incorporate this information into the rangewide assessment. To accomplish the additional work needed to complete the California chapter of the Conservation Initiative, it was deemed necessary to delay the completion of this chapter until 2012. We anticipate the updated Conservation Assessment (that includes the California chapter, and an update of the range wide risk assessment), will occur in the winter of 2012.



Figure 13-1. Map of watersheds within the Northern California Sub-Region.

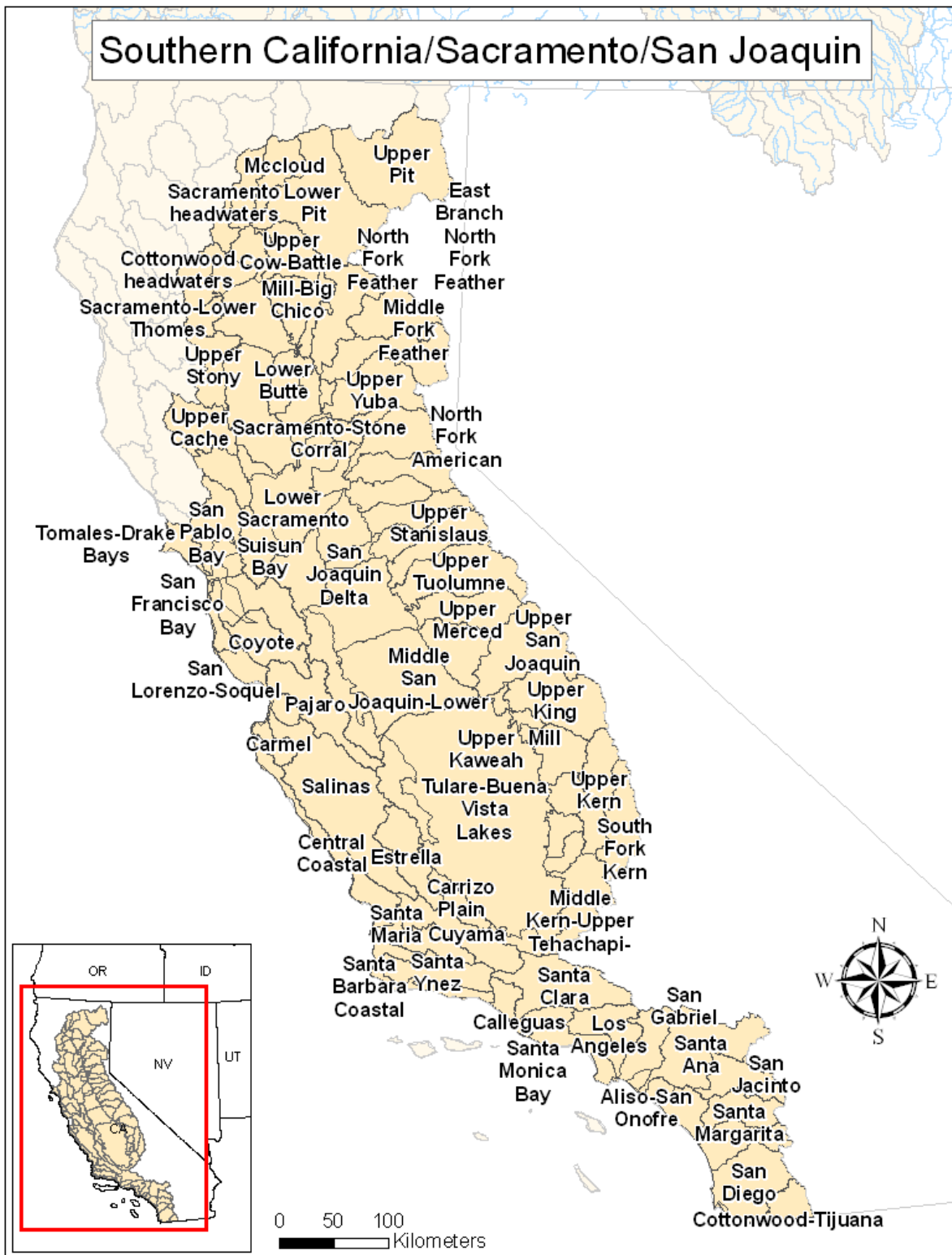
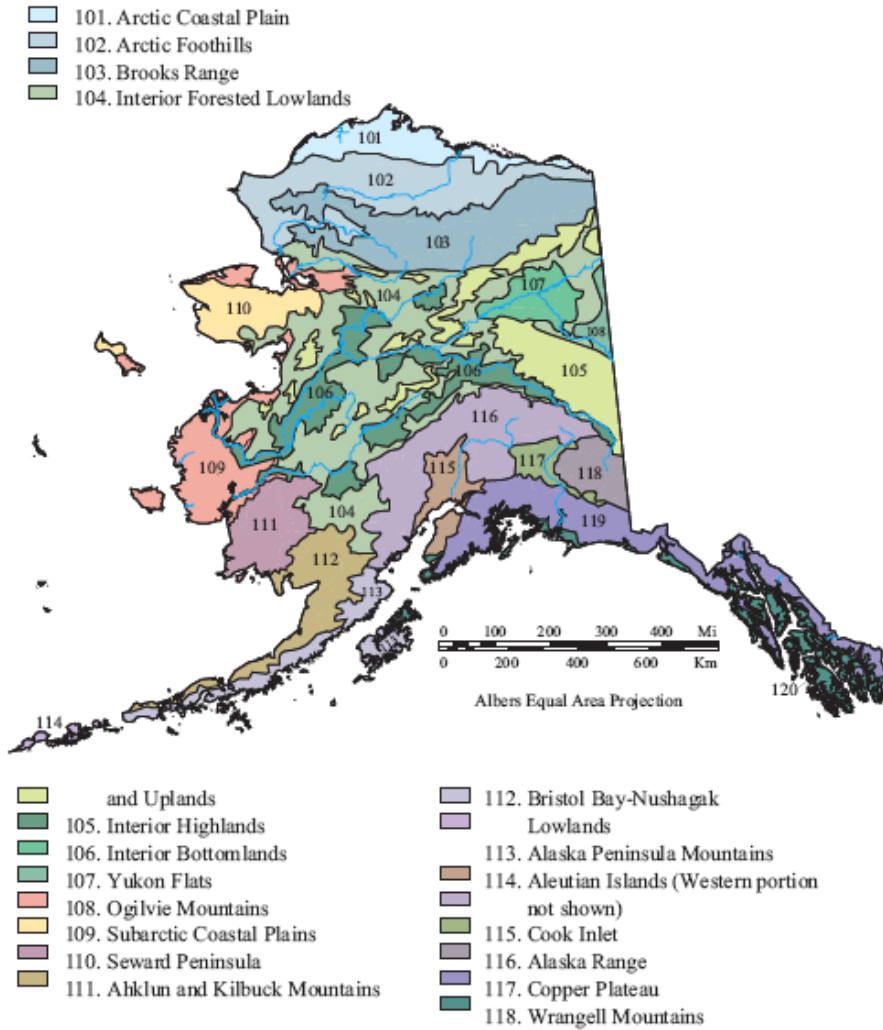


Figure 13-2. Map of watersheds within the Southern California/Sacramento/San Joaquin Sub-Region.

14. ALASKA REGION

Geographic Description of the Region

The Alaska Region within the boundaries of the Pacific Lamprey Conservation Assessment is comprised of 18 Level III Ecoregions described by the Environmental Protection Agency (EPA) (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm) (Figure 14-1). Descriptions of each ecoregion (Gallant et al. 1995) are in Appendix A.



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Figure 14-1. Level III Ecoregions of Alaska.

Population Status and Threats for Pacific Lamprey in Alaska

Regional Meetings were not held in Alaska. However, Team members R.D. Nelle and Bianca Streif co-chaired a Pacific Lamprey session, which was very well attended, at the 2009 Alaska Chapter of American Fisheries Society Meeting in Fairbanks, Alaska on November 2, 2009. Four talks concerning lampreys were presented including a presentation on the USFWS Pacific Lamprey Conservation Initiative and Plan. During the meeting a booth was setup to collect information about lampreys in Alaska from participants. Primarily names of individuals known to have observed lamprey in Alaska were collected.

Additionally, R.D. and Bianca met with staff from of the USFWS Fairbanks Fish and Wildlife Office Branch in Fairbanks to discuss information on lampreys of Alaska. Branch Chief Jeff Adams and Fish Biologists Randy Brown and David Daum discussed lamprey distribution, known harvest sites and general life history information concerning lampreys in Alaska. There is a recently developed winter commercial/subsistence fishery for Arctic Lamprey on the Yukon River. The lamprey run occurs during November and December. This short migration was monitored using DIDSON technology by ADFG. The ADFG Sport Fish Division in Fairbanks conducts a small educational outreach juvenile lamprey project identifying habitat and distribution of juvenile lamprey in the lower Chena River. The University of Alaska, School of Fisheries and Ocean Sciences staff also have a small lamprey project in the Interior in an effort to understanding lamprey distribution. Andree Lopez, Assistant Professor University of Alaska at Fairbanks and Curator of Fishes at the Museum of the North was noted as a point of contact for specimens collected in Alaska.

The State of Alaska has six species of lampreys (ADFG 2006) but little research has been done so their distribution and status are unknown. The Alaska State Comprehensive Wildlife Strategy (ADFG 2006) outlines the species, suspected distribution, general concerns, habitat concerns, conservation goals and objectives, and plan for monitoring the species and habitats. A subsistence harvest occurs on Arctic Lamprey

Following are key excerpts from Appendix 4, pages 91-98 of Alaska's Comprehensive State Wildlife Strategy (ADFG 2006) which concern Alaska lamprey:

Distribution and Abundance

Pacific Lamprey drainages extend up to at least the Bering Sea with records into the lower Yukon/Kuskowim. Found in coastal rivers from the Bering Sea near Nome through Southeast Alaska. Known freshwater occurrences include Wood River (Bristol Bay), small streams of Unalaska Island, Moose River (Kenai Peninsula), Copper and Tazlina rivers (Prince William Sound), Naha River (Yes Bay) and from several locations in southeast (Mecklenburg et al. 2002). Other systems on the Kenai Peninsula (Lower Cook Inlet) known to support lamprey include Crooked Creek, Slikok Creek and Soldotna Creek. Several creeks in Upper Cook Inlet support lamprey, including Fish Creek (Big Lake watershed), Rainbow Lake (Meadow Lakes/Wasilla), Trapper Creek (near Talkeetna), and the Chuitna River (westside of Upper Cook Inlet) and many others. The Fairbanks area streams also support lamprey including the

Chena and Salcha Rivers (B. McCracken USFWS, personal communication). Their abundance is unknown, but they are often found in Alaska at some local abundance. The State trend is unknown.

(http://aknhp.uaa.alaska.edu/zoology/species_ADFG/ADFG_PDFs/Fishes/Pacific_lamprey_ADFG_web_060105.pdf).

Problems, Issues, or Concerns for Species Group

- There is a paucity of information about lamprey species and their habitats in Alaska.
- Lack of basic information on topics such as abundance, age structure, diet, trophic ecology, homing/migration, species identification, range, instream flow/water volume and habitat needs.
- The systematics of Alaska's diverse lamprey species is difficult to determine.
- Alaska possibly has many populations with rare or unique life-history characteristics.
- Serious lamprey conservation/management issues exist elsewhere; extent and nature of issues to be expected in Alaska are unknown.
 - Arctic Lamprey are utilized as a food fish in the lower Kuskokwim and Yukon rivers and possibly elsewhere in Alaska.
 - Subsistence harvest locations, levels, species, etc., are poorly documented or unknown.
 - An emerging commercial fishery for Arctic Lamprey is possible in Yukon River watershed, with unknown impacts.
 - Lamprey are possibly an important forage fish for species of conservation concern.
 - Lamprey eggs and ammocetes are known prey species for rainbow trout, sheefish, and burbot.
 - Anadromous lampreys appear to have similar life history and habitat needs to salmonids; it is unknown whether factors causing decline of salmon stocks also cause declines in lamprey populations within the same drainages.

Location and Condition of Key or Important Habitat Areas

Key important habitat areas are largely undescribed and unknown in Alaska; lampreys may occur in other habitat types than listed for salmonids or other lamprey species. Observations of Alaskan brook lamprey document them using habitats that are not used by salmon, and they are often found in headwater areas in Bristol Bay.

Lampreys seem to have similar habitat requirements as salmon, and concerns about habitat destruction and degradation include effects originating instream (channelization, instream flow/water volume alteration, temperature, impoundment, passage, sedimentation) and those influences originating from outside the stream (pollution, riparian zone loss, ocean (or lake) conditions, and climate change)

Alaska's Goals and Objectives for Their Lamprey Populations

Goal.—To conserve and manage populations of Alaska lamprey species throughout their natural range to ensure sustainable use of these resources.

Objectives.—Maintain species distribution, population abundance, and life history variability indicative of viable lamprey species complexes throughout their native habitats in Alaska.

Targets.—

1. Identify the distribution of lamprey species in Alaska through literature review and surveys for ammocoetes in potential habitat.
2. Lamprey ammocoetes are present in at least 90% of identified index areas, presence to be determined.
3. Density of ammocoetes is within natural variability in at least 90% of selected lamprey rearing areas, measured by density of ammocoetes annually over a 10-year period in selected index areas.

Issues and Conservation Actions.—

1. Difficult to identify species.
 - a. Develop criteria and an approach for identification of ammocoetes and adult lampreys.
2. Unknown distribution of lamprey.
 - a. Document freshwater distribution of the various species of lampreys in Alaska by sampling for ammocoetes and adults in a representative selection of drainages.
 - b. Develop sampling protocols and implement sampling schedule across geographic range in Alaska.
 - c. Identify representative index areas.
 - d. Identify and describe the habitat types or categories used by various species and their life forms; develop and conduct sampling in rearing areas for ammocoetes to document distribution.
 - e. Develop sampling techniques and document the migration and movement patterns of different species and life stages.
 - f. Develop a network of biologists/organizations to establish unified protocols, share data, leverage sampling efforts, and provide voucher specimens to museums.
3. Habitat alteration, sufficient instream flow/water volume, fish passage and sedimentation are potential concerns.
 - a. Determine instream flow/water volume needs and habitat requirements for all life history phases of lampreys.
 - b. Consider lamprey species when there are issues of fish passage and habitat alteration (e.g., water diversions, dams, timber harvest, mining, sedimentation).
 - c. Develop a coordinated effort among government and nongovernment agencies to coalesce and exchange information on the habitat and instream flow/water volume needs of lampreys.
4. Lampreys are utilized as a food fish; harvest levels are not monitored.
 - a. Obtain local information and knowledge on local lamprey distribution, relative abundance, and harvest.

- b. Develop sampling protocol to monitor locations, timing, magnitude and catch per unit effort of harvest.
- c. Involve communities in monitoring, and share information.
- d. Train local communities to monitor abundance and harvest effort.
- 5. Emerging commercial fishery for lamprey on the Yukon River with a lack of assessment
 - a. Document the number and magnitude of the commercial fisheries for lampreys that are occurring in the state; collect biological samples of lampreys (e.g., size, sex ratio, and if possible species, age structure).
- 6. Lampreys may be important forage fish for various freshwater and marine predators, some of which have been identified in this Strategy as species of conservation concern.
 - a. Determine the trophic ecology of lampreys.

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16. APPENDICES

Appendix A. Calculating Overall Status Scores in NatureServe (from NatureServe 2009)

The progression of tasks automatically performed by the rank calculator to generate a calculated rank score is:

1. Rules for the use of factors (e.g., range extent, short term trend) are applied to status factors that have assigned ratings.
2. Rules for minimum required factors are applied (either two rarity factors or 1 rarity and 1 trend or threat).
3. Conditions for automatic status rank assignment are applied to the assigned ratings. If a rarity factor has a U, the conservation status rank is SU; if a rarity factor has an X, the conservation status is SX; if a rarity factor has a Z, the conservation status is SH.
4. A specific point value is assigned by the calculator for each factor rating value.
5. A prescribed weight is applied by the calculator to each individual factor.
6. Three sub-scores are calculated based on the points and weightings assigned to the factors contained within each category.
7. A specific weight is assigned to each factor category and, with the category sub-scores, used to compute an overall calculated status score.

The rank calculator automatically translates calculated scores to the appropriate conservation status ranks according to the value ranges and rank equivalencies shown in Table 9 (from NatureServe 2009).

Table 9. Score Value Ranges for NatureServe Conservation Status Ranks

Value Range for Calculated Score	Calculated Status Rank	Status Description
score containing U (unknown)	SU	Status rank is unknown
score containing X (extirpated)	SX	Presumed extirpated
score containing Z (zero)	SH	Possibly extirpated
score ≤ 1.5	S1	Critically imperiled
$1.5 < \text{score} \leq 2.5$	S2	Imperiled
$2.5 < \text{score} \leq 3.5$	S3	Vulnerable
$3.5 < \text{score} \leq 4.5$	S4	Apparently secure
score > 4.5	S5	Secure

Appendix B. Descriptions of the Level III EcoRegions within the Geographical Range Covered by the Pacific Lamprey Conservation Assessment

Idaho, Washington, and Oregon

Blue Mountains

The Blue Mountains are distinguished from the neighboring Cascades and Northern Rockies ecoregions by their lower height and more open landscape. The region is mostly volcanic in origin. Carved by two rivers, this dramatic landscape includes steep, deep hillsides, bluffs, and sheer rimrock faces. Land uses include grazing, logging, recreation, and wildlife habitat. On the plateau, the upland soils are fertile, owing to a generous covering of volcanic ash and windblown silts. Vegetation is mixed, forests dominated by Douglas-fir, ponderosa pine, and lodgepole pine, with shrublands and grasslands with bluebunch wheatgrass, Sandberg's bluegrass and other species adapted to grow in hot, dry conditions in lower elevations. Coniferous forests dominate much of the Blue Mountains. Vegetation changes dramatically as hillsides plunge toward river bottoms. In the higher canyons, shrublands can be found. At lower elevations grasslands are common. Much of the grasslands and shrub-steppe have been displaced by agricultural operations. Along the river valleys, precipitation ranges from 23–46 cm (9–18 in) annually, while in the nearby mountains it can reach more than 254 cm (100 in) a year. Elevation ranges from 366–3,018 m (1,200–9,900 ft) (Washington Biodiversity Project www.biodiversity.wa.gov/ecoregions/blue_mts/blue_mts.html)

Cascades

This mountainous ecoregion is underlain by Cenozoic volcanics and has been affected by alpine glaciations. It is characterized by steep ridges and river valleys in the west, a high plateau in the east, and both active and dormant volcanoes. Elevations range from 244 m upwards to 4,392 m at Mount Rainier. Its moist, temperate climate supports an extensive and highly productive coniferous forest. At the lower elevations the forests consist of western hemlock, western red cedar, Douglas-fir, grand fir, white fir, Pacific silver fir, some Shasta red fir, and mountain hemlock. Herbaceous and shrubby subalpine meadow vegetation; mountain hemlock, ponderosa pine, and subalpine fir stands occur at high elevations. Land use is mainly forestry and recreation, followed by pastureland and grazing. Mean annual precipitation varies by elevation, ranging between 114 and 356 cm (45–140 in) over the ecoregion.

Coast Range

The Coast Range consists of Coastal Lowlands, Coastal Uplands, and Volcanics sub-ecoregions. Elevation of this ecoregion ranges from sea level to 1,737 m (5,700 ft). Mean precipitation ranges from 127 to over 500 cm (50–200 in) per year. In the western portion of this region, the Coast Range low mountains are covered by highly productive, rain-drenched coniferous forests. Sitka spruce and coastal redwood forests originally dominated the fog-shrouded coast, while a mosaic of western red cedar, western hemlock, and seral Douglas-fir blanketed inland areas. Today Douglas-fir plantations are prevalent on the intensively logged and managed landscape, with western hemlock, Sitka spruce, western red cedar forests, red alder, Pacific silver fir, big leaf maple, and wetlands also found. Land use is a mosaic of forestry, rural/urban residential development, pastureland, and recreation. The Coastal Lowlands encompass estuarine marshes,

freshwater lakes, black-water streams, marine terraces, and sand dune areas. Elevations range from sea level to 91 m (300 ft). Many of its wetlands have been converted into dairy pastures. The Coastal Uplands extend to an elevation of about 150 m (500 ft). The climate of the Uplands is marine-influenced with an extended winter rainy season, enough fog during the summer dry season to reduce vegetal moisture stress, and a lack of seasonal temperature extremes. The uplands roughly correspond with the historic distribution of Sitka spruce, of which the distribution has been greatly reduced by logging. The Volcanics portion of the Coastal Ecoregion varies in elevation from 300–1200 m (1000–4000 ft) and is disjunct. Columnar and pillow basalt outcrops occur. Its mountains may have been offshore seamounts engulfed by continental sediments about 200 million years ago. The basaltic substrate preserves relatively stable summer stream flows that still support spring Chinook Salmon and summer Steelhead. Its forests are intensively managed. The Mid-Coastal Sedimentary portion is commonly underlain by massive beds of siltstone and sandstone. Its dissected, forested mountains are more rugged than the rest of the ecoregion and are prone to mass movement when the vegetal cover is removed. Stream gradients and fluvial erosion rates can be high.

Columbia Plateau

Millions of years ago, vast lava flows covered this region in basalt. In more recent millennia, epic glacial floods carved away the deep rock. Layered atop that basaltic bedrock are wind-driven silts and volcanic ash from the Cascades. The Cascade Mountains cast a long rain shadow over the Columbia Plateau. Annual precipitation averages vary from 15 cm (6 in) along the Columbia River near Hanford Reach to 64 cm (25 in) in the Palouse Hills on the ecoregion's eastern edge. With its low elevations, and a moderating maritime effect, annual temperatures average 4–14 °C (40–57 °F), though extremes can range from subzero to over 38 °C (100 °F) degrees. The Columbia Plateau is an arid sagebrush steppe and grassland in the northwest, surrounded on all sides by moister, predominantly forested, mountainous ecological regions. Underlain by basalt up to two miles thick, in some places it is covered by loess soils that have been extensively cultivated for wheat, particularly in the eastern portions of the region where precipitation amounts are greater. Native grasses include Idaho fescue and bluebunch wheatgrass. Streams are perennial in mountainous areas, but in farmed areas they are frequently intermittent and highly erosive. Forests of ponderosa pine and Douglas-fir grow where the foothills of the Columbia Plateau meet the surrounding mountain ranges. Elevation ranges from 61–1,340 m (200–4,400 ft). (Washington Biodiversity Project www.biodiversity.wa.gov/ecoregions/blue_mts/blue_mts.html)

Eastern Cascade Slopes and Foothills

The East Cascades Ecoregion varies dramatically from its cool, moist border with the West Cascades Ecoregion to its dry eastern border where it meets sagebrush country. The Eastern Cascade Slopes and Foothills Ecoregion is in the rainshadow of the Cascade Mountains. Its climate exhibits greater temperature extremes and less precipitation than ecoregions to the west. Terrain ranges from forested uplands to marshes and agricultural fields at lower elevations. Open forests of ponderosa pine and some lodgepole pine distinguish this region from the higher ecoregions to the west where fir and hemlock forests are common, and the lower dryer ecoregions to the east where shrubs and grasslands are predominant. The vegetation is adapted to the prevailing dry continental climate and is highly susceptible to wildfire. Historically, creeping ground fires consumed accumulated fuel and devastating crown fires were less common

in dry forests. Volcanic cones and buttes are common in much of the region. Elevation ranges from 183– 2,530 m (600–8,300 ft). Mean annual precipitation ranges between 250 and 140 cm (10–55 in). Tourism, recreation, forestry, and agriculture support a diverse economy.

Idaho Batholith

The Idaho Batholith is a dissected, partially glaciated, mountainous plateau. Many perennial streams originate here and water quality can be high if basins are undisturbed. Deeply weathered, acidic, intrusive igneous rock is common and is far more extensive than in the Northern Rockies or the Middle Rockies. Soils are sensitive to disturbance especially when stabilizing vegetation is removed, and have limited fertility, contributing little nutrients to aquatic ecosystems. Streams are likely to suffer from increased loads of fine sediments after disturbance by humans. Nutrients once brought by robust anadromous fish runs have declined with the decline in runs. Land uses include logging, grazing, mining and recreation. Mining and related damage to aquatic habitat is widespread. Much of the area is in extensive wilderness, particularly in the Selway and Salmon River basins. Grand fir, Douglas-fir and, at higher elevations, Engelmann spruce, and subalpine fir occur; ponderosa pine, shrubs, and grasses grow in very deep canyons. Maritime influence lessens toward the south and is never as strong as in the Northern Rockies, so Pacific plant species are rare. Mean annual precipitation ranges from 20–150 cm (8–60 in).

Klamath Mountains

The Klamath Mountains Ecoregion contains wide ranges in elevation, topography and climate -- from the lush, rainy west to the dry, warmer interior valleys to cold, snowy mountains. The Klamath-Siskiyou region of southwest Oregon and northwest California is recognized internationally for its global biological significance and is considered a world “Centre of Plant Diversity” by the World Conservation Union. The Klamath Mountains Ecoregion has the second fastest-growing human population in Oregon behind the Willamette Valley. Much of the population growth is concentrated in valleys along the Interstate 5 corridor. Demands for choice building sites often coincide with good quality habitat.

Middle Rockies

The Middle Rockies lacks the strong maritime influence of the Northern Rockies. Elevations are higher than in adjacent ecoregions, surpassing 3,048 m (10,000 ft) in some areas. Vegetation includes Douglas-fir, subalpine fir, and Engelmann spruce forests and alpine areas; Pacific tree species are never dominant. Forests can be open and foothills are partly wooded or shrub- and grass-covered. Intermontane valleys are grass- and/or shrub-covered, including Mountain Big sagebrush and mountain brush and contain a mosaic of terrestrial and aquatic fauna that is distinct from the nearby mountains. Many mountain-fed, perennial streams occur and differentiate the intermontane valleys from the Northwestern Great Plains. Granitics and associated management problems are less extensive than in the Idaho Batholith. Recreation, logging, mining, and summer livestock grazing are common land uses. Mean annual precipitation ranges from 15–112 cm (6–44 in).

Northern Basin and Range

In the rain shadow of the Cascades Mountains, the Northern Basin and Range is Oregon's driest ecoregion and marked by extreme ranges of daily and seasonal temperatures. Sagebrush communities dominate the landscape. Isolated mountain ranges have few forests or woodlands, with rare white fir stands. Aspen and mountain mahogany are more widespread. In the southern portion of the ecoregion, there are vast areas of desert shrubland, called salt-desert scrub, dominated by spiny, salt tolerant shrubs. Throughout the ecoregion, soils are typically rocky and thin, low in organic matter, and high in minerals. Elevation ranges from 762–2,956 m (2,500–9,700 ft). Precipitation ranges from 15–115 cm (6–45 in) per year. (ODFW www.dfw.state.or.us/conservationstrategy/document_pdf/b-eco_nb.pdf)

Northern Cascades

The terrain of the North Cascades is composed of high, rugged mountains. It contains the greatest concentration of active alpine glaciers in the conterminous United States and has a variety of climatic zones. A dry continental climate occurs in the east and mild, maritime, rainforest conditions are found in the west. It is underlain by sedimentary and metamorphic rock in contrast to the adjoining Cascades which are composed of volcanics. Natural vegetation consists of herbaceous and shrub alpine meadow vegetation, Pacific silver fir, mountain hemlock, western hemlock; some subalpine fir, alpine larch, lodgepole pine, and whitebark pine at high elevations. At lower elevations the native vegetation consists of western red cedar, Douglas-fir, big leaf maple, Pacific silver fir, and western hemlock. Land use is mainly forestry, followed by rural residential development, grazing, and recreation. Elevation ranges from 122–3,284 m (400–10,775 ft) and mean annual precipitation is 25–635 cm (10–250 in).

Northern Rockies

The high, rugged, mountainous Northern Rockies lie east of the Cascades. Despite its inland position, climate and vegetation are typically marine-influenced. Douglas fir, subalpine fir, Englemann spruce, and ponderosa pine and Pacific indicators such as western red cedar, western hemlock, and grand fir are common, and depending on elevation Idaho fescue, bluebunch wheatgrass, bluegrass, snowberry also occur. While not as high in elevation as the Canadian Rockies, alpine characteristics occur at highest elevations and include numerous glacial lakes. Logging, mining, farming and grazing are the main land use, and have caused stream water quality problems in the region. Natural stream fish assemblages have low diversity and seldom have more than four native species present which are adapted to cold water. Higher elevations can often have deep annual snowpack and a short growing season. Mean annual precipitation ranges from 30–200 cm (12–80 in).

Puget Lowland

The Puget Lowland Ecoregion occupies a continental glacial trough and is characterized by a mild maritime climate. It is composed of many islands, peninsulas, and bays in the Puget Sound area. Coniferous forest originally grew on the ecoregion's ground moraines, outwash plains, floodplains, and terraces. The distribution of forest species is affected by the rainshadow from the Olympic Mountains. Today, the natural vegetation consists of western hemlock, western red cedar, Douglas-fir, red alder, big leaf maple, black cottonwood, grasslands, some oak woodlands, and wetlands. Land use is a mosaic of pasture and cropland, dairy farming, rural/urban residential development, industrial development, forestry, and recreation. Elevation of this

ecoregion ranges from sea level to 816 m (2,677 ft). Mean annual precipitation ranges from 25 cm in the Olympic Mountain rainshadow to 178 cm (10-70 in).

Willamette Valley

Rolling prairies, deciduous/coniferous forests, and extensive wetlands characterized the pre-19th century landscape of this broad, lowland valley. The Willamette Valley is distinguished from the adjacent Coast Range and Cascades by lower precipitation, less relief, and a different mosaic of vegetation. Landforms consist of terraces and floodplains that are interlaced and surrounded by rolling hills. Productive soils and a temperate climate make it one of the most important agricultural areas in Oregon. Elevation ranges from 0–457 m (0–1500 ft). Precipitation ranges from 102–152 cm (40–60 in) per year.

Alaska

Arctic Coastal Plain

The northernmost ecoregion in the United States is bounded on the north and the west by the Arctic Ocean and stretches eastward nearly to the international boundary between Alaska and the Yukon Territory, Canada. The poorly drained treeless coastal plain rises very gradually from sea level to the adjacent foothills. The region has an arctic climate, and the entire area is underlain by thick permafrost. Because of poor soil drainage, wet graminoid herbaceous communities are the predominant vegetation cover, and numerous thaw lakes dot the region.

Arctic Foothills

This ecoregion consists of a wide swath of rolling hills and plateaus that grades from the coastal plain (101) on the north to the Brooks Range (103) on the south. The east-west extent of the ecoregion stretches from the international boundary between Alaska and the Yukon Territory, Canada, to the Chukchi Sea. The hills and valleys of the region have better defined drainage patterns than those found in the coastal plain to the north and have fewer lakes. The area is underlain by thick permafrost and many ice-related surface features are present. The region is predominantly treeless and is vegetated primarily by mesic graminoid herbaceous communities.

Brooks Range

This ecoregion consists of several groups of rugged, deeply dissected mountains carved from uplifted sedimentary rock. The region traverses much of the east-west extent of northern Alaska, from the Canadian border to within 100 km (62 mi) of the Chukchi Sea. Elevation of mountain peaks ranges from 800 m in the relatively low Baird Mountains in the west to 2,400 m in the central and eastern Brooks Range (2,624-7,874 ft). Pleistocene glaciation was extensive, and small glaciers persist at elevations above 1,800 m (5,905 ft). An arctic climatic regime and unstable hillslopes maintain a sparse cover of dwarf scrub vegetation throughout the mountains through some valleys provide more mesic sites for graminoid herbaceous communities.

Interior Forested Lowlands and Uplands

This ecoregion represents a patchwork of ecological characteristics. Region-wide unifying features include a lack of Pleistocene glaciation, a continental climate, a mantling of undifferentiated alluvium and slope deposits, a predominance of forests dominated by spruce and hardwood species, and a very high frequency of lightning fires. On this backdrop of

characteristics is superimposed a finer grained complex of vegetation communities resulting from the interplay of permafrost, surface water, fire, local elevational relief, and hillslope aspect.

Interior Highlands

This discontinuous ecoregion is composed of rounded, low mountains, often surmounted by rugged peaks. The highlands primarily sustain dwarf scrub vegetation and open spruce stands, though graminoid herbaceous communities occur in poorly drained areas. Mountains in most parts of this region rise to at least 1,200 m (3,937 ft), and many rise higher than 1,500 m (4,921 ft). Most of the higher peaks were glaciated during the Pleistocene.

Interior Bottomlands

This ecoregion is composed of flat to nearly flat bottomlands along larger rivers of interior Alaska. The bottomlands are dotted with thaw and oxbow lakes. Soils are poorly drained and shallow, often over permafrost. Predominant vegetation communities include forests dominated by spruce and hardwood species, tall scrub thickets, and wetlands.

Yukon Flats

The Yukon Flats is a relatively flat, marshy basin floor in east central Alaska that is patterned with braided and meandering streams, numerous thaw and oxbow lakes, and meander scars. Surrounding the basin floor is a variable band of more undulating topography with fewer water bodies. In many respects the ecoregion is similar to the Interior Bottomlands Ecoregion (106), but differs in climatic characteristics. Temperatures tend to be more extreme; summers are warmer and winters are colder than in other areas of comparable latitude. The ecoregion also receives less annual precipitation than the Interior Bottomlands. Forests dominated by spruce and hardwood species, tall scrub communities, and wet graminoid herbaceous communities are the predominant vegetation types.

Ogilvie Mountains

This ecoregion, along the eastern edge of Alaska, consists of flat-topped hills eroded from a former plain and broad pediment slopes built up from mountains that are much subdued from their former stature. Karst topography is common. Mesic graminoid herbaceous communities and tall scrub communities are widespread throughout the region. Forest communities occupy lower hillslopes and valleys.

Subarctic Coastal Plains

This ecoregion mainly includes coastal plains of the Kotzebue Sound area and the Yukon and Kuskokwim River delta area. Flat, lake-dotted coastal plains and river deltas are characteristic of the region. Streams have very wide and serpentine meanders. Soils are wet and the permafrost table is shallow, providing conditions for wet graminoid herbaceous communities, the predominant vegetation type. The region is affected by both marine and continental climatic influences.

Seward Peninsula

Some of the oldest geologic formations in Alaska provide a backdrop for this predominantly treeless ecoregion. Mesic graminoid herbaceous and low scrub communities occupy extensive areas. The ecoregion is surrounded on three sides by water, yet this has little ameliorating effect on the climate. Winters tend to be long and harsh and summers short and cool.

Ahklun and Kilbuck Mountains

Located in southwestern Alaska off Bristol and Kuskokwim Bays, this ecoregion is composed of steep, sharp, often ringlike groupings of rugged mountains separated by broad, flat valleys and lowlands. The mountains were glaciated during the Pleistocene epoch, but only a few small glaciers persist. Dwarf scrub communities are the predominant vegetation cover in the mountains. Tall scrub and graminoid herbaceous communities are common in valleys and on lower mountain slopes. Valley bottoms may support stands of spruce and hardwood species.

Bristol Bay-Nushagak Lowlands

This lowland ecoregion is located in southwestern Alaska off Bristol Bay. The region has rolling terrain, formed from morainal deposits. Soils of the lowlands are somewhat better drained than soils of the Subarctic Coastal Plains Ecoregion (109). Dwarf scrub communities are widespread, but large areas of wetland communities occur. Lakes are scattered throughout the lowlands, but are not nearly as numerous as in the Subarctic Coastal Plains.

Alaska Peninsula Mountains

This ecoregion is composed of rounded, folded and faulted sedimentary ridges intermittently surmounted by volcanoes. The mountains were heavily glaciated during the Pleistocene epoch. A marine climate prevails, and the region is generally free of permafrost. Many soils formed in deposits of volcanic ash and cinder over glacial deposits and are highly erodible. Vegetation cover commonly consists of dwarf scrub communities at higher elevations and on sites exposed to wind, and low scrub communities at lower elevations and in more protected sites.

Aleutian Islands

This ecoregion in southwestern Alaska is composed of a chain of sedimentary islands (eroded from older volcanic formations) that are crowned by steep volcanoes. Maritime climate prevails. The region is south of the winter sea ice pack and generally free from permafrost. Vegetation cover mainly consists of dwarf scrub communities at higher elevations and on sites exposed to wind, and of graminoid herbaceous communities in more protected sites.

Cook Inlet

Located in the south central part of Alaska adjacent to the Cook Inlet, the ecoregion has one of the mildest climates in the State. The climate, the level to rolling topography, and the coastal proximity have attracted most of the settlement and development in Alaska. The region has a variety of vegetation communities but is dominated by stands of spruce and hardwood species. The area is generally free from permafrost. Unlike many of the other nonmontane ecoregions, the Cook Inlet Ecoregion was intensely glaciated during the Pleistocene.

Alaska Range

The mountains of south central Alaska, the Alaska Range, are very high and steep. This ecoregion is covered by rocky slopes, icefields, and glaciers. Much of the area is barren of vegetation. Dwarf scrub communities are common at higher elevations and on windswept sites where vegetation does exist. The Alaska Range has a continental climatic regime, but because of the extreme height of many of the ridges and peaks, annual precipitation at higher elevations is similar to that measured for some ecoregions having maritime climate.

Copper Plateau

This ecoregion in south central Alaska occupies the site of a large lake that existed during glacial times. The nearly level to rolling plain has many lakes and wetlands. Soils are predominantly silty or clayey, formed from glaciolacustrine sediments. Much of the region has a shallow permafrost table, and soils are poorly drained. Black spruce forests and tall scrub, interspersed with wetlands, are the major types of vegetation communities.

Wrangell Mountains

This ecoregion consists of steep, rugged mountains of volcanic origin that are extensively covered by ice fields and glaciers. Most slopes are barren of vegetation. Dwarf scrub tundra communities, consisting of mats of low shrubs, forbs, grasses, and lichens, predominate where vegetation does occur. The climate has harsh winters and short summers.

Pacific Coastal Mountains

The steep and rugged mountains along the southeastern and south central coast of Alaska receive more precipitation annually than either the Alaska Range (116) or Wrangell Mountains (118) Ecoregions. Glaciated during the Pleistocene, most of the ecoregion is still covered by glaciers and ice fields. Most of the area is barren of vegetation, but where plants do occur, dwarf and low scrub communities dominate.

Coastal Western Hemlock-Sitka Spruce Forests

Located along the southeastern and south central shores of Alaska, the terrain of this ecoregion is a result of intense glaciation during late advances of the Pleistocene. The deep, narrow bays, steep valley walls that expose much bedrock, thin moraine deposits on hills and in valleys, very irregular coastline, high sea cliffs, and deeply dissected glacial moraine deposits covering the lower slopes of valley walls are all evidence of the effects of glaciation. The region has the mildest winter temperatures in Alaska, accompanied by large amounts of precipitation. Forests of western hemlock and Sitka spruce are widespread.

Appendix C. Summary of Lamprey Federal Caucus Focus Area: Past, ongoing, and planned projects and restoration measures.

December 14, 2009

Identify past, ongoing, and planned lamprey projects and restoration measures from the following groups:

- BPA Fish and Wildlife program
- 2008 Columbia River Fish Accord projects
- USACE projects and operations
- U.S. Fish and Wildlife Service projects
- USGS Science support projects
- Bureau of Reclamation
- U.S. Forest Service/ Bureau of Land Management

Projects by Agency:

A. Bonneville Power Administration Lamprey Projects

Existing (pre-Accord) –

Project ID: 199402600; CTUIR; Expanded under the LRT Fish Accord; currently funded for an average of \$500,000/year for 10 years. Annual Reports are available for 1994-2007¹¹

Title: Pacific Lamprey Research and Restoration Project

Abstract: The purpose of this study is to provide the critical information to restore Pacific lampreys *Lampetra tridentata* in the Umatilla River that is called for in the Draft Umatilla/Willow Subbasin Plan. Lamprey are a critical cultural resource for tribal members. Restoration of Umatilla lamprey populations will both provide harvest opportunities and will recover the ecosystem functions that lamprey provide. Pacific lampreys are vital components of intact ecosystems that have been affected directly and indirectly by dams, habitat deterioration, and possibly food web shifts in the ocean. Previous restoration efforts have proven that outplanting adult lamprey can result in successful adult reproduction and increased larval production. The next step in this project is to insure that outplanted lamprey will result in a self-sustaining population in the Umatilla Subbasin. In addition to increasing the abundance of larval lamprey in the subbasin, key components are to establish that more adult lamprey are now returning to the Umatilla Subbasin, and that they are able to reach historical spawning areas. Consequently the project objectives are: (1) estimate the numbers of adult lampreys entering the Umatilla River, (2) investigate the olfactory cues lamprey use to orient in the Umatilla Subbasin, (3) monitor passage success to spawning areas, (4) develop structures to improve passage success, 5) increase larval abundance in the Umatilla

¹¹ Many of the projects listed here have resulted in journal publications instead of or in addition to BPA Annual Reports. A complete list of citations could be compiled at some point, if necessary.

River by continuing to outplant adult lamprey, 6) monitor larval population trends in the Umatilla River by conducting electrofishing surveys, and 7) estimate the numbers of juvenile lampreys migrating out of the Umatilla River.

Project ID: 200201600; CTWSRO; Expanded under the LRT Fish Accord; currently funded for an average of \$172,000/year for 10 years. Annual Reports are available for 2002-2007.

Title: Evaluate the Status of Pacific Lamprey in the Lower Deschutes River Subbasin, Oregon

Abstract: Pacific lamprey (*Lampetra tridentata*) populations are declining throughout the Columbia River Basin (CRB). The reasons for the decline are poorly understood or unknown. Decreasing numbers of adult Pacific lamprey returning to traditional collection sites has resulted in reduced harvest opportunities for Confederated Tribes of Warm Springs (CTWSRO) tribal fishers. This project is a continuation of work funded by the BPA (Project 200201600) to determine the status and life history of lamprey in the Deschutes River Subbasin that began during 2002. The objectives presented are a logical continuation of research needed to answer basic biological questions about lamprey that will be applied towards the species' restoration in the Deschutes subbasin. The objectives of this project are to: (1) determine escapement and estimate the harvest of adult Pacific lamprey at Sherar's Falls; (2) determine Pacific lamprey spawn timing, over-wintering, and spawning habitat; (3) evaluate the use of redd caps to determine redd production; and (4) determine the range of water temperatures experienced by lamprey by monitoring water temperatures in perennial streams used by lamprey in the lower Deschutes Subbasin. Information gathered from this project will be used in conjunction with the results from two projects that are currently underway in the lower Deschutes Subbasin (USFWS TWG and PGE Contract No. TERM001368) to restore lamprey in the lower basin as well as possibly lead to re-introduction above the Pelton-Round Butte Hydroelectric projects.

Project ID: ?: Nez Perce Tribe

Title: Adult Pacific Lamprey Translocation Initiative

Description (from CRITFC Restoration Plan Appendix): The objective is to annually translocate up to 500 adult Pacific lamprey from the mainstem Columbia River to five or six Snake Basin tributaries. Assuming half of the fish are females, and an average fecundity of 50,000 eggs per female, the translocated lamprey would augment production in the Snake River tributaries by 12,500,000 eggs. This constitutes a significant increase in lamprey production in the Snake basin, especially in consideration of the extremely low counts adult lamprey passing Lower Granite Dam.

Ammocoete densities will be monitored to evaluate translocation and spawning success. These efforts will also provide benchmark monitoring data needed to track larval distributions and densities through their four to six year freshwater rearing cycle. Fixed monitoring sites employed during previous surveys would be employed (Hyatt et al. 2007). This will provide useful data to help evaluate the contribution of migrating juveniles, or

macrophthalmia, resulting from the translocation effort. In addition to the translocation initiative, tributary actions include presence/absence surveys and larval density trend monitoring at key locations within the major subbasins. Fixed monitoring sites will be identified for long-term trend monitoring. Incidental observations of larval and metamorphosed (macrophthalmia) juvenile lamprey made by non-project staff within the Nez Perce Department of Fisheries Resources management will also be documented. Incidental observations are most likely to occur from screw trap operations monitoring juvenile anadromous salmonids.

New Accord Projects

Project ID: 200852400; CRITFC; Funded for an average of \$575,000/year for 10 years.

Title: Tribal Pacific Lamprey Restoration Plan Implementation

Preliminary Abstract (project narrative is being revised following ISRP review):

This ten year project provides resources to finalize and implement objectives of the *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin* (CRITFC 2008). The objectives include improving adult and juvenile Pacific lamprey passage through mainstem and tributary blockages, providing information and actions to reduce uncertainties with respect to mainstem lamprey distribution and abundance, habitat quality, habitat utilization and genetic characteristics, and providing resources to implement a pilot lamprey safety net artificial production program. Resources from this project will also be directed toward overall regional lamprey coordination/collaboration including CRITFC member tribal lamprey projects, Corps of Engineers' Anadromous Fish Evaluation Program lamprey projects, CBFWA lamprey technical working group functions and the USFWS Pacific Lamprey Rangelwide Conservation Initiative. An outreach component described in the Tribal Plan is also included as a specific objective for the project.

The scope of the project includes the following subbasins as designated by the Northwest Power and Conservation Council' Fish and Wildlife Program: Willamette, Lower Snake, Upper Middle Columbia, Lower Middle Columbia, Lower Columbia, Mid-Columbia.

Project ID: 200830800; CTWSRO; Funded for an average of \$150,000/year for 10 years.

Title: Willamette Falls Lamprey Escapement Estimate

Objectives

Objective 1. Investigate the performance of a half-duplex PIT tag interrogator at the Sullivan Plant at Willamette Falls to detect PIT tagged Pacific lamprey for a population estimate.

Objective 2. Develop a protocol for long-term monitoring and index of abundance of adult Pacific lamprey at Willamette Falls.

Objective 3. Create a Willamette River Pacific Lamprey Working Group to coordinate research and monitoring activities and provide technical guidance.

The ISRP has reviewed the proposal for this project and finds that the project meets scientific criteria in part. ISRP finds Objective 3 to meet scientific criteria and a response is requested for Objectives 1 and 2. The ISRP review comments are recommendations and requests for further information. These concerns can be addressed in the response back to the ISRP, and in the additional detail that will be in the SOW. The CTWSRO is working on the response to the ISRP and hopes to have that done by ~ January, 2010. Contracting is expected to begin February 1, 2010.

Project ID: 200700700; CTWSRO; Funded for an average of \$234,000/year for 10 years.

Title: Determine the status and limiting factors of Pacific lamprey in the Fifteenmile Creek and Hood River Sub-basins, Oregon.

Abstract: The numbers of Pacific lamprey (*Lampetra tridentata*) are declining throughout the Columbia River Basin (CRB). While the reason(s) for the decline are unclear it has meant reduced harvest opportunities for members of the Confederated Tribes of Warm Springs Reservation, Oregon (CTWSRO) and other CRB tribes. Fifteenmile Creek is an important harvest location for CTWSRO tribal members. Little information is available about the status of Pacific lamprey in the Fifteenmile Subbasin. Determining Pacific lamprey status in Fifteenmile Cr. has been identified in the Fifteenmile Subbasin Plan as a key RM&E objective. The goal of this project is to determine the status and limiting factors of Pacific lamprey in Fifteenmile Subbasin by:

1. Determining larval and spawning distribution of Pacific lamprey within the Fifteenmile Subbasin;
2. Estimating adult escapement and tribal harvest near the mouth of Fifteenmile Creek;
3. Documenting larval out-migration timing; and
4. Identifying factors that may limit lamprey production within the Fifteenmile Subbasin.

Information obtained from this project will be used to develop a lamprey management plan for the Fifteenmile Subbasin as well as guide restoration activities for this species within the Columbia Basin. We are proposing to implement this project with assistance from basin co-managers including the Oregon Department of Fish and Wildlife (ODFW), United States Forest Service (USFS), and Wasco County Soil and Water Conservation District (SWCD).

Project ID: 200847000; YN; Funded for an average of \$250,000/year for 10 years.

Title: Yakama Nation Lamprey. (The LRT Accord included 3 YN lamprey projects that have been combined into 1. Budget titles of the original 3 projects were: Ammonoete densities; Lamprey presence/absence and other baseline in Upper Columbia and Yakima; Translocation and other data.

The proposal was submitted to the ISRP for review, and on March, 6, 2009 the ISRP provided a review (ISRP document 2009-5). The ISRP found that the proposal “Meets Scientific Review Criteria (In Part)”.

Abstract: The objective of this project is to restore natural production of Pacific lamprey to a level that will provide robust species abundance, significant ecologic contributions and meaningful harvest within the Yakama Nation Ceded Lands and in the Usual and Accustomed areas. The YN is proposing a phased approach to the implementation of this project. The first phase of the project is to collect and report critical information to evaluate status, relative abundance and distribution of Pacific Lamprey. The second phase will identify known and potential limiting factors for Pacific lamprey within Columbia River tributaries within the Yakama Nation Ceded Lands (YNCLs), and the third phase will develop and implement Pacific lamprey restoration actions and evaluate the effects of implemented actions. To accomplish this approach the YN have defined eight objectives.

1. Document historic distribution of adult lamprey from historical records, literature reviews and oral interviews and compare with known current distribution.
2. Participate in and contribute to regional consistency in data collection, data management, analysis and reporting.
3. Document current status of larval Pacific lamprey with presence/absence surveys to determine distribution of recruitment.
4. Document biologic condition, migration behaviors and environmental cues that trigger migration for both adult and juvenile Pacific lamprey.
5. Identify habitat characteristics that are preferred at various life stages and determine the extent these habitats are available and are being utilized (habitat mapping).
6. Identify and inventory all known and potential limiting factors, and current threats existing in tributary habitats. Develop and implement a Pacific Lamprey Action Plan for the following subbasins: Methow, Entiat, Wenatchee, Crab Creek, Yakama, Rock Creek, Klickitat, White Salmon, Wind, and Little White Salmon (including all perennial tributary streams to the Columbia River within the YNCLs).
7. To increase larval abundance in tributary streams, implement a pilot adult Pacific lamprey translocation program from main-stem Columbia River hydro-electric projects into various subbasins (to be determined) and evaluate methodology and potential biological benefits and risks of expanding this program as appropriate.
8. Evaluate the potential for and participate in the development of supplementation / artificial propagation techniques of Pacific lamprey.

The ISRP found the proposal to be technically justified and clearly linked to other regional programs and plans. They found that 4 of the objectives were scientifically supported (i.e., Obj. 1, 2, 4 and 5) and provided the following recommendations for the remaining four objectives.

- Objective 3 – document current status of larval Pacific lamprey with presence/absence surveys.
- Objective 6 – identification of “all known and potential” limiting factors – is a very large undertaking and should be described in greater detail, particularly with regard to the specific life history requirements of Pacific lamprey in the Yakima subbasin. Taking a full life-cycle approach, the major limiting factor may be either adult or ammocoete passage at mainstem Columbia River dams, so this really needs to be recognized and discussed more in Objective 6. The ISRP concludes that enough published data exist on

this species to scope a more strategic approach before beginning the extensive field work proposed.

- Objectives 7 and 8, which involve lamprey reintroductions and initiation of a supplementation program, can be phased in pending the outcome of the survey and limiting factor analysis.

On March 19, 2009 the Council received a submittal from the YN addressing the response that the ISRP requested. This was provided to the ISRP and on March 31, 2009 the ISRP provided their review (ISRP document 2009-9). The ISRP found that the response “Meets Scientific Review Criteria (Qualified)”.

Closed Projects

Project ID: 200001400; USFWS; Last contract ended 6/30/08

Title: Evaluate Habitat Use And Population Dynamics Of Lampreys In Cedar Creek. Annual Reports are available for 2000-2005.

Abstract: Pacific lampreys (*Lampetra tridentata*) in the Columbia River Basin (CRB) have declined to a remnant of their pre-1940s populations. The Northwest Power Planning Council’s (NPPC’s) Fish and Wildlife Program (NPPC 1994) noted this decline and requested a status report identifying research needs. This status report identified a need for information on lamprey abundance, current distribution, and habitat use. More recently, the NPPC (2000) identified a need for any information necessary to restore the characteristics of healthy lamprey populations. Much of what managers and policy makers in the Pacific Northwest envisions for lamprey is now contained throughout the 64 subbasin plans that have been developed or in documents produced by the Columbia River Basin Lamprey Technical Workgroup. Studying the biology, population dynamics, ecology, identification, as well as the relationships among sympatric species of lampreys (*L. ayresi*, and *L. richardsoni*) in the CRB will assist in rehabilitating Pacific lamprey populations. The U.S. Fish and Wildlife Service at the Columbia River Fisheries Program Office has been collecting baseline data including adult and larval abundance estimates, larval distribution and habitat requirements, immigration and emigration timing, and spawning habitat requirements for lamprey on Cedar Creek, Washington since 2000. To improve our understanding of the dynamic nature of lamprey in this watershed as well as to maintain a continuous time series of data, we are proposing to continue baseline assessments of lamprey in Cedar Creek. Throughout the CRB, increased rigor in quantitative assessments would improve management and conservation efforts associated with lamprey. Thus, we are also proposing to assess and improve standard sampling techniques and approaches that are used on lamprey.

Project ID: 200002800; IDFG; Last contract ended 6/30/08; Annual Reports are available for 2000-2006.

Title: Evaluate status of Pacific lamprey in Idaho.

Abstract: Pacific lamprey *Lampetra tridentata* is a native fish species of the Columbia River Basin extending into the Snake River subbasin in Idaho. This species faces the same hazards of upstream and downstream migration through the lower Snake and Columbia rivers hydroelectric facilities as other anadromous fish. Consequently the number of adult Pacific lamprey migrating into spawning areas in upstream locations has decreased dramatically during the last half century. The Pacific lamprey has been identified as a focal and important anadromous fish species in the Clearwater, Salmon, and Snake Hells Canyon Subbasin plans. The Northwest Power and Conservation Council Fish and Wildlife Program also identifies Pacific lamprey as a species requiring action. This ongoing BPA-funded project has been addressing status, relative abundance, and habitat utilization in Idaho since 2000. Through the project, we have determined present day distribution in most of the Clearwater River drainage, approximately 50% of the Salmon River drainage, and 10% of the mainstem Snake River between Lewiston, ID and Hells Canyon Dam. In addition we have documented required and desired habitat for larval and juvenile rearing and have determined relative abundance throughout a major portion of the present day Idaho range. Because larval (ammocoete) and juvenile (macrophthalmia) Pacific lamprey have extended freshwater rearing (up to seven years), we have focused on these life history phases to meet our objectives of describing status, distribution, and habitat utilization. Collecting the freshwater phases has been accomplished by electroshocking and rotary screen trapping techniques. Because populations of Pacific lamprey are disappearing in some of the streams surveyed, we have established a number (100) sites on which we will continue to monitor to determine trends in localized populations. The emphasis in coming years will be to complete distribution knowledge, add to habitat utilization data, and develop protocols for restoration of Pacific lamprey in Idaho. The work is conducted by the Idaho Department of Fish and Game with primary funding from the Bonneville Power Administration and additional funding from the Idaho Department of Fish and Game and the Bureau of Land Management.

Project ID: 200002900; USGS; Last contract ended 12/31/03

Title: Identification of Larval Pacific Lampreys, River Lampreys and Western Brook Lampreys and Thermal Requirements of Early Life History Stages of Lampreys.
Annual Reports are available for 1999 - 2004.

Abstract: The following project is a continuation of Bonneville Power Administration project number 2000-029-00 (Identification of larval Pacific lampreys (*Lampetra tridentata*), river lampreys (*L. ayresi*), and western brook lampreys (*L. richardsoni*) and thermal requirements of early life history stages of lampreys). This project has successfully characterized aspects of the thermal ecology of embryonic and larval stage Pacific and western brook lamprey, and has also provided information on the fine-scale morphology of embryonic and larval Pacific and western brook lampreys (Meeuwig et al. 2003). This work also provides rationale for development of molecular techniques suitable for discrimination

of closely related species of lampreys. Discrimination of larval lampreys based on morphology is tedious and requires special equipment not readily applicable to field situations. Therefore, molecular techniques, specifically those that are field applicable, may provide a more accurate and less technical method for species identification.

Alteration to the hydrologic regime of the Columbia River Basin (CRB) has been widespread. In an attempt to alleviate anthropogenic stress placed on the CRB, much work has been conducted to recover or stabilize aquatic systems. Conservation and recovery efforts within aquatic systems of the CRB have focused primarily on salmonids and other game fish; however, the ecological, economic, and cultural significance of lampreys within the CRB has been underestimated (Kan 1975; Close et al. 1995; NPPC 1995). Historically, Native American tribes used Pacific lampreys for sustenance, ceremonial, and medicinal purposes (Close et al. 1995). Lampreys also provide a food source for a variety of animals, both terrestrial and aquatic (Semakula and Larkin 1969; Jameson and Kenyon 1977; Beamish 1980; Close et al. 1995), and like semelparous salmonids, may provide a seasonally abundant source of nutrients to stream systems due to post spawning mortality (Close et al. 1995; Chaloner et al. 2002; Thomas et al. 2003). Currently, information concerning the basic biology of lampreys found within the CRB, including information on distribution, abundance, taxonomy, and ecology, is lacking. The current distribution and abundance of lampreys within the CRB is largely unknown. Anecdotal distribution data are abundant, as are observational data from dam passage; however, systematic inventories of lamprey distributions within the CRB are limited to a few projects encompassing small geographical areas (Close et al. 1995; Cochnauer and Claire 2001).

With increasing interest in the role of lampreys within the CRB (Kostow 2002), primary information gaps will need to be filled, including data on the distribution and abundance of lamprey species within the CRB. Documenting the distribution and relative abundance of lampreys in streams and rivers tributary to the Columbia River will help identify factors limiting lamprey populations, identify areas in need of rehabilitation, and help to assess the efficacy of management actions. Surveys of larval lampreys, which spend up to seven years in fluvial habitats (Hardisty and Potter 1971), may provide an effective means of determining distribution and abundance since larvae are readily collected from rearing areas by electrofishing. Comprehensive monitoring and assessment programs for CRB lampreys, which historically included the Pacific lamprey, the western brook lamprey, and the river lamprey (although the current presence of this species in the CRB is unknown), may depend on accurate techniques for identifying larval lampreys. However, our inability to positively identify larvae of different lamprey species limits the utility of sampling efforts directed towards larval lampreys. Identification of Pacific, western brook, and river lamprey larvae is not resolved and pigmentation patterns currently used to differentiate species (Richards et al. 1982) may be geographically variable and have proven to not be diagnostic (USGS unpublished data); also, multivariate morphometric techniques, while promising, may require specialized equipment in order to achieve the resolution necessary for species separation (USGS unpublished data). Due to the high priority placed on developing larval lamprey identification techniques (Kostow 2002), we propose to provide genetic molecular markers suitable for discriminating between lamprey species found in the CRB.

To date genetic analyses performed on lamprey species native to the CRB have proven to be inefficient in separating species. While Docker et al. (1999) were able to separate Pacific lampreys from other lamprey species found in the CRB, they found no difference between western brook lampreys and river lampreys based on sequencing 735 base pairs from the cytochrome *b* and NADH dehydrogenase subunit 3 (ND3) genes. Attempts by researchers at the University of Idaho also failed in detecting variation in mitochondrial DNA sequences from CRB lampreys. The inability to separate western brook lampreys and river lampreys may be due to a relatively recent species divergence (less than 70,000 years ago) and the conservative nature of mitochondrial DNA (Docker et al. 1999).

We propose to develop a series of nuclear genetic markers to non-lethally discriminate species of CRB lampreys at any life-history stage. Two approaches will be taken: sequence analysis of ribosomal DNA (rDNA) and genomic scanning using single primer PCR (spPCR). We have used these strategies to generate genetic systems to non-lethally discriminate gender and run-timing in Chinook salmon (*Oncorhynchus tshawytscha*), and differentiate species of closely related trout (*O. mykiss* and *O. clarki*), insects, fungi, plants, and bacteria (Perring et al. 1993; Bartholomew et al. 1994; Freeman and Rodriguez 1995; Clifton and Rodriguez 1997; Ostberg and Rodriguez 2002).

Project ID: 200005200; USGS; Last contract ended 4/17/03

Title: **Upstream migration of Pacific lampreys in the John Day River, timing and habitat use.** Annual Reports are available for 1999 - 2000.

Abstract: Pacific lamprey (*Lampetra tridentata*) populations in the Columbia River Basin (CRB) have declined dramatically compared to their populations prior to hydropower development (Close et al. 1995). Consequently, state, federal, and tribal organizations have recently expressed concern for this species. For example, in 1993 the Oregon Department of Fish and Wildlife designated the Pacific lamprey at risk of being listed as threatened or endangered should its status continue to deteriorate. Similarly, the Pacific lamprey was designated as a Category 2 candidate species by the U.S. Fish and Wildlife Service in 1994. Columbia River treaty tribes have also voiced concern about the decline of this culturally significant species (Close et al. 1995; Jackson et al. 1998). The Northwest Power Planning Council's Fish and Wildlife Program (1994) noted the apparent decline of Pacific lampreys and requested a status report to identify research needs. The resulting report (Close et al. 1995) called for studies on lamprey abundance, evaluation of their current distribution, and determination of habitat limiting factors. Rehabilitation is now being planned in some areas where lampreys are believed to have been extirpated (Close et al. 1995; Jackson et al. 1998).

Identification of the biological and ecological factors that may limit lamprey production is critical to population assessment and recovery efforts. Although some biological and ecological information for this and sympatric species (western brook lamprey *L. richardsoni* and river lamprey *L. ayresii*) is available from studies conducted in Canada (Pletcher 1963, Beamish 1980, Richards 1980, Beamish and Levings 1991), little is known of the biology and ecology of lampreys in the CRB (Kan 1975, Hammond 1979). Participants in the Columbia Basin Pacific Lamprey Workshop (Pendleton, OR October 1998) concluded that in

addition to evaluating the population status of lampreys, fundamental biological questions must be answered, including identification of biological and ecological factors limiting lamprey production in the CRB.

Documentation of the life history strategy and habitat preferences of Pacific lampreys in streams and rivers tributary to the Columbia River will help identify factors limiting lamprey populations, identify areas in need of rehabilitation, and help to assess the efficacy of management actions. At present, we only have a cursory understanding of the life history pattern of Pacific lampreys. Pacific lampreys are believed to migrate into freshwater and move upstream to spawn from May-September, overwinter, and spawn in early spring the following year (Beamish 1980, Beamish and Levings 1991). Migration behavior and timing of Pacific lampreys in the CRB are presently unknown, including rate of movement through the mainstem Columbia River, timing of movement into tributaries, rate of movement in tributaries and habitat preferences during migration.

We propose to conduct this study in the John Day River Basin for several reasons. First, larval and adult stages of Pacific lampreys have been documented in the basin (Jackson et al. 1998; ODFW pers. comm.). Second, the John Day River is unimpounded and provides the opportunity to study migration behavior and timing of fish unimpeded by passage constraints. And third, since the John Day River Basin shares certain characteristics with the Umatilla River Basin, data collected during this study may be useful in the implementation and evaluation of the proposed restoration of Pacific lampreys in the Umatilla River. Migration behavior, timing, and the quantification of habitat preferences will provide a means to assess the suitability of overwintering and spawning habitat and help to establish goals for recovery projects.

Radiotelemetry is a well-established technique to evaluate migration behavior and timing in fishes (Winter 1983). Radiotelemetry is currently being used to assess adult lamprey passage at Bonneville Dam (NMFS, pers. comm.) and to examine Pacific lamprey homing behavior in the lower Columbia River by CRITFC (personal communication).

This project will answer questions about Pacific lampreys posed by regional fishery managers. Specifically, the quantification of habitat needs will help managers to develop strategies that assure long-term population viability of Pacific lampreys. Data from this project would provide information necessary to examine other aspects of lamprey biology and ecology, such as quantification of rearing habitat and determination of relative abundance of sympatric species of lamprey present in the CRB and western brook lamprey.

B. U.S. Army Corp of Engineers Projects –

1994 Pacific Lamprey Passage Studies Program

Based on regional concerns about the diminishing numbers of Pacific lamprey, the Pacific Lamprey Passage Studies Program was initiated in June of 1994 with requests issued by the USACE for preliminary proposals.

- USACE Fishery Field Unit reviewed the literature and historic passage records to characterized run timing, diel passage, and passage numbers, and compiled areas of

potential problems for adult and juvenile passage based on observations and discussions with researchers.

- Underwater camera observations of fish through orifices in BON2 ladder section found some lamprey spent substantial time in or near orifices.

1996 Radiotagging study at Bonneville Dam

85 radiotagged lamprey released below BON to evaluate passage upstream.

- 94% returned to dam.
- Top of ladder detection problems limited meaningful passage estimates.

1997 Radiotagging study at Bonneville Dam

147 radiotagged lamprey released below BON.

- 88% returned to BON dam.
- 38% BON passage efficiency. 1 fallback fish.
- 55% TDA passage efficiency.
- too few fish at JDA for meaningful passage estimates.

1998 Radiotagging study at Bonneville Dam

205 radiotagged lamprey released below BON to evaluate passage upstream.

- 89% returned to BON dam.
- 40% BON passage efficiency. 1 fallback fish.
- 63% TDA passage efficiency. 4% fallback.
- too few fish at JDA for meaningful passage estimates.
- 1 fish found in Klickitat River, 3 in Fifteen Mile Creek, and 8 in the Deschutes.

1999 Radiotagging study at Bonneville Dam

197 radiotagged lamprey released below BON to evaluate passage upstream.

- 92% returned to BON dam.
- 45% BON passage efficiency. 4 fallback fish.
- 50% TDA passage efficiency.
- too few fish at JDA for meaningful passage estimates.
- 4 fish found in Hood River and 2 in the Deschutes River.

Lab tests found adult lamprey critical swim speed of 0.86 m/sec, burst speed to 2.1m/sec, and that they recovered quickly from a single stressor exposure (USGS-Cook).

NMFS found a FGE of 1.4% for juvenile lamprey in fyke net catches at John Day Dam Powerhouse with 86% of the juveniles captured in the bottom four net levels.

1999 Passage improvement design and implementation

Adult experimental fishway

- Baseline passage rates under normal fishway ladder conditions were established.
- Adding velocity refuges reduced passage times, did not affect success.

2000 Radiotagging Study at Bonneville Dam

299 radiotagged lamprey released below BON.

- 87% returned to BON dam.
- 47% BON passage efficiency. 3.3% (4) fallback.
- 82% TDA passage efficiency.
- 35 fish detected in Deschutes River, 13 in John Day River.
- 55% JDA passage efficiency. 17% fallback.

Lab and field test found count window lighting did not affect adult passage.

1999-2000 field and lab **juvenile lamprey** swim behavior studies (PNNL) found;

- Impingement problems (15-75%) at 1/8 inch extended length bar screens that increased with flow rates and time, but little problem with 1/8 traveling screen mesh or 3/32 bar screen.
- Exposure to simulated shear and pressure changes indicate turbine passage may be fairly benign as no injuries to juveniles were found.
- Light from the sides or above eliciting a diving response in lab studies of juveniles.

OSU studies on juvenile tagging protocols found existing active tags are too large, external tags are poorly tolerated by the animal, short term PIT tag studies on larger sized juveniles (>150 mm) may work, and fungus growth on handled juveniles are a problem.

2000 Passage improvement design and implementation

Adult experimental fishway

- Daytime passage was less successful than nighttime passage; artificial nighttime light could reduce passage success.
- Adding a 20.3 cm step at the base of an orifice reduced passage rates from 69 to 49%. Diffuser gratings slowed passage but this difference disappeared when a plate was attached.
- Simulated count windows found no effects on passage with or without simulated count window lights or picketed lead weirs.

2001 Radiotagging study at Bonneville Dam (drought year - very low flow and reduced spill)

298 radiotagged lamprey released below BON.

- 93% returned to BON dam.
- 46% BON passage efficiency. 12% fallback.
- 73% TDA passage efficiency. 7% fallback.
- 8 fish detected in Deschutes River, 4 in John Day River.
- 53% JDA passage efficiency. 36% fallback.

2000-2001 evaluations at Cascade Island researchers concluded that rounding of entrance bulkheads improved entrance efficiency based on a 11% increases over previous 2 years (51.5 vs. 62.5%).

2000-2001 evaluations of reduced flow at spillway entrances found no passage improvements but controlling entrance test velocities was problematic.

High passage efficiency exists through ladder sections; entrances, collection, transition areas and serpentine weirs are problematic.

2002 Radiotagging Study at Bonneville Dam

201 radiotagged lamprey released below BON.

- 96% returned to BON dam.
- 48% BON passage efficiency. 1 fallback fish.
- 66% TDA passage efficiency. 1 fallback fish.
- 2 fish detected in Deschutes River, 1 in John Day River.
- 50% JDA passage efficiency. 35% fallback.

Limited underwater and acoustic camera investigations (FFU) of floor plates on diffusers between weirs in BON 2 transition pools found no evidence of preferential use of orifices with plates and limited use of the plates, suggesting adult lamprey may move laterally to the walls.

In 2001, 41 cm wide plates over diffuser gratings in BON2 ladder transition section resulted in an increase in passage efficiency through that section (weir 1-10) compared to 2000 (72 vs.82%) but efficiency dropped to 74% in 2002.

Field and lab evaluations of **juvenile lamprey** at JDA and PNNL found;

- Juveniles contact (78%) and may be impinged on extended bar screens at high rates, but most are able to continue to move along the screen face and that reducing the bar spacing to 1.75mm prevented impingement.
- 52% of PIT-tagged juveniles released to contact the screens were unaccounted for and likely passed through the gap at the top of the screen . The remaining fish passed efficiently through the JBS.
- 78% of run of river juveniles were captured in the 2nd, 3rd, and 4th fyke nets from the bottom and would have passed beneath extended screens and into the turbines. One explanation of this observation of fyke net captures is that juveniles were not observed in fyke nets higher in the water column because they may have been impinged or guided by the STS nets in front of the vertically distributed fyke net banks.
- Mean maximum burst speed for untagged juveniles was 2.5 ft/s.
- Sustained swim speed for untagged juveniles was 1.38 ft/s

Serpentine weirs and the area immediately downstream of weir 1 in BON2 transition section of the ladder were found to be major passage problems.

Evaluations of yearly chemical/hormonal cycle of adult Pacific lamprey (USGS-Cook) found no differences between fish that did or did not pass; that there were few indications of any migratory related changes.

Of the 711 juvenile lamprey collected in the gatewell and fyke nets at BON2, 75% were caught in net levels 3 and 4 (from elevation -0.3 m to -5.1 m msl). This was comparable to results seen previously at BON Dam First and Second Powerhouse. In all cases, most juvenile lamprey were well below an area where they were susceptible to interception by the STS. Although it is possible that juveniles were not observed in fyke nets higher in the water column because they may have been impinged or guided by the STS nets in front of the vertically distributed fyke net banks.

2002 Passage Improvement Design and Implementation

Lamprey Passage Systems (LPS)

First prototype sections of an LPS designed and installed in the Bradford Island Exit AWS channel show some promise to pass fish.

Adult experimental fishway

- Tests on a simulated entrance weir found increases in passage rates from 4% with 45.7 cm of head to 78% with 15.2 cm of head.
- Rounding the bulkhead shape increased passage rates from 34 to 41%.
- Offering a side channel with reduced velocities increased passage from 3 to 44%.

2003 Passage improvement design and implementation

Lamprey Passage Systems (LPS) - Bradford Island AWS Channel

Three prototype collection structures were built and evaluated in both an upstream and downstream configuration to evaluate effectiveness at collecting adults. 5458 adults were collected and 1089 were marked and rereleased in the channel to estimate treatment efficiency. Downstream-oriented ramps performed the best, recapturing 18%.

Bradford Island Ladder Exit Area Vertical slot Adult PIT installation

Installation designs incorporated lamprey features; chamfering of right angle corners, reduction of gap tolerances for antennae inserts, and less roughness for concrete.

Diffuser Grating

Preliminary tests of grating gap size found adults pass readily through 1 inch gap but do not in $\frac{3}{4}$ inch gap openings.

Dewatering procedures

Methods altered to reduce impacts to lamprey; diversion pipes from upper diffuser chambers to tailwater (JDA), use of orifice blockers to sustain pools above weirs at key points to keep fish in water for salvage, more equipment and personnel, start salvage early in the week.

2004 Passage improvement design and implementation

Lamprey Passage Systems (LPS) - Bradford Island AWS Channel

- System was extended to include PIT readers, resting boxes a volitional egress section to forebay.
- 7,500 adults (21% of Bradford Island passage) passed via LPS from mid-June to mid-September.

- 25% of tagged fish released in AWS passed via LPS; median time of 1 hour from first rest box to exit.

Adult experimental fishway

LPS collection test ramp evaluations found

- Passage efficiency (88%+) did not differ among flows but mean passage times were considerably faster with reduced flows.
- Passage efficiency (90%+) did not differ among flows but mean passage times were slowest (0.84 hr) for 35 degree ramp that 45 and 60 degree slope ramps (0.31hr and 0.40 hrs, respectively).
- Adding adults above the ramp as a potential olfactory attractant did not improve passage.

Washington Shore Ladder Exit Area Vertical Slot Adult PIT installation

Installation designs incorporated lamprey features; chamfering of right angle corners, reduction of gap tolerances for antennae inserts, and less roughness for concrete.

2005 Half Duplex PIT Tag Study

- Half duplex PIT tag readers were installed at Bradford Island auxiliary water channel, at the entrance to BON Washington shore ladder, and at MCN and IHR ladder entrances and exits. Initial efforts involved testing detection rates and refining systems.
- Lamprey that successfully migrated to upstream sites were significantly larger than unsuccessful fish (mean weights of 570 vs. 508grams). Condition factor declined as fish migrated from BON to MCN and ICE.
- MCN & IHR study
 - 40 dual tagged (radio and PIT) released below MCN; 20 released below IHR.
 - 52.5% returned to MCN tailrace; 45% returned to IHR tailrace.
 - 61.9% (13 of 21) dam passage efficiency at MCN; 33.3% (3 of 9) at IHR.
 - fish had problems passing ladder areas similar to other dams; entrances, transition sections, and exit areas associated with auxiliary water channels.

2005 Passage improvement Design and Implementation

Lamprey Passage Systems (LPS) - Bradford Island AWS Channel

- No changes in passage metrics were found between 2 flow levels tested in the LPS.
- 8,889 (29% of Bradford Island passage) lamprey passed using the LPS.
- 42% of tagged fish released in AWS passed via LPS; median passage time through complete LPS was 1.5hrs.

Lamprey Passage Systems (LPS) – Washington Shore Ladder Entrance

Prototype LPS installed downstream in late August of entrance in tailrace to evaluate attraction near but outside of ladder.

Adult experimental fishway

LPS collection test flume evaluations found

- When presented with 3 alternative choices (left wall, mid channel, and right wall) with varying flow rates, lamprey preferred routes adjacent to walls;

- Increasing flows differentially to mid channel could increase its use but with increased passage times.

Diffuser Grating

In NMFS vertical gap size volitional passage testing, 100% of adult Pacific lamprey (mean length 67.5cm) passed 2.5cm gaps, 47% through 2.2cm gap, and none passed through 1.9cm gaps.

2006 Half Duplex PIT Tag Study

PIT Conversions

- Half duplex PIT systems added to tops of ladders at BON2, TDA, and JDA.
- Median travel times from dam top of ladder to dam top of ladder were;
 - 5.1 days BON – TDA.
 - 4.1 days TDA – JDA.
 - 12.8 days JDA – MCN.
- Lamprey that successfully migrated to upstream sites were significantly larger than unsuccessful fish (mean weights of 541 vs. 504grams).
- Eleven fish tagged in 2005 overwintered and were detected at dams in 2006; 5 at BON.

Hydraulic analysis of adding lamprey PIT antenna in the exit area of JDA north ladder found no problems; a increased head differential of 0.01 to 0.02 ft depending on forebay elevation with no measurable effects downstream.

MCN and IHR study

- 40 dual tagged (radio and PIT) released below MCN; 20 released below IHR.
- 45% returned to MCN Dam; 65% to IHR Dam.
- 61% (11 of 18) dam passage efficiency at MCN; 77% (10 of 13) at IHR.
- fish had problems passing ladder areas similar to other dams; entrances, transition sections, and exit areas associated with auxiliary water channels.
- Condition factor declined as fish migrated from BON to MCN and ICE.

2006 Passage improvement design and implementation

Lamprey Passage Systems (LPS) - Bradford Island AWS Channel

- A two ramp design collection system was installed for the AWS channel LPS.
- 14,975 (34% of Bradford Island passage) lamprey passed using the LPS.

Adult experimental fishway

LPS collection test ramp evaluations found;

- Passage behavior, efficiency, and times were not altered or different by the addition of either or 2 rest box design.
- Using water jets, air bubbles, and waterfall action to attract fish to base of ramp did significantly improve passage.

Diffuser Grating

- In NMFS dewatering simulations, 86% of adult Pacific lamprey (mean length 67.5cm) passed through a grating with 2.5 cm bar spacing but none passed through a 1.9cm bar spacing.
- A ¾ inch (1.9cm) gap diffuser grating was installed at pool 16 just above the JDA north ladder count station. No adult lamprey were found beneath it during winter dewatering even though it has a history of stranding.

2007 Radiotagging Study

Summary of 1997-2002 and 2007 radiotagged fish data for BON, TDA, and JDA.

- Fish tagged in 2007 were considerably smaller.
- 75% TDA passage efficiency. 29% fallback fish (highest % ever).
- 82% (9 of 11) JDA passage efficiency; 2 (22%) fallback fish; both entered the John Day River.

2007 Passage improvement design and implementation

Nighttime Entrance Velocity Reduction Test

Passage efficiency increased at both the north and south entrances with velocities reduced to approximately 4 fps with 0.5 ft of head differential; however increases in the total number of fish entering only occurred at the north entrances which had higher velocities under normal conditions. The south entrances showed a net reduction in the number of fish entering as a result of a reduction in attraction to the entrance, likely related to the reduced flows. At the north entrance, where normal flow velocities are considerably higher than the south entrances, both entrance efficiency and numbers entering increased.

PIT Data

Reach Conversions and Detection rates

- Median travel times from dam top of ladder to dam top of ladder were;
 - 4.0 days BON – TDA.
 - 4.3 days TDA – JDA.
 - 8.8 days JDA – MCN.
- Radiotagged based conversions were much lower than PIT based conversions pointing to possible radiotag effects or failures.
- Lamprey that successfully migrated to upstream sites were significantly larger than unsuccessful fish.

Preliminary Ladder Window Counts at BON and TDA dams

Tabulated by video at night and by counters during the day

Pheromone Tests

NMFS built a Y-maze and did initial testing of the effects of current velocity, ambient larval pheromone, and ammocoete washings on lamprey movements. Final research results and report pending.

MCN study

- 59 dual tagged (radio and PIT) released below MCN.
- 28% returned MCN Dam.
- 86% (12 of 14) dam passage efficiency at MCN.
- Sampled fish were smaller on average than in previous studies.

Lamprey Passage Systems (LPS) - Bradford Island AWS Channel

- 7,387 (38% of Bradford Island passage) lamprey passed using the LPS.

Lamprey Passage Systems (LPS) – Washington Shore AWS Channel

A dual ramped LPS similar to the final Bradford Island design was installed by late June. 2,517 lamprey passed via this route.

JDA north ladder modifications

- The new exit section and count station were evaluated in a 1:5 scale physical model at ENSR Corporation's laboratory. There were five lab site visits; two were with agency representatives during which the final configuration design was established.
- The proposed changes to the upper ladder section that are expected to aid lamprey are summarized below:
 - Remove 1st (upstream) vertical slot and sill baffle in forebay transition section.
 - Modify 2nd baffle (remove 2.5-foot sill and add orifice) in forebay transition.
 - Remove all 18 serpentine weirs + holey wall and replace with 23 lamprey friendly JDAS-type weirs with 15- to 18-inch vertical slots and 18- x 18-inch orifices.
 - Smooth contiguous floor surface through all orifices from count station to exit.
 - Raise Count Station floor one foot to match invert at new weir 1 (holey wall site).
 - Add 12-inch-wide metal strip over left side of floor diffuser 16.
 - Remove 23-inch ramp through count slot and lower viewing window.
 - Replace antiquated crowder, adding new transition fairings and horizontal vanes.

Diffuser Grating

- In-ladder inspections found most ladder floor diffuser gratings are not supported adequately to hold required load and will need modification.
- Intake trash racks leading to diffuser pools will also need to be replaced with $\frac{3}{4}$ inch gaps if diffusers are changed to prevent debris build up below diffusers.
- BON, TDA, and JDA develop list of diffuser gratings with history of lamprey strandings and mortalities.

TDA and JDA put together list of potential minor ladder modification to assist lamprey passage based on structural inspections of dewatered ladders. See Appendix.

2008 Lamprey Passage Studies Research, Design Development, and Implementation:

- Evaluating effects of ladder modifications and improvements on lamprey passage at BON.
- Obtain/improve baseline passage metric information at upstream dams (JDA, MCN, and Snake River dams if adequate sample sizes)
 - Determine problem areas, prioritization, and evaluate effects of future improvements.

- Second year of evaluation of new BON WA ladder AWS channel Lamprey passage system.
- Evaluate effects of radiotags on adult lamprey passage behavior.
- Lab flume tests of bottom velocity reducing structures as a part of new entrance designs.
- Second year of study of methodology to improve lamprey counts at dams, including night video counts at window and tabulation of LPS passage.
- First year of lab evaluations of the effects of juvenile lamprey pheromones on adult migration.
- Finalizing designs for new lamprey safe diffuser gratings, intake screens, and prioritization. Grating replacements planned to begin winter maintenance period 09-10.
- Finalizing designs of new entrance shape, bottom structure, and connections to LPS systems to improve entrance efficiencies for lamprey.
 - BON Cascade Island prototype lamprey fixed weir entrance planned installation this winter with evaluations of effectiveness next summer.
 - JDA north ladder entrance modification designs into DDR phase this fall. Planned installation in 2012.
- Finalizing DDR of exit section modifications at JDA north ladder that include many lamprey improvements. Planned implementation in 2010-11.
 - Remove serpentine weir section (known problem area for lamprey).
 - Providing orifice routes with smooth contiguous surface from count station to exit: rounding of corners and no right angle barriers.
 - Raise floor on either side of count station and improve hydraulics through the count slot.
 - Add attachment plate over lamprey grating diffuser just above count station.
 - Provide resting areas.
- Finalizing O&M manual for Bradford Island AWS lamprey passage system including as-built drawings as part of handoff of system to BON project.
- Initiated additional adult lamprey trapping in JDA ladders to provide fish for translocation efforts.
- Development of 10 year Lamprey Passage Improvement implementation strategy.
- Continue development of juvenile lamprey separator in JBS.

2008 Tagging Studies

Lamprey Passage Systems (LPS) - Preliminary results.

- 6,441 (42% of Bradford Island passage) lamprey passed using the LPS.
- 1,985 lamprey passed via the WA shore ladder LPS.
- 12% of all tagged fish passed BON using an LPS.

PIT Data

Twice as many PIT tagged fish made it from release to the top of BON dam compared to radiotagged fish (26 vs. 52%), 12% more from top of BON to top of TDA, and 23% more from top of TDA to top of JDA, indicating radiotagging negatively effects adult performance . This tagging effect and smaller median sized fish being captured at BON makes it more difficult to assess relative passage improvements related to modifications. As was found over the last several years, larger fish were more likely to pass farther upstream.

Nighttime Entrance Velocity Reduction Evaluation (0 ft head)

PH2 fishway velocities at Bonneville Dam were manipulated by placing fish units on standby to float debris off of the trash racks. Shutting off fish units occurred only at night (typically between 2200 and 0430) to minimize potential effects on adult salmonid passage. This created 0 ft of head dif and minimum velocities at the entrances. Passage during the 0 head dif condition was compared to nights with normal head. Preliminary results indicate that passage efficiency may be negatively affected by this operation.

2008 Radiotag study results

MCN study - study results pending report.

2008 Passage improvement design and implementation

JDA north ladder modifications

- Exit section modifications move to final DDR phase.
- Entrance section design development move to alternative evaluation report phase and includes many lamprey features; fixed weir, improved AWS water distribution, floor velocity reducing structures, smaller gapped diffusers in all alternatives.

Diffuser Grating

- New designed ¾ inch diffuser gap grating developed that does not alter flows or ladder hydraulics.
- Concerns about large quantities of galvanized steel grating being replace at one time leads to adding powdercoating to new grating design criteria.

Cascade Island entrance modifications

Developed designs for a prototype lamprey-friendly modified entrance; fixed weir, floor velocity reducing structures, and a tailwater to forebay LPS to be installed and tested in 2009.

Bradford Island LPS

As-built drawing of Bradford Island LPS completed and available.

2009 Lamprey Passage Studies Research, Design Development, and Implementation Planning

- Finalized 10 year Lamprey Passage Improvement implementation Plan.
- Annual report to MOA participants on progress of 10 year plan
- Annual prioritization of Lamprey research and implementation goals with MOA participants.

Structural and Operational Implementation

- Finalized Plans of exit section modifications at JDA north ladder that include many lamprey improvements. Planned implementation in 2010-11 in-water work-period.
- Develop JDA north ladder entrance and AWS modification designs (DDR) for planned installation in FY12-14.
- Initiate design development of new entrances for BON WA DS north and MCN south ladder entrances.

- Develop designs/methods for quick and easy fixes for MCN ladders for next in-water work period.
- Continue development of juvenile lamprey separator in JBS.
- Assisted Umatilla Tribe with collection of adults at JDA for translocation evaluations.

Research Monitoring and Evaluation

- Evaluating effects of ladder modifications and improvements on lamprey passage at BON and upstream.
- First year of evaluations of prototype BON Cascade Island entrance weir, bottom structure, and LPS system.
- Second year of night time flow reduction testing at BON WA shore ladder.
- Initiate flow reduction evaluations at MCN south entrance.
- Obtain/improve baseline passage metric information at upstream dams (TDA, JDA, MCN, and Snake River dams) to better determine problem areas.
- Third year of evaluation of new BON WA ladder AWS channel Lamprey passage system.
- Conduct nighttime video window counts at BON, MCN, LGR.
- Evaluate materials, sizes, and shape criteria for a functional juvenile lamprey active tag.
- Develop JSAT mobile tracking system to begin determining fate of adults in reservoirs in 2010.

2010 Lamprey Implementation and Research Prioritization Planning

Following is a preliminary list of priority items for funding in FY10 based on ongoing planning discussions and meetings. A critical part of how much can be accomplished depends on cost estimates and 09 evaluation results.

Structural and Operation Implementation

- Continue design development for ladder entrance modification
 - a. BON WA shore north entrance
 - b. MCN physical model testing and alternative design development.
- Implement quick, relatively inexpensive fixes in MCN and ICH ladders.
- Investigate possibility of delaying installation of turbine intake extended screens at Snake River dams as was done at MCN
- Investigate feasibility of LPS from BON WA ladder count station area to exit channel.
- Design exit section for BON Cascade Island LPS.
- Implement nighttime flow reductions at Bonneville PH2 if supported by studies.

Research

- 2nd Year of Evaluations of CI Entrance Modification if needed
 - Review adult salmon and lamprey results so far
 - Consider any LPS changes or additions
- 4th year of JBS separation screen research
- 2nd year of Juvenile tag criteria development (Mesa and Peery)
- Initiate Adult JSAT mobile tracking of adults to determine fate
 - BON pool first priority

- Nodes at major tributaries
- Work out tag signal strength and pulse rate needs and receiver performance to adequately be able to locate fish in large reservoirs.
- Obtain general conversion and passage assessment metrics with fish tagged at BON, JDA, and MCN.

C. U.S. Fish and Wildlife Service Projects

FY2006-2009

- Evaluation of factors affecting migration success and spawning distributions of adult Pacific lamprey in the Snake River, Washington and Idaho. In this three-year study, the IFRO radio tagged adult Pacific lamprey and monitored their movements through the lower Snake River drainage above Lower Granite Dam. Objectives were to determine the migration timing, behavior, migration rates, and overwintering habitat of tagged adults and determine which environmental factors were correlated with these movement patterns.

FY2007-08

- U.S. Fish and Wildlife Service OFWO initiated a lamprey passage project with the Confederated Tribes of the Umatilla on the Umatilla River, which has subsequently increased interest to provide passage at the remaining diversions.

FY2008-09

- Pacific Lamprey Conservation Initiative - Initiated a process to develop a rangewide conservation initiative for Pacific Lamprey. Began to develop a Conservation Plan (Plan) to restore and sustain Pacific lamprey populations throughout their historical range by coordinating efforts among states, tribes, Federal agencies, and other involved parties. Conservation Agreements developed through this process will rely on voluntary participation from a variety of entities to implement conservation actions such that listing is not necessary.
- Larval lamprey use of mainstem habitats - The goal of the project is to determine whether and where larval Pacific lamprey are present in the mainstem Willamette and Columbia Rivers. The study was designed to incorporate dredge technology to assess distribution in deep water habitats and coordinated with the contaminants and toxicity study being performed by the OFWO. Larval lamprey were found in the mainstem of the Willamette River as well as the Columbia River above and below the confluence with the Willamette River.
- Tryon Creek Monitoring - Culvert retrofit construction was delayed a year. Therefore, final pre-restoration monitoring occurred in FY 2008. Conducted presence/absence surveys for lamprey species. Spawning surveys were conducted for lamprey and salmonids. Adult anadromous fish migration was monitored via a picket weir and PIT tag arrays installed at both downstream and upstream ends of the Hwy 43 culvert. Salmonid juveniles were collected above and below the culvert and PIT tagged to monitor passage through culvert.
- Lamprey Population Structure - Provided preliminary microsatellite markers for western brook lamprey (WBL) to the University of Manitoba (UM). Markers were characterized and optimized. Began writing a primer note for publication. Collected western brook

lamprey from various geographical areas for population structure analysis. Collaborating with lamprey geneticist from the University of Manitoba who has western brook lamprey samples from Continental U.S. range. Sent Pacific lamprey to GIS for microsatellite loci isolation.

- White Salmon River (WA) Lamprey - The first portion of a multi-year assessment of lamprey distribution in the White Salmon River was continued. A random, spatially-balanced sampling approach was implemented to determine distribution of Pacific and western brook lamprey in the White Salmon R. subbasin.
- U.S. Fish and Wildlife Service OFWO Lamprey Developed a field-friendly adult and ammocoete ID Guide (handed out at AFS meeting).

FY 2008

- Evaluate Habitat Use and Population Dynamics of Lampreys in Cedar Creek. CRFPO continued the evaluation of mark recapture data for abundance estimates. Controlled trials were conducted to assess efficiency of electroshocker and susceptibility of larvae. Evaluate detection probability and capture efficiency for larval lamprey. Use information to assess methods to monitor distribution and abundance of larval lamprey.

FY 2009

- U.S. Fish and Wildlife Service OFWO obtained \$13,570 in FY2009 USGS funding under the Science Support Partnership (SSP) for a study by Carl Schreck on the “Maturation Timing and Run Identification of Adult Pacific Lamprey, *Lampetra tridentata* (*Entosphenus tridentatus*), at Willamette Falls, Oregon” and matched it with an additional \$500 from our discretionary funds.

D. U.S. Bureau of Reclamation Projects

Approach to Implementing Pacific Lamprey Actions in 2008 Fish Accords

Reclamation has agreed to address two action items regarding lamprey that are part of the 2008 Fish Accords with Lower Columbia River Tribes. The actions are as follows:

1. Beginning in 2008, and concluding in 2010, Reclamation will conduct a study, in consultation with the Tribes, to identify all Reclamation projects in the Columbia Basin that may affect lamprey. The study will also investigate potential effects of Reclamation facilities on adult and juvenile lamprey, and where appropriate, make recommendations for either further study or for actions that may be taken to reduce effects on lamprey. The priority focus of the study will be the Umatilla and Yakima projects and related facilities.
2. Beginning in 2008, Reclamation and the Tribes will jointly develop a lamprey implementation plan for Reclamation projects as informed by the study above, the tribal draft restoration plan, and other available information. The plan will include priority actions and identification of authority and funding issues. It will be updated annually based on the most recent information. Reclamation will seek to implement recommended actions from the implementation plan.

The approach to addressing action item number 1 would involve:

Compiling a list of Reclamation projects in the Columbia River basin, with initial emphasis on the Umatilla and Yakima rivers and

- identifying whether Reclamation projects have structures that are or could be impediments to adult or juvenile lamprey passage and survival;
- estimating or describing the current abundance and distribution of lamprey in the area, if known;
- noting historic presence of lamprey in the area, if known;
- identifying whether there are structural devices, such as screens, or modifications, such as rounded rather than sharp edges to structures, that would improve lamprey passage;
- determine if structural modifications are effective in providing safe passage routes for lamprey;
- recommend structural devices and modifications to project features to improve lamprey passage, based on known or developing criteria for lamprey;
- begin discussions with fisheries co-managers to initiate laboratory and/or field investigations of new or novel devices or applications of devices to reduce lamprey impingement and entrainment and improve passage survival;
- begin discussions with fisheries co-managers to develop a plan to implement or install devices to improve lamprey passage as informed by laboratory and/or field investigations. This is basically a transition to action item number 2.

The approach to addressing action item number 2 would involve:

Developing an implementation plan with the Tribes informed by the results of the investigations in action item number 1, the tribal draft restoration plan, and other available information. Some actions might be implementable relatively quickly while other actions may be more difficult and complicated.

E. U.S. Geological Survey Projects

FY 2003-2004.

- Survival and tag retention of Pacific Lamprey larvae and macrophthalmia marked with coded wire tags. Meeuwig, M. H., A. L. Puls, and J. M. Bayer. 2007. Survival and tag retention of Pacific lamprey larvae and macrophthalmia marked with coded wire tags. *North American Journal of Fisheries Management* 27:96-102. Funded by USGS Science support.

FY 2005-2006.

- Passage and behavior of radio-tagged adult Pacific lamprey (*Entosphenus tridentata*) at the Willamette Falls Project, Oregon. Matthew G. Mesa, Robert J. Magie, and Elizabeth S. Copeland. Funded by Portland General Electric, the U.S. Fish and Wildlife Service, the Bureau of Reclamation, and the Confederated Tribes of the Grand Ronde.

FY 2010.

- Impact of irrigation diversion screens on juvenile lampreys in the Columbia River basin. Research. FWS Project Officer: Jody Brostrom, Idaho Fishery Resources Office. USFS PI: Matt Mesa, Columbia River Research Laboratory. \$27,799 for FY 2010 and \$27,799 for FY 2011.

- Pacific lamprey overwintering habitat research in North Umpqua Basin. Research. FWS Project Officer: Howard Schaller, Columbia River Fisheries Program Office. USGS PI: Carl Schreck, Oregon

Appendix D. Columbia River Basin Lamprey Technical Workgroup Critical Uncertainties for Anadromous Lampreys (2005)

Status

1. Develop methods to differentiate among species at all life stages (field-based).
2. Develop standardized sampling protocols and conduct systematic basin-wide surveys to assess adult and juvenile abundance and distribution.
3. Review historic databases to better understand historic distributions and abundance.
4. Define, improve, and continue historic distribution and abundance indices (e.g., dam counts, tribal harvest records, smolt trap collections, etc).
5. Coordinate information exchange with existing and future projects not targeting lamprey specifically.

Passage

1. Identify potential obstacles to passage (e.g., loss of recruitment upstream from a potential obstacle, observation of lamprey aggregations or mortalities at potential obstacles during migration periods).
2. Assess passage efficiency, direct mortality, and/or other metrics that relate to loss of fitness (i.e., stresses or injuries that reduce ability to reproduce).
3. Determine the specific structures or operations that delay, obstruct, or kill migrating lamprey.
4. Develop aids to passage (e.g., modify structures or operations, provide lamprey-specific fishways, or bypasses).
5. Monitor lamprey passage to evaluate aids to passage and to identify any new passage problems that might occur.

Population Delineation

1. Supplement existing libraries of genetic markers for lamprey (e.g., microsatellites, single nucleotide polymorphisms)
2. Build and maintain lamprey tissue collections from the CRB and neighboring basins
3. Investigate other methods to delineate populations
4. Determine if anadromous lamprey in the CRB represent a panmictic population (completely mixed)

Limiting Factor Analysis

1. Document habitat preferences and habitat availability for all life stages of anadromous lamprey.
2. Evaluate the physiological and behavioral responses of lamprey to a variety of environmental stressors (e.g., capture and handling, elevated temperatures, contaminant exposure, sedimentation).
3. Assess trophic relationships (e.g., predation by exotics, reduced host availability).

Restoration Activities

1. Identify ongoing restoration activities and their effects on lamprey.
2. Develop, implement, and evaluate lamprey-specific restoration projects (restoring natural processes in the absence of information on limiting factors).
3. Develop, implement, and monitor reintroduction methods (e.g., transplantation, hatchery production).

Biology/Ecology

1. Understand the ecological function of anadromous lamprey (e.g., predator/prey relationships, linkages to other aquatic and terrestrial organisms).
2. Understand the biology of anadromous lamprey (e.g., reproduction, feeding).
3. Develop methodology for gender identification in the field and laboratory (e.g., identify spawning sex ratios, sex related behavioral characteristics).
4. Develop aging techniques.
5. Assess life history characteristics of freshwater and ocean-phase anadromous lamprey (e.g., age, growth, timing of metamorphosis, movement, basin-specific comparisons).

Population Dynamics

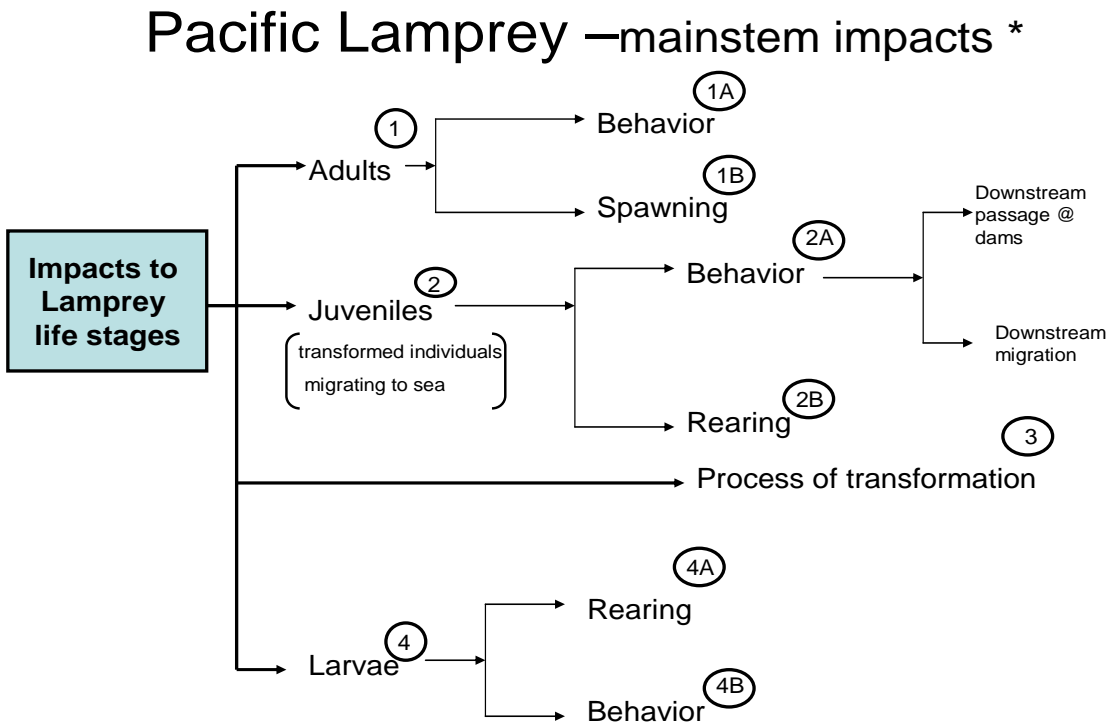
1. Estimate demographic rate parameters capable of changing the size of populations such as birth, death, immigration, and emigration rates.
2. Build life tables.
3. Develop a predictive model to assess the rate of increase/decrease of lamprey populations in the CRB including abiotic and biotic factors.

Appendix E. Lamprey Federal Caucus Focus Area: Summary of existing restoration/conservation plans and guidance documents that apply to Pacific Lamprey conservation in the Columbia River Basin.

We have synthesized and summarized the existing restoration/conservation plans and guidance documents that apply to Pacific lamprey conservation in the Columbia River basin. We identified the following plans:

- A. NPCC Fish and Wildlife program/BPA
- B. Tribal Pacific Lamprey Columbia Basin Restoration Plan
- C. 2008 Columbia River Fish Accords
- D. U.S. Army Corps of Engineers 10 year plan for passage at dams
- E. U.S. Fish and Wildlife Service Pacific Lamprey Conservation Initiative
- F. Critical Uncertainties for Lamprey in the Columbia River Basin: Columbia Basin Fish and Wildlife Authority-Columbia River Lamprey Technical Workgroup
- G. Passage Considerations for Pacific Lamprey: Columbia Basin Fish and Wildlife Authority-Columbia River Lamprey Technical Workgroup

This first draft of summarizing the existing Pacific lamprey restoration/conservation plans and guidance documents is organized around the following life stages described in the following diagram (Figure D-1) and outline.



* Numbers refer to bullet numbers on attached outline

Figure D-1. Outline of Columbia River mainstem impacts for Pacific Lamprey life stages.

Outline of Columbia River mainstem impacts for Pacific Lamprey life stages:

1. Adults

A. Behavior – Upstream Passage

1

- i. How can lamprey be better attracted to ladders?
 - a. Physical structure (lower velocity, surfaces *{irregular}* for attachment)
 - b. Operational changes (reduce flow at night)
 - c. Pheromones
- ii. How can lamprey negotiate ladder passage more efficiently?
 - a. Structural changes (round corners, size of grating)
- iii. Is passage adequate through all dams?
 - a. Should additional upstream facilities be equipped with LPS?

B. Spawning

- i. Do lamprey spawn in the mainstem?²
- ii. If the answer is yes;
 - a. what are the identified areas?
 - b. what is the influence of reservoirs on the success of lamprey spawning?

2. Juveniles (completely transformed individuals migrating to seawater)

A. Behavior – Downstream Passage

- i. Where are juveniles located in the water column?
- ii. If a significant proportion of juveniles are migrating relatively low in the water column and likely go through the turbines, what are the impacts of turbines on juvenile lamprey?
- iii. What are the impacts to juveniles from pressure changes in turbine units?
- iv. What is the utility of the Juvenile Bypass System (JBS)³ to the passage of juvenile lamprey?
 - a. Does the system guide juvenile lamprey?
 - b. How could the system be improved?
- v. What is the survival of juvenile lamprey by passage route?
 - a. Develop a mark-recapture techniques/system.
 - b. Identify a source of juveniles (via broodstock or capture wild fish).
 - c. Test: paired-release studies.
- vi. What is the influence of reservoirs on migration of juveniles (including speed, swimming performance, and bioenergetics).⁴

B. Rearing

- i. Theoretically, not applicable for Corp studies.

¹ Indicates that some information is available and that the current literature needs to be summarized.

² Indicates that we are not aware of any background information.

³ Summarize JBS and transportation information for presence of juveniles/larvae in system (anecdotal data)

⁴ Indicates that we are not aware of any background information.

3. Process of Transformation ⁵
 - A. Influence of habitat (i.e. reservoir v. natural river, increased depth/pressure, no or low flow, temperature) on:
 - i. Transformation start time
 - ii. Transformation end time
 - iii. Duration of transformation
 - B. What proportion of larvae meet criteria to begin transformation?
 - C. What stages of transforming lamprey are in the mainstem and where are they located?⁶
4. Larvae (lamprey which have not transformed and are thought to be obligatory (?) to fresh water).
 - A. Rearing
 - i. Are larvae in the mainstem, where, and how many?⁶
 - ii. What is the growth and survival of larval lamprey in the mainstem?
 - iii. What are the impacts of reservoir conditions (compared to free-flowing stream) on growth and survival of larval lamprey?
 - B. Behavior
 - i. Do larvae pass dams?⁷
 - ii. Where are larvae located (surface or lower in the water column)?
 - iii. What is the survival estimate based on the passage route?
 - a. Develop a mark-recapture technique/system.
 - b. Identify a source of juveniles (via broodstock or capture wild fish).
 - c. Test: paired-release studies.

⁵ Summarize specific information we have on transformation process.

⁶ Do not know stages present or abundance in the mainstem. Will know presence/absence by location.

⁷ Summarize JBS and transportation information for presence of juveniles/larvae (anecdotal data).

A. NPCC Fish and Wildlife program/BPA

In the Columbia River Basin, Pacific lampreys traditionally migrate hundreds of miles through both mainstem Columbia and Snake River habitats, encountering a variety of obstacles that could negatively affect their populations. Large mainstem hydropower dams, were designed or have been modified primarily to effectively pass salmon and Steelhead. However, these dams delay and obstruct adult and juvenile lamprey passage. Predation may also be a limiting factor for mainstem passage of lamprey. Juvenile lamprey have been observed in the stomach contents of Smallmouth Bass and Northern Northern Pikeminnow in the tailraces of lower Columbia River federal dams, and adult lamprey have been observed being taken by California sea lions downstream of Bonneville Dam.

1. Adult Behavior-upstream passage

- a. Restore lamprey passage and habitat in the mainstem and in tributaries that historically supported spawning lamprey populations.
- b. For example, passage through the hydrosystem causes loss to salmon, Steelhead, lamprey, and some resident fish. Measures at the dams can and should be taken to reduce this loss.
- c. Improve adult Pacific lamprey passage survival and reduce delays in migration through mainstem hydroelectric projects.
- d. The ultimate survival and successful spawning of adult fish are a high Council priority because returning adults determine the size and health of future fish populations.
- e. The U.S. Army Corps of Engineers should improve the overall effectiveness of the adult fish passage program.
- f. Specific Measures:
 - i. Identify specific fish passage structures;
 - ii. Identify operations at mainstem hydropower dams that delay, obstruct or kill migrating lamprey;
 - iii. Develop and implement lamprey passage aids at known passage obstacles;
 - iv. Monitor lamprey passage at mainstem hydropower dams to evaluate passage improvement actions and to identify additional passage problem areas;
 - v. Assess lamprey passage efficiency, direct mortality and/or other metrics relating to migratory success of lamprey; and
 - vi. Determine predation on lamprey during mainstem passage.
 - vii. The Council will consult with state and federal fish and wildlife agencies and tribes, the Independent Scientific Advisory Board, and federal operating agencies to determine the possibility of adopting hydrosystem survival performance standards for non-listed populations of anadromous fish, including lamprey.
 - viii. Expediting schedules to design and install improvements to fish passage facilities.
 - ix. Where it is beneficial, cool water releases from reservoirs should continue to be used to facilitate adult migration.
 - x. More emphasis should be placed on research; monitoring and evaluation;

- xi. Increased accuracy of fish counts and evaluate adult survival (conversion rates).
 - 1. expansion of fish counting to all species of interest; including lamprey,
 - 2. installation of PIT-tag and radio-tag detectors;
 - 3. evaluation of escapement numbers to spawning grounds and hatcheries;
- xii. Research into water temperature and spill effects on fish passage;
- xiii. Research into the connection between fish passage design and fish behavior. In particular as a priority for the Corps of Engineers' capital construction program, implement structural improvements to correct adult fish passage problems or improve reliability of adult passage facilities and report annually to the Council on progress.
- xiv. The federal action agencies should also evaluate the extent of marine mammal predation on salmonids, sturgeon and Pacific lamprey in the lower Columbia River from below Bonneville Dam to the mouth of the river.

2. Adult Spawning and Habitat

- a. Restore lamprey passage and habitat in the mainstem and in tributaries that historically supported spawning lamprey populations.
- b. As an offset for hydrosystem-caused losses, the program may also call for improvements in spawning and rearing habitats in tributaries, the lower river, and estuary. By restoring these habitats, which were not damaged by the hydrosystem, the program helps compensate for the existence of the hydrosystem.
- c. Habitat considerations extend beyond the tributaries, however. Historically, the mainstem Columbia and Snake Rivers were among the most productive spawning and rearing habitats for salmonids and provided essential resting and feeding habitat for mainstem resident and migrating fish. Protection and restoration of mainstem habitat conditions must be a critical piece of this habitat-based program.

3. Juvenile Behavior – downstream passage

- a. Improve juvenile Pacific lamprey passage survival and reduce delays in migration through mainstem hydroelectric projects.
- b. Specific Measures
 - i. Identify specific fish passage structures;
 - ii. Identify operations at mainstem hydropower dams that delay, obstruct or kill migrating lamprey;
 - iii. Develop and implement lamprey passage aids at known passage obstacles;
 - iv. Monitor lamprey passage at mainstem hydropower dams to evaluate passage improvement actions and to identify additional passage problem areas;
 - v. Assess lamprey passage efficiency, direct mortality and/or other metrics relating to migratory success of lamprey; and
 - vi. Determine predation on lamprey during mainstem passage.
 - vii. The Council will consult with state and federal fish and wildlife agencies and tribes, the Independent Scientific Advisory Board, and federal operating agencies to determine the possibility of adopting hydrosystem survival

performance standards for non-listed populations of anadromous fish, including lamprey.

4. Juvenile Rearing
5. Process of Transformation
6. Larvae Rearing
7. Larvae Behavior
8. Other/General
 - a. Continue restoring the characteristics of healthy lamprey populations.
 - b. Attain self-sustaining and harvestable populations of lamprey throughout their historical range.
 - c. Mitigate for lost lamprey production in areas where restoration of habitat or passage is not feasible.
 - d. Under the Northwest Power Act, however, the Council has an obligation to protect, mitigate and enhance all the fish and wildlife of the Columbia Basin affected by the development, operation and management of the hydrosystem. Concern over the listed populations is only one part of the Council's broader mandate. Therefore, a goal of the Council's program, as set forth in the program's vision statement, is to provide habitat conditions that sustain abundant, productive, and diverse fish and wildlife populations that support the recovery of listed species and abundant opportunities for tribal trust and treaty-right harvest and non-tribal harvest.

B. Tribal Pacific Lamprey Columbia Basin Restoration Plan

Plan Goal: Immediately halt population declines and reestablish lamprey as a fundamental component of the ecosystem by 2018. Restore Pacific lamprey to sustainable, harvestable levels throughout the historical range and in all tribal usual and accustomed areas.

The emphasis of this Tribal Restoration Plan is to provide an explicit and timely path, including specific actions that can be implemented in the next ten years for both the mainstem Columbia/Snake Rivers and associated tributary streams. The ultimate goal is restoration of Pacific lamprey to levels supportive of their unique cultural and ecosystem values. Our primary objectives include 1) improving mainstem passage and survival, 2) improving tributary habitat conditions, 3) implementing translocation/re-introduction actions and 4) continuing research to improve our understanding of their life history and biology.

1. Adult Behavior

Improve mainstem lamprey passage efficiency, survival and habitat. The overarching goal of this objective is to achieve the same rate of adult passage survival through the hydrosystem area without delayed passage impacts as if the hydrosystem was not present. Improving lamprey passage efficiency. Reduction of passage timing.

 - a. Specific Measures
 - i. Determine adult passage rates for each route of passage at each mainstem dam
 - a. It is important to secure accurate adult lamprey counts at mainstem dams to provide an index of population abundance over time.

- b. There is an immediate need to establish and maintain, as a very high priority, 24 hour counts for adult lamprey at all mainstem dams.
 - c. The use of half duplex PIT-tag and radio telemetry techniques can be incorporated with dam counts to provide more assessment of lamprey dam passage accurate counts (Peery 2007).
 - ii. Determine individual and cumulative impacts of mainstem hydroprojects (dams and reservoirs) on lamprey.
 - iii. Identify and apply scheduled structural and operational improvements to achieve volitional adult passage standards approximating the best known achievable rates at mainstem dams and reservoirs (i.e. 80% passage efficiency at The Dalles).
 - a. Fishway surveys – all fishways surveyed and inventoried for structural improvements
 - b. Inspections – protocols established at all dams for formal inspection and annual lamprey passage reporting
 - c. Prioritization – for needed actions
 - d. Grating replacement
 - e. Counting – 24 hour video counting
 - f. Night time fishway flow rates – implement and evaluate decreased nighttime fishway flows
 - g. Corners – blunt or round off
 - h. Plates – install over diffusers
 - i. Ramps – install at sills and lips and evaluate
 - j. Ladder dewatering – evaluated and improved with lamprey in mind
 - k. Fishway entrances and transition pools – modified to improve lamprey passage
 - iv. Implement flow regimes to benefit adult lamprey passage and survival.
 - v. Determine water quality impacts of hydroprojects on lamprey and implement actions to reduce these impacts.
 - vi. Assess and address impacts of irrigation water withdrawal structures on adult lamprey.
 - vii. Assess and address irrigation related water quality impacts on adult lamprey.
 - viii. Implement actions to address excessive hydro-related avian, piscivorous and marine mammal predation.
- 2. Adult Spawning
 - a. Specific Measures
 - i. Inventory and protect spawning habitat in reservoirs
- 3. Juvenile Behavior

Improve mainstem lamprey passage efficiency, survival and habitat. The overarching goal of this objective is to achieve the same rate of juvenile passage survival through the hydrosystem area without delayed passage impacts as if the hydrosystem was not present.

 - a. Specific Measures
 - i. Determine discrete and cumulative impacts of hydro projects (dams and reservoirs) on lamprey populations.
 - a. Improving flow regimes appears to be a good restoration strategy to speed juvenile lamprey to saltwater, conceal juveniles from predation as well as decreasing duration of exposure to predators, disease and increasing water temperatures.

- b. Impingement
 - c. Turbine and spill impacts
 - ii. Aggressively pursue development of juvenile lamprey tag technology. Determine juvenile passage and survival rates via each route of passage at each dam.
 - iii. Implement flow regimes to benefit juvenile lamprey passage and survival.
 - iv. Develop structures and project operations at each dam and reservoir to facilitate juvenile lamprey passage and survival and reduce migration delays.
 - v. Establish juvenile passage standards.
 - vi. Determine water quality impacts of hydro projects on juvenile lamprey populations.
 - vii. Assess impacts of irrigation water withdrawal structures and correct defective structures.
 - viii. Implement actions to address excessive hydro-related avian, piscivorous and marine mammal predation on juvenile lamprey.
- 4. Juvenile Rearing
 - a. Specific Measures
 - i. Inventory and protect rearing habitat in reservoirs.
- 5. Process of Transformation
- 6. Larvae Rearing – included in juvenile rearing
- 7. Larvae Behavior – included in juvenile behavior
- 8. Reintroduction and Translocation
 - a. Specific Measures
 - i. Implement and monitor translocation or supplementation programs from mainstem dams to upstream watersheds
 - a. Nez Perce translocation
 - 1. Coordinate with U.S. Army Corps of Engineers main stem dam fishway dewatering activities for the salvage and collection of adult lamprey. Establish a tribal-Corps technical team with both the Portland and Walla Walla District biologists and dam operators.
 - 2. Establish adult collection facilities at select main stem projects to facilitate translocation efforts.
 - 3. Target 500 adult Pacific lamprey to be translocated from main stem dams to Snake River tributaries annually.
 - 4. Hold transported adults for over wintering at the Nez Perce Tribal Hatchery within the Nez Perce Reservation.
 - 5. Release over-wintered adults in the spring into target spawning streams. A subset of the target streams will be stocked on an annual, ongoing basis. Use radio-telemetry methods to monitor and evaluate passage and, where possible, spawning success for a sample of these individuals.
 - 6. Collect ammocoete data to evaluate effectiveness of the translocation efforts.
 - b. Umatilla translocation
 - 1. Coordinating with U.S. Army Corps of Engineers mainstem dam fishway dewatering activities for the salvage and collection of adult lamprey
 - 2. Establishing adult collection facilities at select mainstem projects to facilitate translocation effort

3. Targeting 500 adult Pacific lamprey to be translocated from mainstem dams to the Umatilla River and tributaries annually.
 4. Holding transported adults for overwintering at the South Fork Walla Walla River Adult Lamprey Holding facility and Minthorn Springs Adult Lamprey Holding facility
 5. Releasing over-wintered adults in the spring into the Umatilla River Basin
 6. Long-term monitoring of translocation success
9. Status Monitoring and Research
- a. Monitor lamprey population status and trends
 - b. Establish regional data protocols for collection, storage and analysis.
 - c. Develop means to widely access and share information.
 - d. Expand existing knowledge on limiting factors and critical uncertainties
 - e. Determine genetic structure and maintain genetic integrity
 - f. Evaluate the need for a lamprey aquaculture facility based upon a limiting factor analysis
10. Education and Outreach
- Establish, coordinated public education and other outreach programs to communicate and establish:
- a. An awareness of the importance of Pacific lamprey and their current status and
 - b. The need to implement actions in this plan to restore them throughout the Columbia River Basin,
 - c. The consequences of failing to act.
11. Tributary Action Plans
- a. Specific Measures – general for subbasins
 - i. Describe ammocoete distribution and relative abundance
 - ii. Status monitoring
 - iii. Identify tributary passage problems
 - iv. Genetic libraries
 - v. Describe outmigration timing and abundance
 - vi. Describe historic and current use by adult lamprey
 - vii. Document and describe life history types
 - viii. Improve knowledge of lamprey habitats
 - ix. Broaden understanding of population dynamics
 - x. Describe and address limiting factors for all life stages
 - xi. Develop, implement and monitor lamprey restoration projects
 - xii. Restore historic lamprey distribution and maintain harvestable population size
 - xiii. Disseminate information and collaboration

C. 2008 Columbia River Fish Accords

3.0 MUTUAL COMMITMENTS OF THE ACCORDS

Under the terms of the Accords, the parties are committing to implement projects for the benefit of fish affected by the FCRPS, to be funded primarily by BPA. The focal point of the agreements is to provide actions to help ocean-going (anadromous) fish listed under the Endangered Species

Act. The agreements also provide actions to help other fish in the Basin, including non-ocean-going (resident) stocks in Montana such as the listed bull trout, as well as for non-listed anadromous and resident species in the Basin, such as Pacific Lamprey. The agreements are intended to work in concert with draft Biological Opinions for the FCRPS and Upper Snake developed by NOAA Fisheries and released for public review on October 31, 2007, and with the final versions of those Biological Opinions set for release on May 5, 2008.

3.2.9 Lamprey actions

The Pacific Lamprey, though not a listed species, are of considerable importance to the Three Treaty Tribes, who use the fish for food and medicine. The parties agreed upon a suite of actions to address concerns about the decline in lamprey populations both to address the tribal interests and to help avoid a listing of the species in the future. BPA's commitment to the lamprey effort includes funding of up to \$18.66 million in projects over the term of the Agreement.²⁴ In addition, because the Corps also has made commitments to address lamprey passage issues at Corps-managed facilities,²⁵ BPA would expect to repay to the Treasury the power share of any capital construction changes the Corps implements through Congressional appropriations to address lamprey.

5.1.3 BPA's compromises to reach agreement are reasonable

As is the nature of such accords, the parties had to make some compromises in their respective positions and objectives to reach agreement. For BPA, the compromises came in agreeing to support some activities that BPA might otherwise assign a lower priority for funding. While all the activities proposed for implementation are consistent with the Council's Program (and are thus in compliance with BPA obligations under the Northwest Power Act), this does not mean that the activities would otherwise have been a priority for BPA. For example, in the 2007-2009 Council solicitation process, the Three Treaty Tribes sought a variety of projects for lamprey research, which BPA generally declined as not an FCRPS priority.¹³⁸ Through the course of negotiations, BPA was persuaded that the health of lamprey populations are of such critical importance to the Tribes that agreeing to support lamprey work was essential to reaching agreement, and BPA was willing to compromise to support that work. The parties also believed it would be beneficial to undertake this work to help preclude a future listing of the species as endangered or threatened.

5.2.3.3 The Agreements Support Equitable Treatment for Fish and Wildlife

The Northwest Power Act requires that BPA exercise its FCRPS management responsibilities "in a manner that provides equitable treatment for fish and wildlife with the other purposes for which such system and facilities are managed and operated."¹⁵⁴ The Council describes equitable treatment as "meet[ing] the needs of salmon with a level of certainty comparable to that accorded the other operational purposes."¹⁵⁵ Historically, BPA has provided equitable treatment on a system-wide basis primarily by implementing the Council's integrated fish and wildlife program and relevant Biological Opinions related to FCRPS operations.¹⁵⁶ The Columbia Basin Fish Accords continue this tradition. They support and expand on BPA's commitments in the draft FCRPS Biological Opinion. They also go beyond mitigation for ESA-listed species and include commitments to other species of interest affected by hydro operations, such as Pacific lamprey. Overall, the Accords in combination with the BiOps provide a higher level of financial and

operational certainty for fish, further solidifying BPA's efforts to manage the FCRPS equitably for both fish and power.

6.2.3 Consistency with The PA 2002

Fourth, the PA 2002 considers that a balanced management approach for both listed and non-listed fish and aquatic species should be used. This Policy Direction allows for substantial human intervention to protect habitat and enhance degraded habitat for fish and wildlife, especially in areas designated as critical habitat. The Accords meet this objective by ensuring that both listed and non-listed fish and aquatic species are addressed. Projects under the Accords target fish populations and habitat including both ESA listed species and resident fish. These projects include: habitat acquisition and restoration and other habitat conservation methods; waterway nutrient enhancement; water transaction funding; research, monitoring, and evaluation; hatchery operation, production, and new facilities; harvest; and a comprehensive lamprey improvement program. The Accords include habitat protection and enhancement projects for listed fish and habitat enhancement for non-listed fish. Under the terms of the Accords, Parties will work with the Council and ISRP on project reviews, and in particular BPA and the Tribes will recommend that the ISRP review projects collectively on a subbasin scale. These actions are consistent with the approach to addressing habitat under the PA 2002.

D. U.S. Army Corps of Engineers 10 year plan for passage at dams

1. Overall Program
 - a. Employ an adaptive management approach.
 - b. Work with the tribes and the USFWS towards developing its existing 5-year lamprey plan into a 10-year plan, covering both adult and juvenile passage issues.
 - c. Program \$1.8 million in 2008 with funding ramping up to \$2-\$5 million for 10 years.
2. Adult Behavior
 - a. Specific Measures – MOA Adult Lamprey
 - i. Address adult lamprey conditions in the main stem hydropower projects using PIT/radiotelemetry to determine overall effectiveness including the following.
 - ii. Develop numerical passage metrics through the Lamprey Technical Workgroup.
 - iii. Conduct site inspections of each dewatered fish ladder.
 - iv. Evaluate, fully develop and implement as warranted Lamprey Auxiliary Passage Systems (LAPS).
 - v. Evaluate reducing entrance flows at night to assist lamprey entrance passage; and as warranted, expand through FCRPS main stem dams.
 - vi. Complete keyhole entrances Cascade Island 2009 and John Day North 2010/2011 then implement as warranted through FCRPS main stem dams.
 - vii. Inventory all picketed leads, fish way cracks, blind openings and ladder exits. Begin replacing existing grating with new 3/4" grating in most identified problem areas.
 - viii. Round sharp corners as warranted.
 - ix. Develop feasibility, techniques and protocols for counting.
3. Adult Spawning

New acoustic tags and monitoring systems (nodes and mobile tracking systems) can detect lamprey at depth and are being developed to better investigate the fate of adult lamprey in reservoirs.

4. Juvenile Behavior – MOA Juvenile Lamprey
 - a. Specific Measures
 - i. Continue to monitor the passage of juvenile lamprey collected at projects with juvenile fish bypass facilities.
 - ii. Replace with smaller gap screens as warranted when turbine intake bar screens are in need of replacement.
 - iii. Consider lifting extended length screens (primarily at McNary but also at Columbia and Snake River dams) in consultation with the NOAA and the Tribes.
 - iv. Develop prototype Lamprey separators.
 - v. Work actively with industry to further miniaturize active tags then determine passage routes, outmigrant timing and survival of lamprey through FCRPS main stem dams.
5. Juvenile Rearing
6. Process of Transformation
7. Larvae Rearing
8. Larvae Behavior
9. Monitoring, Research and Evaluation
 - a. Adults
 - i. Lamprey counts – develop a more accurate strategy
 - a. Night time video counts
 - b. Lamprey PIT detection
 - c. LPS counts
 - b. Juveniles
 - i. Screens – modification to minimize impingement
 - ii. Bypass Systems – effect of on juvenile lamprey
 - iii. Separator – modification to pass juvenile lamprey
 - iv. Tag Development
10. Potential Future Actions - based on success of current actions
 - a. Diffuser gratings – modification of
 - b. Rounding of corners
 - c. Auxiliary Water Supply Channels/Cul-De-Sacs – use of LPS

E. U.S. Fish and Wildlife Service Pacific Lamprey Conservation Initiative

The goal of the Conservation Plan (Plan) is to restore and sustain Pacific lamprey populations throughout their historical range by coordinating conservation efforts among states, tribes, Federal agencies, and other involved parties. This Plan development and any subsequent Conservation Agreements will rely on voluntary participation from a variety of entities.

The primary objectives of the initial phase of conservation efforts will be to implement actions known to benefit Pacific lampreys, to minimize threats to their existence, and improve understanding of them in order to recover their abundance and distribution.

Preliminary discussions have indicated that the Plan will resemble a recovery plan for a listed species (even though lampreys are not listed), but the goal will be conservation such that listing is not necessary because threats to the species will be reduced. It is expected that while the Service would facilitate this effort, it would do so with partners that are interested in the development of this Plan and implementation of its subsequent conservation actions.

1. Expected Plan Outcomes

- a. An enhanced description and tracking of current knowledge of Pacific lamprey life history, biology, and habitat requirements.
- b. Identification of Pacific lamprey populations, and their current distribution, abundance, and population structure.
- c. A rangewide map of historical and current Pacific lamprey distribution.
- d. Description of known threats and reasons for decline.
- e. Identification and implementation of a strategy for restoring Pacific lamprey populations that includes:
 - i. prioritized threats and actions to address them,
 - ii. prioritized restoration actions,
 - iii. prioritized research, monitoring, and evaluation needs,
 - iv. identified partnerships and potential funding sources to implement actions.

2. Rangewide Recommended Actions Needed To Initiate Conservation

The full range of conservation actions has not yet been developed and ultimately will be accomplished through partnerships. This includes coordination with Tribes, States, local governments, federal agencies and private landowners. Heightened public awareness will play a role in generating voluntary efforts to implement these actions. Conservation efforts should build upon ongoing research and monitoring efforts. Actions that should be undertaken early in the process include the following:

- a. Conserve, enhance and restore habitat for Pacific lampreys by addressing them in current aquatic projects, fisheries management, and monitoring plans.
- b. Identify specific structures or operations that obstruct migrating lampreys, develop aids to passage (e.g., modify structures or operations, provide lamprey-specific fishways, or bypasses) and develop passage criteria.
- c. Prioritize research studies that provide information to aid in the mitigation of known threats and limiting factors of Pacific lampreys.
- d. Conduct rangewide surveys to assess the range, status, and trends of populations of Pacific lampreys.
- e. Assess population structure to identify population management units and conservation emphasis areas.
- f. Assess the influence of disease on Pacific lamprey populations.
- g. Assess the influence of contaminants on Pacific lamprey populations.
- h. Assess the influence of current and forecasted climate change to adult holding and juvenile incubation temperature tolerances.
- i. Create an outreach and information program specific to Pacific lampreys.

3. Research, Monitoring and Evaluation

- a. Improved understanding of status, distribution, and migratory behavior,
- b. Improved understanding of Pacific lamprey biology/ecology and the assessment of limiting factors to identify and ensure the long-term protection of priority habitats.
- c. Improved understanding of life history characteristics of Pacific lampreys.
- d. Identification and assessment of threats and effectiveness of treatments to reduce effects of threats to Pacific lampreys.
- e. Identification of conservation and restoration actions that result in improvements in conditions for all life history stages
- f. Improved understanding of Pacific lamprey population dynamics and genetic (population) structure.

F. Critical Uncertainties for Lamprey in the Columbia River Basin: Columbia Basin Fish and Wildlife Authority-Columbia River Lamprey Technical Workgroup

1. Anadromous Lamprey Status

- a. Ranking: Imminent (Biological Benefit = 4.5; Knowledge Gap = 3)
- b. Strategies:
 - i. Develop methods to differentiate among species at all life stages (field-based)
 - ii. Develop standardized sampling protocols and conduct systematic basin-wide surveys to assess adult and juvenile abundance and distribution
 - iii. Review historic databases to better understand historic distributions and abundance
 - iv. Define, improve, and continue historic distribution and abundance indices (e.g., dam counts, tribal harvest records, smolt trap collections, etc)
 - v. Coordinate information exchange with existing and future projects not targeting lamprey specifically

2. Anadromous Lamprey Passage

- a. Ranking: Imminent (Biological Benefit = 4.5; Knowledge Gap = 3)
- b. Strategies:
 - i. Identify potential obstacles to passage (e.g., loss of recruitment upstream from a potential obstacle, observation of lamprey aggregations or mortalities at potential obstacles during migration periods)
 - ii. Assess passage efficiency, direct mortality, and/or other metrics that relate to loss of fitness (i.e., stresses or injuries that reduce ability to reproduce)
 - iii. Determine the specific structures or operations that delay, obstruct, or kill migrating lamprey
 - iv. Develop aids to passage (e.g., modify structures or operations, provide lamprey-specific fishways, or bypasses)
 - v. Monitor lamprey passage to evaluate aids to passage and to identify any new passage problems that might occur

2. Anadromous Lamprey Population Delineation

- a. Ranking: Highly Important (Biological Benefit = 4; Knowledge Gap = 4.5)
- b. Strategies:

- i. Supplement existing libraries of genetic markers for lamprey (e.g., microsatellites, single nucleotide polymorphisms)
 - ii. Build and maintain lamprey tissue collections from the CRB and neighboring basins
 - iii. Investigate other methods to delineate populations
 - iv. Determine if anadromous lamprey in the CRB represent a panmictic population (completely mixed)
- 4. Anadromous Lamprey Limiting Factors
 - a. Ranking: Highly Important (Biological Benefit = 4; Knowledge Gap = 4)
 - b. Strategies:
 - i. Document habitat preferences and habitat availability for all life stages of anadromous lamprey
 - ii. Evaluate the physiological and behavioral responses of lamprey to a variety of environmental stressors (e.g., capture and handling, elevated temperatures, contaminant exposure, sedimentation)
 - iii. Assess trophic relationships (e.g., predation by exotics, reduced host availability)
- 5. Anadromous Lamprey Restoration
 - a. Ranking: Important (Biological Benefit = 3.5; Knowledge Gap = 3)
 - b. Strategies:
 - i. Identify ongoing restoration activities and their effects on lamprey
 - ii. Develop, implement, and evaluate lamprey-specific restoration projects (restoring natural processes in the absence of information on limiting factors)
 - iii. Develop, implement, and monitor reintroduction methods (e.g., transplantation, hatchery production)
- 6. Anadromous Lamprey Biology/Ecology
 - a. Ranking: Important (Biological Benefit = 3; Knowledge Gap = 4)
 - b. Strategies:
 - i. Understand the ecological function of anadromous lamprey (e.g., predator/prey relationships, linkages to other aquatic and terrestrial organisms)
 - ii. Understand the biology of anadromous lamprey (e.g., reproduction, feeding)
 - iii. Develop methodology for gender identification in the field and laboratory (e.g., identify spawning sex ratios, sex related behavioral characteristics).
 - iv. Develop aging techniques
 - v. Assess life history characteristics of freshwater and ocean-phase anadromous lamprey (e.g., age, growth, timing of metamorphosis, movement, basin-specific comparisons)
- 7. Anadromous Lamprey Population Dynamics
 - a. Ranking: Needed (Biological Benefit = 1.5; Knowledge Gap = 5)
 - b. Strategies:
 - i. Estimate demographic rate parameters capable of changing the size of populations such as birth, death, immigration, and emigration rates
 - ii. Build life tables

- iii. Develop a predictive model to assess the rate of increase/decrease of lamprey populations in the CRB including abiotic and biotic factors

G. Passage Considerations for Pacific Lamprey: Columbia Basin Fish and Wildlife Authority-Columbia River Lamprey Technical Workgroup

The following summary of passage considerations for Pacific lamprey was developed in response to concerns raised regarding the passage of both adult and juvenile lamprey through culverts. Due to the lack of information available, specific passage criteria are not defined in this document. However, we identified data gaps and research needed to address these concerns.

Relatively little is known about the migration behavior of Pacific lamprey and the cues that they use to orient and navigate. The following basic information is needed to better assess lamprey use of culverts:

1. Adult Behavior
 - a. information on the mechanisms of migration initiation
 - b. availability and quality of attachment surfaces in culverts
 - c. the ability of lamprey to enter perched culverts (or any structure that featured an overhanging lip or vertical barrier)
 - d. the effects of lighting at culverts
2. Adult Spawning
 - a. the cues adult lamprey use to find spawning areas.
3. Juvenile/Larvae Behavior
 - a. the extent to which ammocoetes move upstream
 - b. behavior of ammocoetes and macrophthalmia in strong currents
 - c. the effects of lighting on behavior
4. Juvenile/Larvae Rearing
5. Process of Transformation

A. ISAB Snake River Spill-Transport Review

Question 4. What are the possible impacts of alternative spill-transport scenarios on other native species, in general, and on Pacific lamprey and Snake River sockeye, in particular?

ISAB Response 4. The impacts of alternative spill-transport scenarios on native species are expected to vary greatly, and careful consideration of several viewpoints, including impact on many populations, groups of species, ecological processes and habitats, is advised. Unfortunately, the limited data impede quantitative analyses of alternative scenarios.

For example, the magnitude of the impact of spill-transport scenarios on Pacific lamprey is unknown, due to a paucity of data. Evidence exists that juvenile lamprey are killed during downstream migration through the hydrosystem by impingement on bar screens, but the

magnitude of this mortality is unknown. There is some evidence that bar screens could be designed to reduce mortality due to impingement. However, dams also impede the upstream migration of adult lampreys, and that modifications to improve upstream passage may do more to improve the viability of lamprey populations than modifications to bar screens.

ISAB Recommendations:

3. Studies should be conducted to reduce critical uncertainties related to the impact of spill-bypass-transport operations on downstream juvenile lamprey migration, including estimation of the population; evaluation of the effect of bar screen design on mortality and migration route; and estimation of mortality rates due to route of hydrosystem passage. Furthermore, the hydrosystem's impact on the entire life cycle of Pacific lamprey should be thoroughly investigated in a timely manner.

CRITFC (Review of Snake River spill and transport operations, April 22, 2008)

4. What are the possible impacts to the small remaining populations of Pacific lamprey in the Snake River and Upper Columbia with the continuation of the use of screen bypass systems and transportation and the reduction of spill and surface bypass? Will the continued use of these systems increase the probability of extirpation of Pacific lamprey in these areas?

In an internal memo to CRITFC, Lorz (1998) provided early empirical evidence of impingement of juvenile lamprey on extended-length bar screens (ESBS) used to direct juvenile salmonids to bypass systems at dams. Depending on the screen size of the guidance structure, lamprey are injured or killed by wedging in the screens. ISAB (1999) pointed out that installation of extended-length bar screens that harmed lamprey or other non-salmonid species would be inconsistent with objectives to restore lamprey populations and maintain biodiversity in the Columbia River Basin.

Technology to reduce impingement

At this time, the impact of impingement on migrating juvenile lamprey is unknown.

Nevertheless it is worthwhile to consider factors, such as screen removal, modification of screen mesh size, and changes in spill-transport operations, that can potentially reduce impingement and thereby impact survival.

Reduction in the probability of extirpation

Pacific Lamprey are anadromous, and as for salmon, survival to maturity is determined by factors that operate in fresh water, estuarine, and marine habitats. These factors will also influence the viability of lamprey populations.

The major points identified in the ISAB response to key questions include:

There are insufficient data to provide an assessment of the impact of extended length bar screens, spill, and transport on downstream migrating lamprey in the Columbia River Basin. Existing data point to adult passage mortality at mainstem dams as a key factor limiting recovery of lamprey populations in the Basin, but juvenile mortality during passage through the hydrosystem also could be influential.