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# Outline of the Pacific Lamprey Conservation Plan

## Introduction

Pacific lampreys (*Lampetra tridentata*) historically 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, for nutrient cycling and storage, and as a prey buffer for other species.

Conservation interest in Pacific lampreys has grown in recent years, with increasing attention from Tribes, agencies, and others. In 2003, four lamprey species were petitioned for listing under the Endangered Species Act: the Pacific, western brook, Kern brook, and river lamprey. For the Pacific lamprey, the U.S. Fish and Wildlife Service (Service) review of the petition indicated a likely decline in abundance and distribution throughout California, Oregon, Washington, and Idaho, and the existence of both long-term and proximate threats to this species. However, the petition did not adequately define what portion of the species range should be listed under the Endangered Species Act; hence no status review was initiated (U.S. Fish and Wildlife Service 2004).

It is the Service's strategy to improve the status of lampreys by proactively engaging in a concerted conservation effort. In addition, the Service has determined that an incremental approach to the conservation of each petitioned species is the best avenue given limited time and resources. Consequently, the Service is suggesting that the initial effort focus on Pacific lamprey, as our level of knowledge and status relative to Pacific lamprey, compared the other petitioned species, is significantly greater. The Service feels that this will allow our agency and co-managers to move forward in a more constructive time-frame. This collaborative conservation effort will facilitate opportunities to address threats, restore habitat, increase our knowledge of Pacific lampreys, and improve distribution and abundance of Pacific lampreys.

## Conservation Strategy

### **Goal**

The goal of this 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.

### **Objectives**

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.

### **Strategy**

The overall strategy will involve the Service as the coordinating agency to engage entities willing to participate and coordinate conservation efforts; facilitate increased knowledge about distribution, abundance, population structure, and threats; and work with partners in the development of strategies for restoring Pacific lamprey populations. Coordination of efforts with Tribes is essential to the success of this Plan.

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### **Partnerships**

The development and implementation of the Plan will be 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.

### **Development and Organization of the Plan**

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.

### **Expected Plan Outcomes**

- 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.
- Identification and implementation of a strategy for restoring Pacific lamprey populations that includes:
  - prioritized threats and actions to address them,
  - prioritized restoration actions,
  - prioritized research, monitoring, and evaluation needs,
  - identified partnerships and potential funding sources to implement actions.

### **Current Pacific Lamprey Activities** (known to date)

#### **Management**

The following efforts have occurred or are underway for the benefit of lamprey conservation:

- Discussions between the Service and the Army Corp of Engineers (ACOE) to address lamprey passage and research needs.
- The Columbia River Intertribal Fish Commission (CRITFIC) is developing a plan for Pacific lamprey in the Columbia River Basin.
- The Service initiated the Pacific Lamprey Conservation Initiative (USFWS 2007).
- The Columbia River Basin Lamprey Technical Workgroup published: Critical Uncertainties for lamprey in the Columbia River Basin (CRBLTWG 2005).
- Idaho has developed a Draft Management Plan for Conservation of Pacific lamprey in Idaho (IDFG 2008).
- Oregon Native Fish Status Report addresses Pacific lamprey in Oregon (ODFW 2005).

#### **Passage**

Efforts to improve upstream passage specifically for lampreys are limited to areas primarily in the Columbia River Basin and include:

- Lamprey Alternative Passage Systems (LAPS) have been installed on both the north and south sides of Bonneville Dam.

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- LAPS designs are underway for passage over Three Mile Dam on the Umatilla River and Willamette Falls on the Willamette River.
- Modifications are being made in the salmonid fish ladders at ACOE facilities on the McKenzie River and on other Columbia River dams to make them more passable by adult Pacific lamprey.

### **Reintroduction**

The Confederated Tribes of the Umatilla Indian Reservation began a reintroduction program in the Umatilla River in 1998. In 2007, the Nez Perce Tribe relocated adult Pacific lamprey into tributaries of the Clearwater River drainage and Asotin Creek.

### **Monitoring / Research for Pacific lampreys**

Research and monitoring underway in Region 1 and Region 8 include the following activities:

- Research and monitoring in the Columbia River Basin began in the 1990s.
- Studies have been recently initiated in the Klamath River Basin.
- Current study is underway on the Elwha River, Washington.
- Several studies are underway in the Willamette River and coastal rivers of Oregon.
- Tribes, State and Federal agencies are now beginning to incorporate the needs of lampreys into other fisheries management and monitoring plans.

### **Habitat Management and Protection**

Each of the five states in the range of Pacific lamprey has completed a Comprehensive Wildlife Conservation Strategy and Action Plan in order to receive federal funds. The plans identify species of need and conservation actions required, including habitat management and protection activities. A summary of global, state, federal, local, and Canadian Pacific lamprey status is listed in Table 1.

### **Background**

#### **Species Description**

Pacific lamprey belong to the genus Lampetra in the family Petromyzontidae and subfamily Petromyzontinae, a primitive group of fishes that are eel-like in form but lack jaws and paired fins. These species have a round sucker-like mouth (oral disc), no scales, and multiple gill openings instead of an operculum. Adult Pacific lampreys are characterized by the presence of three large teeth (cusps) and posterior teeth on the oral disc (Wydoski and Whitney 1979; Moyle 2002). Their lack of paired fins and elongated body shape causes them to swim by using an undulatory (snakelike) movement (Mesa et al. 2002; Moyle 2002). They do not have swim bladders that allow them to maintain neutral buoyancy and must, therefore, swim constantly or hold fast to objects to maintain their position in the water column (Liao 2002; Mesa et al. 2002).

#### **Life History**

As adults, Pacific lampreys are parasitic and feed on a variety of marine and anadromous fish. They are preyed upon by sharks, sea lions, and other marine animals. They have been caught in depths ranging from 300 to 2,600 feet (90 to 800 meters), and as far as 62 miles (100 kilometers) off the coast in ocean haul nets (Close et al. 2002).

After spending 1 to 3 years in the marine environment, Pacific lampreys return to freshwater between February and June (Kostow 2002; Moyle 2002). They are thought to overwinter and

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**Table 1. A summary of Pacific lamprey status.**

Entity	NatureServe Rank	State Designation	Notes
Global	G5		Widespread distribution around the margins of the northern Pacific Ocean. Declining.
Alaska	S4/S5	Species in need of conservation	Their six species of lampreys were combined into one group for conservation purposes.
California	S4	None	
Idaho	S1	Species in need of conservation Endangered	State priority species
Oregon	S3	Species in need of conservation Sensitive Species - vulnerable	State priority species City of Portland special status species
Washington	S3	Species in need of conservation	Proposed for WDFW Priority Habitat and Species List
USFWS		Species of Concern	
USFS		Sensitive Species	
BLM		Type 2	Rangewide/globally imperiled
Canada / BC	S4	Yellow list – secure	

***NatureServe Rank definitions:***

S1: Critically imperiled: at high risk because of extreme rarity, rapidly declining numbers, or other factors that make it particularly vulnerable to rangewide extinction or extirpation

S3: Rare, uncommon or threatened, but not immediately imperiled

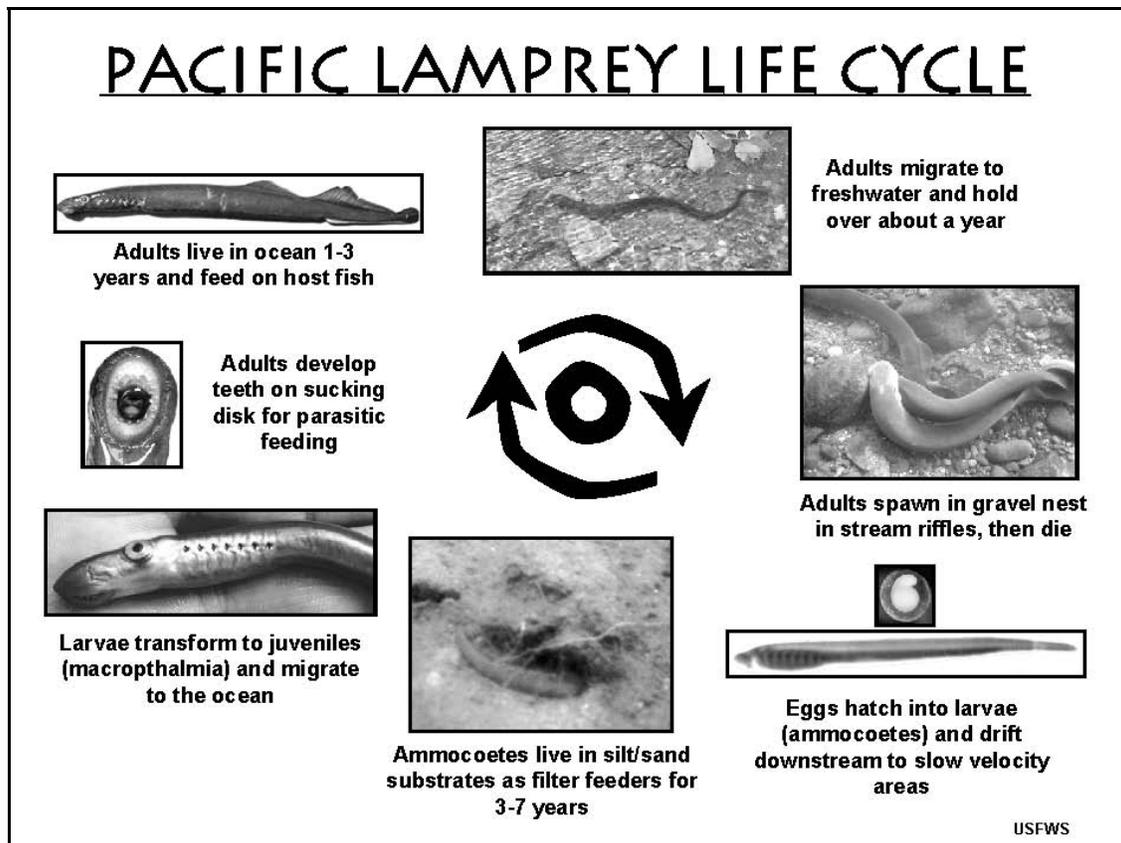
S4: Uncommon but not rare; some cause for long-term concern due to declines or other factors

S5: Secure, widespread, abundant

G5: Globally secure, widespread, abundant

remain in freshwater habitat for approximately one or two years before spawning. Pacific lampreys migrate upstream primarily at night. They spawn between March and July, depending upon location within their range (Beamish 1980), in gravel bottomed streams, at the upstream end of riffle habitat, typically above suitable ammocoete (larvae) habitat (Moyle 2002). Both sexes construct the nests, often moving stones with their mouths. After the eggs are deposited and fertilized, the adults typically die within 3 to 36 days (Kostow 2002).

Fecundity is high but variable, with females producing between 20,000 and 200,000 eggs (Moyle 2002). After the eggs are fertilized and deposited in the nest, embryos hatch in approximately 19 days at 59° Fahrenheit (15° Celsius). The young ammocoetes drift downstream to areas of low velocity and silt or sand substrate. They remain burrowed in the stream bottom, for 3 to 7 years, filter-feeding on algae and detritus (Kostow 2002; Moyle 2002). Once the ammocoetes reach about 6 in (15 cm), they begin metamorphosis into macrophthalmia (juvenile phase), (Moyle 2002; Wydoski and Whitney 2003). This takes place over several months as developmental changes occur, including the appearance of eyes and teeth, as they leave the substrate to enter the water column and begin their migration to salt water (Kostow 2002; Moyle 2002).



### Conservation Genetics

Emerging science has been investigating broad scale population structure in Pacific lampreys. Goodman et al. (In Press) found no significant population structure among 81 populations from six geographic regions from central British Columbia to southern California. Using a different genetic technique, Lin et al. (In Press) investigated population structure among eight populations from northern California to Alaska and Japan. Although slight differences in genetic diversity were apparent among regions (Japan, Alaska, and the Pacific Northwest) and sites, the data indicated high levels of shared genetic information. These studies both indicate high levels of historic gene flow among populations at levels sufficient to homogenize genetics.

The high level of historic gene flow indicated by these studies does not necessarily mean that all Pacific lampreys are a single homogenous population. Several points indicate that the population structure could be more complex. Goodman et al. (In Press) identified higher levels of diversity in samples from southern region drainages. Size differences have been observed in adult Pacific lampreys among some populations (Beamish 1980; Kan 1975) and different migration timings have been observed in some river drainages (Luzier and Silver 2005). All of these data suggest the potential for population structure not elucidated in current genetic studies.

### Aquatic Community

Pacific lampreys play an important role in their native stream ecosystems. Adults returning to headwater streams contribute rich marine nutrients to the food chain when they die and the carcasses decompose. As adults in the marine environment, Pacific lampreys are parasitic and feed on a variety of marine and anadromous fish. Adult lampreys are eaten by otters, sea lions, seals and

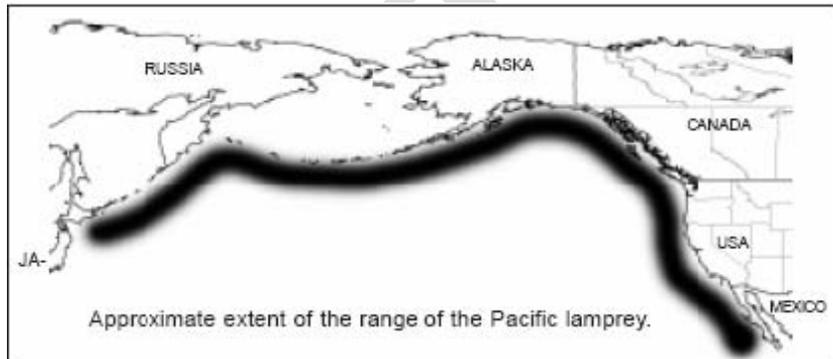
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sturgeon. American mink, birds, raccoons, various fish, and other species feed upon ammocoetes. It is theorized that when macrophthemia and ammocoetes are abundant, they provided a buffer to juvenile salmon predation by birds. Recent data also indicates that ammocoetes grow faster in the presence of mussels and that a decline in native freshwater mussels may have consequences for lamprey populations (M. Limm et al 2007).

### **Distribution & Abundance – Historical, Current, Unknown**

Comprehensive historical and current distribution and abundance data for Pacific lampreys is lacking, especially in areas beyond the coterminous U.S. Only a few observations of Pacific lampreys have been documented in Baja California, and little information is available for areas beyond Alaska around the Pacific Rim to Japan.

*Historical:* Pacific lampreys are thought to have been distributed wherever salmon and steelhead once occurred. Their range extends from Hokkaido Island, Japan, and around the Pacific Rim including Alaska, Canada, Washington, Oregon, Idaho, and California to Punta Canoas, Baja California, Mexico. In North



America, their distribution includes major river systems such as the Fraser, Columbia, Klamath-Trinity, Eel, and Sacramento-San Joaquin Rivers. Pacific lampreys are the most widely distributed lamprey species on the west coast of the United States.

*Current:* Anecdotal and empirical information suggests that Pacific lamprey populations have declined or been extirpated in California, Oregon, Washington, Idaho, British Columbia and Alaska. In the United States, Pacific lampreys 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.

### **Reasons for Decline and Threats**

Pacific lampreys face a variety of threats to its various life history stages, including artificial barriers to migration, poor water quality, predation by 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). There are many reasons for the observed reductions in range and abundance of Pacific lampreys, and no single threat can be pinpointed as the primary reason for their apparent decline. Table 2 summarizes threats that have been currently identified.

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Table 2. Identified threats and their effects to Pacific lampreys.

<b>Threat</b>	<b>Effects of the Threat</b>
Passage (dams, culverts, water diversions, tide gates, other barriers)	Artificial barriers can impede upstream migrations by adult lampreys and downstream movement of ammocoetes and macrophthmia. Downstream migrating macrophthmia may be entrained in water diversions or turbine intakes and due to their size and weak swimming ability, they are often impinged on the diversion and intake screens resulting in injury or death. Many fish ladders and culverts designed to pass salmonids do not effectively pass lampreys due to sharp angles and high water velocities. Lampreys travel deeper in the water column (no air bladder) compared to salmonids, therefore, traditional spill gates may block passage. Culverts that have a drop at the outlet or insufficient resting areas will block passage. Pacific lamprey populations persist for only a few years above impassable barriers before dying out.
Dewatering and flow management (reservoirs, water diversions, instream projects).	Fluctuations in reservoir and stream water levels, irrigation diversions, and stream dewatering can strand ammocoetes in the substrate. A single event can have a significant effect on a local lamprey population.
Dredging (channel maintenance and mining)	Many age classes of ammocoetes in stream substrates can be impacted by mining or dredging activities. Suction-dredge mining may be one of the reasons for the loss of lampreys in the John Day River basin.
Chemical poisoning (accidental spills, chemical treatment)	Ammocoetes are relatively immobile in the stream substrates and tend to concentrate in areas that include many age classes making them susceptible to chemical spills or chemical treatment (rotenone) targeting other species. They spend 3-7 years filter feeding and accumulate chemicals such as PCB's, mercury and other heavy metals.
Ocean conditions (loss of prey, change in conditions)	Pacific salmon, Pacific hake, and other fish have declined in numbers; reductions in the availability of these host/food species may be affecting adult lamprey survival and growth. No information exists on lamprey use of the ocean, hence unknown ocean conditions could be affecting their survival.
Poor water quality	Water temperatures of 72°F (22°C) may cause significant death or deformation of eggs or ammocoetes. Accumulated toxins in the lower reaches of streams/rivers may affect ammocoetes because they are often found in these areas.
Disease	The pathogen that causes furunculosis has been detected in lamprey in the Columbia River Basin and western Oregon. Disease may influence lamprey health resulting in reduction in their ability to reproduce and survive.
Harvest	Harvest of lamprey can change population structure and alter distribution thus reducing population numbers.
Predation by nonnative species	Nonnative fishes such as bass, sunfish, walleye, striped bass, and catfish, among others prey upon lampreys. As Pacific lampreys migrate through reservoirs, they may be more susceptible to predation.
Stream and Floodplain degradation (channelization, loss of side channel habitat, scouring)	Many age classes of ammocoetes in stream substrates can be affected by channel alterations. The loss of riffle and side channel habitats may reduce areas for spawning and ammocoete rearing.

### **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:

1. Conserve, enhance and restore habitat for Pacific lampreys by addressing them in current aquatic projects, fisheries management, and monitoring plans.
2. 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.
3. Prioritize research studies that provide information to aid in the mitigation of known threats and limiting factors of Pacific lampreys.
4. Conduct range-wide surveys to assess the range, status, and trends of populations of Pacific lampreys.
5. Assess population structure to identify population management units and conservation emphasis areas.
6. Assess the influence of disease on Pacific lamprey populations.
7. Assess the influence of contaminants on Pacific lamprey populations.
8. Assess the influence of current and forecasted climate change to adult holding and juvenile incubation temperature tolerances.
9. Create an outreach and information program specific to Pacific lampreys.

### **Landscape Considerations; Intermediate management scales**

The Columbia and Klamath River basins and western Oregon are primary areas where efforts to benefit Pacific lampreys are currently underway. The initial focus of the Plan may focus in these regions because data and support for lamprey conservation already exist, though the opportunity for any other area to move forward is supported.

### **Coordinating Conservation Activities**

The structure and administration for the Plan development has not been determined at this time. A Service staffed Western Lampreys Conservation Team has developed products thus far. It is expected that a steering team and specialized committees will be established to address the various aspects of the Plan and its implementation.

### **Funding Conservation Actions**

An expected outcome of the Plan is to increase funding of lamprey conservation measures, research, monitoring and evaluation. Funding for conservation actions will be solicited from a variety of sources. When appropriate, funding for other fish species may benefit Pacific lamprey and every opportunity to combine and coordinate efforts should be utilized.

### **Conservation Progress Assessment**

An annual assessment of Plan tasks and progress will be summarized and provided to interested parties by the Western Lampreys Conservation Team leader and the multi-entity Conservation Plan Steering Team.

**Research, Monitoring and Evaluation**

The following general research and monitoring needs have been identified:

- Improved understanding of status, distribution, and migratory behavior,
- Improved understanding of Pacific lamprey biology/ecology and the assessment of limiting factors to identify and ensure the long-term protection of priority habitats.
- Improved understanding of life history characteristics of Pacific lampreys.
- Identification and assessment of threats and effectiveness of treatments to reduce effects of threats to Pacific lampreys.
- Identification of conservation and restoration actions that result in improvements in conditions for all life history stages
- Improved understanding of Pacific lamprey population dynamics and genetic (population) structure.

**Appendices**

These would be available in the full document.

- I. Literature Cited - Available upon request
- II. Glossary
- III. List of potential partners
- IV. Specific Geographic Area Conservation Plans
  - a. Alaska
  - b. Canada
  - c. California- North Coast
  - d. California-South / Central Coast
  - e. California- Sacramento and San Joaquin Valleys
  - f. Columbia River Basin
  - g. Oregon - Coast
  - h. Oregon- Klamath River Basin
  - i. Washington - Coast / Puget Sound
- V. Conservation Actions for Lamprey

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