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Regional Implementation Plan for Measures to Conserve Pacific Lamprey (*Entosphenus tridentatus*), California - North Coast Regional Management Unit

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Acronym List

BLM	Bureau of Land Management
CA	California
CalTrans	California Department of Transportation
CDFW	California Department of Fish and Wildlife
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute
HUC	Hydrologic Unit Code (USGS)
Km	Kilometer
NOAA	National Oceanographic and Atmospheric Administration
P.G.&E	Pacific Gas and Electric Company
PLCI	Pacific Lamprey Conservation Initiative
RM	River Mile
RMU	Regional Management Unit
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WQ	Water Quality

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Introduction

Pacific Lamprey, *Entosphenus tridentatus*, were historically 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: cycling marine nutrients, passing primary production up the food chain as filter feeding larvae, promoting bioturbation in sediments, and serving as food for many mammals, fishes and birds. Recent observations of substantial declines in the abundance and range of Pacific Lamprey have spurred conservation interest in the species, with increasing attention from tribes, agencies, and others.

In 2003 the U.S. Fish and Wildlife Service (USFWS) was petitioned by 11 conservation groups to list four species of lamprey in Oregon, Washington, Idaho, and California, including the Pacific Lamprey, under the Endangered Species Act (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's range and the existence of both long-term and proximate threats to this species, but the petition did not provide 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. The USFWS was therefore unable to define a listable entity based on the petition and determined Pacific Lamprey to be ineligible for listing (USFWS 2004).

It is the USFWS's strategy to improve the status of lampreys by proactively engaging in a concerted conservation effort. This collaborative effort, through the development and implementation of the Pacific Lamprey Conservation Initiative (PLCI) initiated in 2004, 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. The approach of the PLCI is to use the best scientific and empirical information available to assess current issues affecting the viability of Pacific Lamprey

throughout its range in the western United States, to resolve knowledge gaps that limit our ability to conserve the species and to identify the specific conditions that must be addressed in order to conserve both regional and local populations. This document reviews risks identified by Goodman and Reid (2012) and introduces implementation actions to aid in conservation of the species. Neither document represents analyses required by the Endangered Species Act to determine if a species is warranted for listing as a threatened or endangered.

The 2012 Assessment and Template for Conservation Measures in California (Goodman and Reid 2012) includes introductory chapters describing the overall assessment and conservation strategy of the PLCI, general biology of and threats to Pacific Lamprey, and methods. Successive chapters focus on Pacific Lamprey in the California Region as a whole and in seven specific geographic subregions (Regional Management Units - RMUs) within California. Each RMU is further examined at the watershed level, using 4th field Hydrologic Unit Code watersheds (HUC). Habitat conditions, population status and threats are evaluated for each HUC. The demographic information and identified threats were then used to qualitatively assess the relative risks of extirpation for Pacific Lamprey within each HUC using a NatureServe Assessment Model.

Implementation Plans

In this stage of the PLCI, we use the combined results of viability and threats assessments in the 2012 California Assessment to develop implementation plans for each of seven RMUs (Figure 1); identifying conservation efforts, knowledge gaps and implementation projects that we believe will reduce risks to Pacific Lamprey within each RMU and its HUCs, thereby promoting conservation and management of the species range-wide.

Regional Conservation Strategy

The California regional conservation strategy uses the combined results of the viability and threats assessments in the 2012 California Assessment to develop implementation plans for each Regional Management Unit (RMU). These plans will identify specific conservation efforts, knowledge gaps and key implementation projects that we believe will reduce risks to Pacific Lamprey within each of California's seven RMUs and their component HUC watersheds, thereby promoting the conservation and management of Pacific Lamprey both locally and range-wide. They are intended to provide a tool for managers and conservation biologists to guide conservation efforts, prioritize projects, and monitor progress. Ultimately, the various subregional plans will be incorporated into a regional plan for the whole of California and coordinated with implementation efforts in other regions.

Our current understanding of the biology and conservation needs of the Pacific Lamprey is relatively limited. Unlike western salmonids, which have long commercial management histories and have been extensively studied, little attention has been given to Pacific Lampreys in the past. Therefore, key conservation needs include the incorporation of lampreys into existing conservation and restoration projects, education of stakeholders and the general public, as well as filling major gaps in our basic understanding of their

Figure 1. Map of seven California Regional Management Units (RMUs).

life history, distribution, behavior, habitat utilization and sensitivity to environmental factors such as temperature, flow regimes, and eutrophication. Nevertheless, it is also a primary goal of this implementation strategy to move forward with prioritized on-the-ground projects and recognized conservation needs that can be rapidly addressed over the next five year to directly benefit Pacific Lamprey. Crucial to the success of this strategy is the collaboration of multiple and diverse stakeholders working together proactively to promote the conservation of a keystone species integral to the health and ecological function of western rivers. Both the Conservation Assessment and this Implementation Plan are intended as living documents that will be updated as we develop new information and understanding of lamprey conservation status and as implementation progresses. Already, many of the proposed implementation projects have been initiated or are well underway.

Implementation Planning - Methods

The initial phase of this implementation planning was assessment of population status and identification of threats within individual 4th field Hydrologic Unit Code watersheds (HUCs) through the 2012 California Assessment process (Goodman and Reid 2012). These results are incorporated into the implementation plans, where they serve to prioritize populations of particular concern and specific threats that need to be addressed by proposed implementation actions. The results of the 2012 California Assessment are summarized herein, but the Assessment itself contains additional detail and background for the reader, including introductory chapters describing the overall assessment and conservation strategy of the PLCI, general biology of and threats to Pacific Lamprey, and methods. Successive chapters focus on Pacific Lamprey in California as a whole and in specific geographic subregions, describing conditions, population status and threats at the watershed level. The demographic information and identified threats were then used to qualitatively assess the relative risks of extirpation for Pacific Lamprey within each watershed using a NatureServe Assessment Model see Goodman and Reid (2012).

Collaborative stakeholder meetings and site visits were held for each HUC to seek out local experience, conservation concerns and suggestions for information needs and conservation actions (see Figure 2 and Appendix A for stakeholder meetings and workshops). Outreach and information gathering included 19 stakeholder meetings or workshops and included 184 different stakeholders. Stakeholder meetings also provided an opportunity to increase collaboration, raise general awareness and promote participation in lamprey conservation, as well as to inform the PLCI team of ongoing conservation actions in local watersheds.

The development of specific information needs and actions to be incorporated into the present implementation plan was guided by the 2012 CA threat assessment and drew upon various sources of information. For each recognized threat, actions were developed to specifically address that threat, or provide information needed for further assessment and development of mitigation measures. Final development of proposed actions incorporated the results of stakeholder meetings, workshops, ongoing conversations with stakeholders and local biologists, site visits, and the experience of the

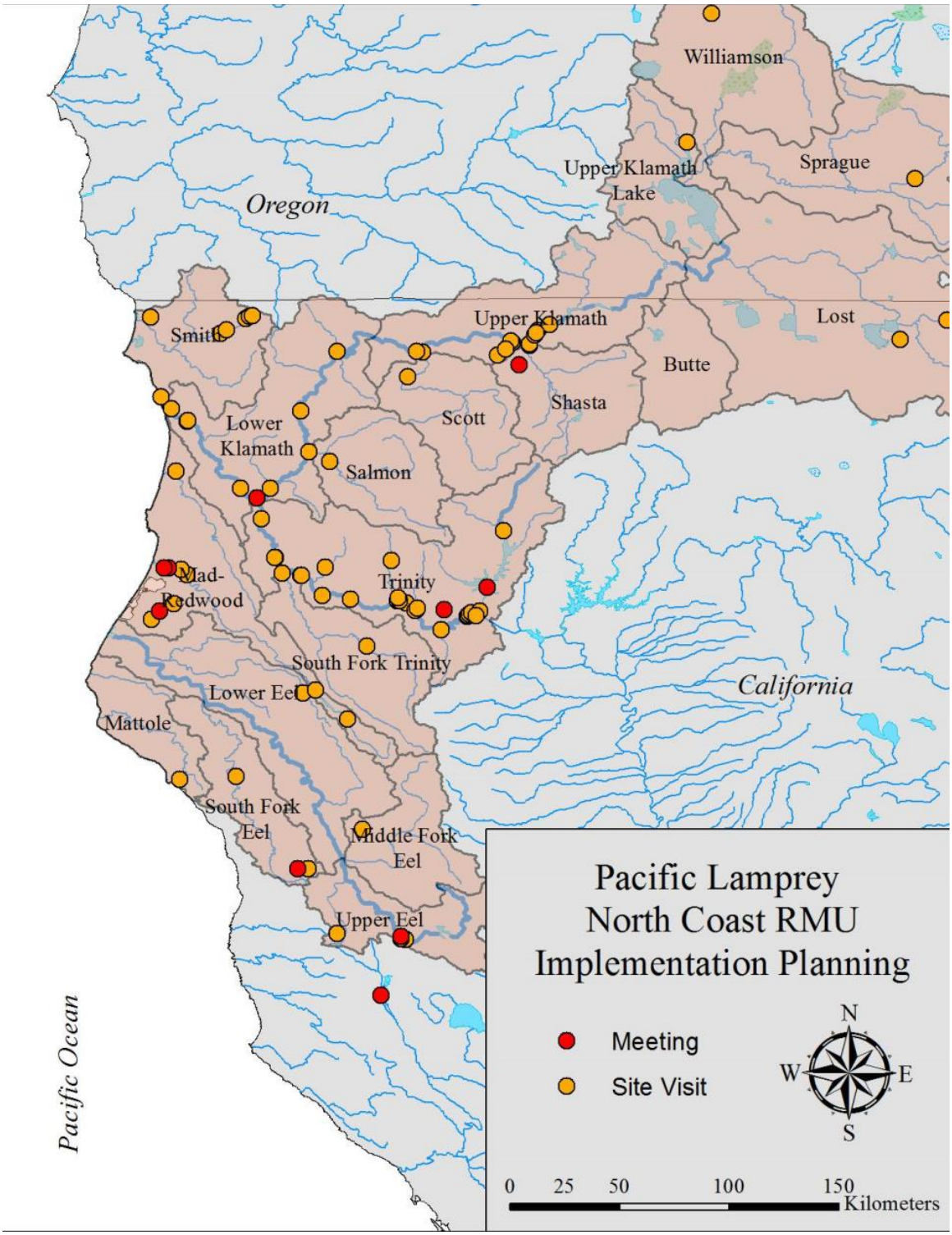

Figure 2. Map of stakeholder meetings, workshops and site visits which informed the development of the North Coast implementation plan.

PLCI team. The principal goal of the implementation plans is to identify specific conservation efforts, knowledge gaps and key implementation projects that we believe will reduce risks to Pacific Lamprey within each RMU and its component watersheds (HUC). However, there were also certain conservation efforts that are universal within the RMU, and often the broader region as well. These include outreach, education coordination and incorporation of lampreys into existing aquatic conservation efforts, as well as basic research into aspects of lamprey life-history that directly relate to their conservation needs.

All proposed actions and conservation needs were entered into an implementation database that incorporates:

1) Information on the threat addressed
2) Description of the action and its rationale
3) Scale and location of the action
4) Prioritization factors
5) Feasibility factors
6) Additional benefits of the project
7) General status and details of the project

Actions are grouped into the following categories:

1) Assessment - assessment of potential threats or project needs
2) Coordination - including, outreach, collaboration and incorporation of lampreys into existing conservation efforts
3) Research - information needs that directly relate to their conservation needs or are needed to assess general threats
4) Survey/monitor - distribution of lampreys, suitable habitat, monitor populations or mapping of point threats (e.g., diversions, barriers)
5) Instream/on-the-ground projects

See Appendix B for specific fields and details of the database structure.

Prioritization of conservation actions is facilitated through the implementation database by inclusion of separate factors that may guide selection of individual projects. Priorities will be influenced by such factors as the specific needs of Pacific Lamprey in an area (region or HUC), the level of threat addressed (scale, scope or severity), habitat gained, specific funds available, capabilities of participants, and stakeholder or program goals. Therefore, actions in the database were not prioritized explicitly, allowing for flexibility to accommodate a broad suite of applications. Instead, a framework is provided with a series of factors ranked independently that may contribute to a prioritization scheme. Factors evaluated for each action include the scope, scale and severity of threats addressed, effectiveness in addressing the threat, and quantity of habitat gain. These factors may be used in combination to guide strategic conservation measures in a variety of implementation scenarios.

The implementation database is intended as a living document that evolves with our understanding of threats to Pacific Lamprey, their conservation needs and the status of specific conservation projects. It is intended to provide a tool to managers and conservation biologists to address the specific needs of Pacific Lamprey, guide conservation efforts, prioritize projects and monitor progress. See Appendix C for contact information.

North Coast RMU - Status and distribution of Pacific Lamprey

The North Coast RMU (Figure 3) includes all coastal drainages from Punta Gorda (Mattole River) north to the Oregon border, including the northern half of the Northern California Coastal (01) and the entire Klamath (02) USGS accounting units. It includes 19 watersheds (4th field HUCS), ranging from 1,292 - 7,759 km^2 (Table 5-1). The RMU extends from the coast inland, cutting through the Klamath and Cascade mountain ranges into the interior and occupies the Coast Range, Klamath Mountains, Cascade, and Eastern Cascade, slopes and foothills ecoregions. Due to subregional differences in hydrology, habitat and threats, we have grouped the HUCs into three sub-groupings: Klamath Basin, Eel Basin and Coastal. The population status and distribution of Pacific Lamprey in the North Coast RMU are reviewed below and in Table 1 (adapted from 2012 Assessment with current information).

Historical Range Extent

Pacific Lamprey are assumed to have been widely distributed and abundant historically in the North Coast RMU, based on current distribution, available habitat and tribal knowledge of fisheries. The principal uncertainty is how far they extended into the upper Klamath Lake Basin (east of the Cascades), for which there are no records. However, for the purpose of this assessment we assume that they were able to utilize all suitable habitat with anadromous access. This is based on the evidence for anadromous salmonids in the past (Hamilton et al. 2005), the widespread presence of other similar species of lamprey (*Entosphenus* spp.) throughout the Klamath Basin, historical records of Pacific Lamprey at elevations of up to at least 4,900' in California, and the absence of natural barriers.

Current Occupancy

Pacific Lamprey currently occupy most historical anadromous habitat in the North Coast RMU downstream of impassable dams, except perhaps in higher gradient reaches or smaller tributaries. The principal dams in the RMU are the Klamath River dams, with the lowest being Iron Gate (constructed 1962, but preceded by Copco #1 constructed a short distance upstream in 1912), the Lewiston and Trinity dams on the Trinity River (constructed 1962), Dwinnell Dam on the Shasta River (constructed 1926), Matthews Dam on the Mad River (constructed 1962), and the Van Arsdale (constructed 1907; fish ladder 1922) and Scott (constructed 1922) dams on the upper Eel River. Only the Van Arsdale Dam has facilities for fish passage, and its fish ladder is not optimized for lamprey passage.

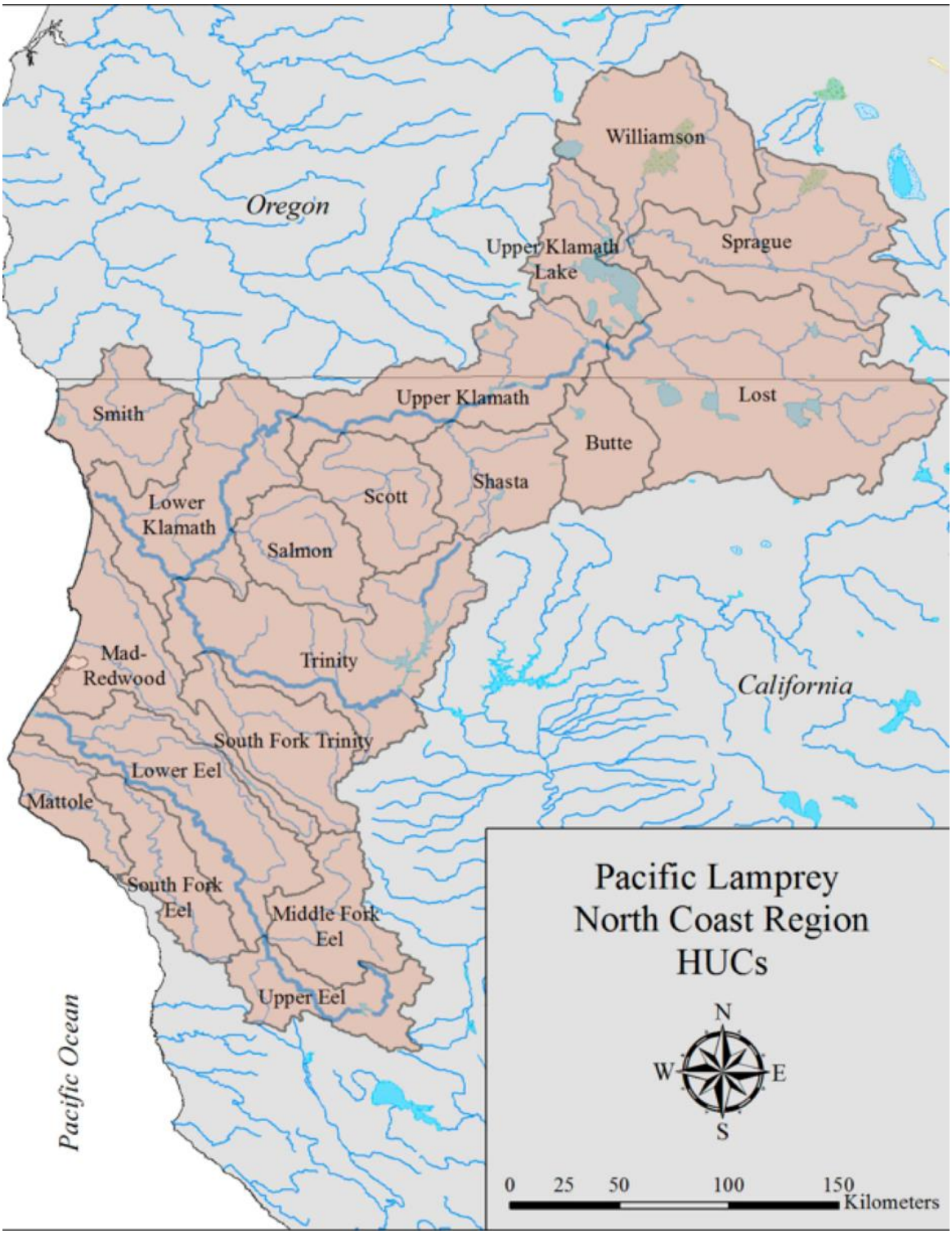

Figure 3. Map of the North Coast Regional Management Unit (RMU) and its watersheds (4th field HUCs).

Table 1. Population status, maximum threat level and NatureServe ranks for Pacific Lamprey in the North Coast RMU. Unoccupied HUCs are included for reference, historically non-anadromous HUCs are indicated by "N/A", and populations extirpated by impassable dams prior to 1985 are indicated as "Extinct". NatureServe ranks: SX, Extinct; SH, Believed extinct; S1, Critically imperiled, S2, Imperiled, S3, Vulnerable, S4 Apparently secure, and S5, Secure [from Goodman and Reid 2012].

NORTH COAST		Distribution				Max. Threats		
Watershed	HUC	Max. Historical (km^2)	Ratio Current/ Historical	Population Size (#)	Short-Term % Decline	Scope	Severity	Risk Rank
Klamath Basin:								
Williamson	18010201	3,761	0.00	Extinct	-	-	-	SX
Sprague	18010202	4,152	0.00	Extinct	-	-	-	SX
Upper Klamath Lake	18010203	1,883	0.00	Extinct	-	-	-	SX
Lost	18010204	7,759	0.00	Extinct	-	-	-	SX
Butte	18010205	NA	-	-	-	-	-	-
Upper Klamath	18010206	3,680	0.75	250-1000	50 - 70%	High	Mod.	S2
Shasta	18010207	2,041	0.90	250-1000	50 - 70%	Mod.	Mod	S2
Scott	18010208	2,106	0.90	250-1000	50 - 70%	Mod.	Mod	S2
Salmon	18010210	1,946	1.00	1000-2500	50 - 70%	High	Low	S3
Trinity	18010211	5,329	0.75	1000-2500	50 - 70%	Mod.	Mod.	S2
South Fork Trinity	18010212	2,360	1.00	1000-2500	50 - 70%	Mod.	Mod.	S2
Lower Klamath	18010209	3,964	1.00	1000-2500	50 - 70%	Mod.	Mod.	S3
Eel Basin:								
Lower Eel	18010105	3,982	1.00	1000-2500	50 - 70%	High	Mod.	S2
Middle Fork Eel	18010104	1,942	1.00	1000-2500	50 - 70%	High	Mod.	S2
South Fork Eel	18010106	1,779	1.00	1000-2500	50 - 70%	High	Mod.	S2
Upper Eel	18010103	1,823	0.75	1000-2500	50 - 70%	High	Mod.	S2
Coastal:								
Smith	18010101	2,075	1.00	Unknown	Unknown	Insig.	Low	S4
Mad-Redwood	18010102	2,989	1.00	Unknown	50 - 70%	High	Low	S3
Mattole	18010107	1,292	1.00	Unknown	Unknown	High	Low	S3

Ratio of Current Occupancy to Historical Range Extent

With the exception of the entire upper Klamath Basin (970 km of potential anadromous habitat), which was blocked in 1917 by the construction of Copco #1 Dam (Hamilton et al. 2005), the North Coast RMU has seen relatively little loss of historical distribution caused by obstruction of passage, generally < 10%. The Lewiston/Trinity dams blocked about 1,860 km^2 of the upper Trinity River (ca. 35% of the HUC). Scott Dam blocks about 750 km^2 of the Upper Eel HUC (ca. 40%), and the Van Arsdale Dam, with a difficult fish ladder constructed in 1922, restricts access to another 140 km^2. Obstruction of smaller tributaries by culverts is currently being assessed in the Eel Drainage (Stillwater Sciences 2014) and Trinity drainages.

Population Size

Adult population size in the North Coast RMU is poorly understood and not formally monitored. However, unlike other areas, there is a long tribal history of subsistence fishing in the North Coast drainages, especially in the Eel and Klamath rivers. Tribal participants estimated 1,000-10,000 adult lampreys migrating into their drainages in recent years (distributed among HUCs). The Hoopa Valley Tribe caught an estimated 2,755 adults in the lower Trinity River in 2012 providing a very conservative estimate of adult population entering the Trinity HUC (Hoopa preliminary tribal creel estimate; Billy Matilton pers. com). In the upper Eel and 156 mi from the mouth 700 adults were collected at and passed over Van Arsdale Dam in Spring 2012 by CDFW, facilitated by collection in the lowest sections of the ladder. In 2013, 255 were counted passing the midsection of the ladder. Nevertheless, there is no formal counting of lampreys in the RMU, and these estimates represent a conservative minimum adult population size for the RMU. Downstream migrant monitoring at screw-traps is generally focused on salmonids and hampered, especially in the Klamath, by the presence of additional lamprey species in the catch, inability to sample during high flows utilized by emigrating juveniles, and seasonal monitoring that may miss the principal lamprey migration times.

Short Term Trend

While in most areas the lack of formal monitoring of adult migrations makes any quantification of population trends impossible, the presence of a long tribal fishery in the North Coast with living recollections of past lamprey runs allows us to get some sense of comparison between historic and present populations. Tribal fishermen who fished in the 1970-80's recollect much larger runs and suggest declines of at least 90% from those days and consistently low runs since the mid 1980's with continued decline. Fish biologists also anecdotally recount seeing large numbers of lampreys at Van Arsdale dam (upper Eel), Hayfork Falls (South Fork Trinity), and in Indian Creek (Lower Klamath), all sites where lampreys still exist, but are not seen in such large numbers. These declines are in agreement with records from the Oregon Coast at Winchester Dam on the North Fork Umpqua River (Goodman and Reid 2012).

NatureServe Risk Ranks

NatureServe risk ranks generally varied from imperiled to vulnerable (S2-S3), except for the upper Klamath Basin HUCs, which were extirpated by mainstem dams, and the Smith River, which was the only HUC with a ranking of Apparently Secure (S4). The Smith

River was also the only HUC in any of the West Coast regions to be ranked as secure. Nevertheless, it is subject to metapopulation declines caused by regional threats outside the watershed. See discussion of threats below.

North Coast RMU - Threats and Limiting Factors to Pacific Lamprey

Threats and limiting factors to Pacific Lamprey in the North Coast RMU are provided in Table 2 for the principal five threats, also discussed below. The remaining threat categories were either of low risk throughout the RMU or were not considered in this assessment as a whole due to lack of information (see discussion under Goodman and Reid 2012, Chap. 4 - California Regional Summary: Small Population Size, Disease, Lack of Awareness, Ocean Conditions, and Climate Change). While Harvest was not a major threat in most of California, the North Coast is the only area where there is substantial tribal harvest which is currently limited to subsistence purposes.

The primary threats in the North Coast RMU vary between areas. The mainstem Klamath River is primarily affected by the presence of multiple hydropower dams, demands for agricultural water and flow management. The Scott River is affected by water withdrawals and the legacy effects of streambed alteration. The Trinity is affected by the Trinity/Lewiston dams, water withdrawals, water management and the legacy effects of streambed alteration. In the Eel River watershed the primary threats are associated with WQ issues such as high water temperatures and nutrient loading, as well as watershed management effects on channel morphology and bedload dynamics in the Lower Eel, and two large dams and diversions in the Upper Eel. Predator threats were not resolved, but included marine mammals at the mouth of the Klamath, Brown Trout in the Trinity, and introduced Sacramento Pikeminnow in the Eel. The three smaller coastal HUCs (Smith, Mad-Redwood and Mattole) and the Salmon (tributary to the Klamath) were all ranked relatively low for threats.

Passage (dams, culverts, water diversions, tide gates, other barriers)

Major impassable dams caused the extirpation of Pacific Lamprey in all the upper Klamath Basin HUCs, as well as isolation of the upper Trinity. The upper Eel River also lost about a quarter of its watershed to the Scott Dam, and the Van Arsdale Dam downstream restricts upstream passage by lampreys, although some do pass the dam. Otherwise, passage concerns in the remaining watersheds are generally limited to culverts and smaller diversions on tributaries and were generally ranked low in scope.

Dewatering and Stream Flow Management (reservoirs, water diversions, instream projects)

Flows in the Klamath River itself are heavily managed. Flow-ramping to meet hydroelectric demands can produce rapid drops in water-level and mortality of ammocoetes in shoreline sediments, and agricultural demands can reduce flows, which when combined with high summer temperatures and eutrophic conditions has resulted in major fish die offs. Dewatering for agricultural uses, including groundwater pumping, also ranked as high in the Shasta and Scott rivers. Outside the Klamath Basin dewatering and flow management associated with large dams were generally ranked as low (scope and severity) in the Eel and other coastal drainages, except in the Upper Eel where the

Table 2. Principal threat rankings, maximum threat level and NatureServe ranks for Pacific Lamprey within the North Coast RMU, grouped by major drainages. See maps in Chapter 4. Historically non-anadromous HUCs are indicated by "N/A" and included for reference. Individual threat rankings for Scope and Severity: 1 to 4, Insignificant to High; U = Unknown. NatureServe ranks: SX, Extinct; SH, Believed extinct; S1, Critically imperiled, S2, Imperiled, S3, Vulnerable, S4 Apparently secure, and S5, Secure [from Goodman and Reid 2012]. Maximum threat ranks: X, Extinct due to dams (prior to 1985); and A to H, substantial and imminent threat to unthreatened.

NORTH COAST			Individual Threats (Scope - Severity)				
Watershed	Risk Rank	Maximum Threat	Passage	Dewatering /Flow	Stream Degradation	Water Quality	Predation
Klamath Basin:							
Williamson	SX	X	X	-	-	-	-
Sprague	SX	X	X	-	-	-	-
Upper Klamath Lake	SX	X	X	-	-	-	-
Lost	SX	X	X	-	-	-	-
Butte	NA	-	-	-	-	-	-
Upper Klamath	S2	B	3 - 3	3 - 3	1 - 1	4 - 3	2 - 1
Shasta	S2	C	2 - 2	3 - 3	1 - 1	3 - 3	1 - 1
Scott	S2	C	2 - 2	3 - 3	3 - 3	3 - 3	2 - 1
Salmon	S3	D	2 - 2	1 - 1	1 - 1	4 - 2	1 - 1
Trinity	S2	C	2 - 3	3 - 2	3 - 3	4 - 2	3 - U
South Fork Trinity	S2	C	2 - 2	1 - 1	3 - 3	4 - 2	2 - 1
Lower Klamath	S3	C	2 - 2	2 - 2	2 - 2	4 - 2	4 - U
Eel Basin:							
Lower Eel	S2	B	2 - 2	2 - 2	3 - 3	4 - 3	3 - U
Middle Fork Eel	S2	B	2 - 2	2 - 2	1 - 1	4 - 3	3 - U
South Fork Eel	S2	B	2 - 2	2 - 2	1 - 1	4 - 3	3 - U
Upper Eel	S2	B	3 - 3	3 - 3	1 - 1	4 - 3	3 - U
Coastal:							
Smith	S4	G	1 - 2	1 - 1	1 - 1	1 - 1	1 - 1
Mad-Redwood	S3	D	2 - 2	2 - 2	1 - 1	4 - 2	2 - 1
Mattole	S3	D	2 - 2	2 - 2	1 - 1	4 - 2	2 - 1

Potter Valley Project diverts a large proportion of summer flow into the Russian River Basin, reducing instream flow for a considerable reach below Van Arsdale Dam. However, dewatering and eutrophication due to small-scale illegal agricultural uses which reduce flow, raise summer temperatures, add nutrients and promote algal blooms in the mainstems are considered major concerns in the Eel, Mattole, and S.F. Trinity drainages.

Stream and Floodplain Degradation (channelization, loss of side channel habitat, scouring)

Stream and floodplain degradation was generally ranked as low threat, except in four HUCs (Scott, Trinity, S.F. Trinity and Lower Eel River), which ranked moderate in scope and severity. The Scott River was ranked for degradation due to gravel operations, channelization, rip-rapping, and historical logging operations. The two Trinity HUCs were ranked due to instream gravel operations, loss of complexity due to historical mining and water management, and dredge mining. In the Lower Eel, historical watershed management has shifted the system to one dominated by coarse bedload, changed the timing and intensity of runoff, and shifted the riparian corridor from narrow and tree-lined with deeper pools to wide, shallow and denuded.

Water Quality (Water temperature, chemical poisoning and toxins, accidental spills, chemical treatment, sedimentation, non-point source)

WQ issues were generally ranked as widespread, but low in severity throughout the RMU, except in the Klamath River itself (Upper Klamath HUC) where significant eutrophication affects WQ in the summer and fall, and in the Eel River where high summer water temperatures and low flows promote the growth of algae and associated dissolved oxygen effects.

Predation

Predation was not generally considered a threat in the north coastal streams, except in the Eel River where introduced Sacramento Pikeminnow (native to the Russian River and Central Valley drainages) are now common in the mainstem, and in the Trinity River which supports a large Brown Trout population. Large pikeminnow are piscivorous and are known to consume juvenile lampreys (Nakamoto and Harvey 2003). However, the two species are sympatric throughout the Central Valley and Russian River drainages. Brown Trout are also known predators of juvenile lamprey and feed nocturnally, so they may encounter lamprey more often than other predatory fishes do (Heggenes et al. 1993). The impact of either predator on local populations is not known and may be ameliorated by downstream migration during periods of high flow and turbidity and, in the case of pikeminnow, by the generally nocturnal activity patterns of lampreys. In the lower Klamath River, and perhaps other rivers, seals and sea lions feed on migrating runs of adult lampreys near the mouth, and this pressure has increased as pinniped populations increase. Nevertheless, the character and severity of threats due to predators could not be assessed, and they were ranked as Unknown for the time being, although they are proposed for assessment.

North Coast RMU – Implementation Plan

This plan is intended to identify conservation efforts, knowledge gaps and implementation projects that we believe will reduce risks to Pacific Lamprey within the North Coast RMU and its component HUCs, thereby promoting the conservation and management of the species range-wide. A summary of the plan is provided below, with details available in the Implementation Database (Appendix C).

General conservation needs within the North Coast RMU

Within the North Coast RMU there are some general conservation needs that pertain to all HUCs. These include coordination efforts (outreach, education, and incorporation of lampreys into existing aquatic conservation efforts), as well as basic research into aspects of lamprey life-history that directly relate and are applicable to their conservation needs region-wide. There are also common needs for distribution surveys, population monitoring, habitat assessments and barrier mapping.

Coordination

As in most of the region, the lack of awareness, understanding and consideration of lampreys by the general public, resource managers and restoration projects in the North Coast RMU has resulted in the conservation needs of Pacific Lamprey being ignored or actively imperiled. A major goal of the PLCI implementation is to increase awareness of Pacific Lamprey, attract more participation by stakeholders and promote consideration of its conservation needs by providing outreach, training and local education to stakeholders, resource managers and community members.

A specific regional focus is proposed for coordination with other passage stakeholders (e.g., USBR, CalTrans, CDFW, Pacificorp, P.G.&E, and USFWS) to insure lamprey consideration in existing passage structures, as well as current and future projects. Passage obstruction has been identified as one of the primary threats to Pacific Lamprey region-wide, isolating over 40% of potential anadromous habitat and eliminating the ecological role of Pacific Lamprey in reaches above barriers. Furthermore, active passage programs/projects focusing on salmonids often ignore the needs of, or actively block lampreys due to their design and/or management.

A specific regional focus is also proposed for increasing awareness of adverse impacts caused by small-scale diversions and nutrient inputs by small-scale legal and illegal agricultural activities in the North Coast RMU. Unregulated water withdrawals reduce flows in or even fully dry up smaller tributaries and ultimately degrade habitat in the mainstem rivers. Even short term loss of surface flow is lethal to ammocoete populations, resulting in the local loss of up to seven year classes. Higher temperatures caused by lower flows and increased nutrient loading promoting algal blooms in mainstem rivers further degrade habitat used by over-summering adults and ammocoetes, who cannot tolerate anoxic sediments.

General research needs

Passage: Although passage obstruction is identified as a primary threat to Pacific Lamprey region-wide, there is limited information on how lampreys move past barriers

or how to design instream structures to facilitate lamprey passage. Therefore, a number of basic research goals will investigate and develop designs or management approaches for passage at culverts, low-head dams or weirs, and fish ladders. Other projects investigate entrainment risk from small-scale (<4") unscreened pumping stations and development of downstream passage/screening criteria for ammocoetes and emigrating juveniles.

Ammocoete habitat: Ammocoetes during their 5-7 year instream development are highly dependent on the habitat provided by fine sediments. We know little about fine-scale habitat selection by ammocoetes, nor about the effect of sediment conditions on ammocoete populations or system carrying capacity. Therefore, a number of basic research goals will investigate sediment habitat needs of ammocoetes, the role of temperature and dissolved oxygen levels in sediment habitat quality, the impact of eutrophication and associated algal blooms on sediment conditions, and mitigation measures for use during in-water projects to reduce mortality of ammocoetes.

Adult holding habitat: Many adult lamprey hold over during the summer/winter and spawn the following spring. Observations of dead adults in summer months, outside the expected spawning period, indicate that high water temperatures and low DO may seriously impact adult survival during the holding period. Research is proposed to determine thermal and DO tolerances for adult lamprey during summer holding period.

Due to our currently limited understanding of the specific distribution and population dynamics of Pacific Lamprey, distributional surveys of ammocoetes, spawning areas and over-wintering habitat, as well as adult population censusing and emigrant monitoring, are recommended for each individual HUC. Although these surveys are common to all HUCs, they are specified individually for each in the database due to differences in threat level, stakeholders and project development, and to facilitate progress monitoring within HUCs.

Similarly, general survey and assessment of potential instream barriers (including low-head dams, diversions and culverts) is recommended for all HUCs to assess and prioritize conservation needs related to lamprey passage and/or entrainment.

Below are brief summaries of principal implementation needs and proposed projects in the three subareas (Klamath, Eel and Coastal) and their individual HUCs. Details are available in the Implementation Database.

Klamath Basin:

The Klamath Basin as a whole represents the largest drainage on the west coast between the Sacramento and Columbia rivers (Figure 4). The Klamath River drainage below Keno represents 21,427 km^2, and the upper Klamath Lake Basin would have potentially added another 17,555 km^2 of anadromous habitat were it not blocked by dams. By contrast, the next largest basin is the Eel, with 9,526 km^2.

Figure 4. The lower Klamath River near the town of Klamath Glen.

In keeping with the importance and long history of tribal lamprey fisheries in the Klamath (incl. Trinity) this basin offers an opportunity to monitor adult populations in association with the tribal fisheries. Furthermore, the presence of established programs for monitoring salmonids in the basin provides opportunities to monitor lamprey production through in-place emigration monitoring programs (downstream rotary screw-traps). Both programs are recommended in the implementation plan as coordinated multi-program projects in each HUC.

Upper Klamath

Much of the upper Klamath River drainage and the entire Klamath Lakes Basin (including the Upper Klamath Lake. Williamson, Sprague and Lost river HUCs) have been isolated and the Pacific Lamprey populations extirpated by the mainstem Klamath dams. The dams and associated flow management issues also adversely influence environmental conditions (WQ, flow and substrate conditions) in the Klamath River mainstem downstream of Iron Gate Dam. Therefore, removal of the dams and restoration of natural hydrologic flow regimes to the Klamath River would have the greatest positive influence on Pacific Lamprey in these HUCs.
Additional implementation needs in the area of the Upper Klamath HUC below Iron Gate Dam include projects to assess the effects of flow management and ramping rates on

lampreys in the mainstem Klamath River, assess and address impacts of summer diversions in principal tributaries, and improve habitat conditions in the mainstem reach from Iron Gate Dam to the Scott River (47 mi), which has been found to represent a "dead zone", containing few ammocoetes, presumably due to flow management, poor WQ, lack of sandy fines and high deposition rates of organic material.

Lower Klamath

The Lower Klamath is generally included under mainstem Klamath projects. This HUC however is unique since it includes the Klamath mouth and estuary. The implementation plan calls for an assessment of the impact of pinnipeds on adult lamprey in river mouths. Pinnipeds are known predators on in-migrating lampreys, but their actual impact on the population is not quantified.

Shasta

The Shasta is a highly managed agricultural region. As such the majority of proposed implementation projects involve the assessment and resolution of issues associated with water diversions and instream structures, including WQ, flow management, entrainment and passage. The implementation plan calls for incorporation of lamprey needs into the Scott and Shasta Rivers Instream Flow Study Plans and Data Needs Assessment. While a number of known structures (e.g., Dwinnel Dam, Granada Diversion, Rice/Novy and Parks dams/diversions) are identified in the plan, additional projects are likely to be added following assessment of the HUC for instream structures.

Scott

The Scott is a highly managed agricultural region. As such the majority of proposed implementation projects involve the assessment and resolution of issues associated with water diversions and instream structures, including WQ, flow management, entrainment and passage. The Scott is also heavily influenced by ground water pumping and associated dewatering of surface flow channels. The implementation plan calls for incorporation of lamprey needs into the Scott and Shasta Rivers Instream Flow Study Plans and Data Needs Assessment. While a number of known structures (e.g., Farmers Ditch Diversion and Scotts Diversion (Young's Dam) are identified in the plan, additional projects are likely to be added following assessment of the HUC for instream structures.

Salmon

The Salmon generally has relatively low threat levels and no major passage issues. There are a few minor instream structures to be assessed in smaller tributaries (Little North Fork Salmon, Knownothing and Hotelling creeks), and additional projects are likely to be added following assessment of the HUC for instream structures. Resident Brown Trout populations are recognized as an active predation threat in both the Salmon and Trinity HUCs. Brown Trout assessment and suppression are proposed to reduce predation on ammocoetes/macropthalmia.

Trinity

The presence of Trinity and Lewiston dams on the mainstem Trinity greatly influence mainstem lamprey habitat through flow reduction, sediment removal, and alteration of natural hydrology, as well as blocking passage to the spawning and rearing habitat in the

upper Trinity Basin above Lewiston. High priority implementation projects include assessment of the impact of managed mainstem flow regimes on spawning lampreys, emigrating macrophthalmia and availability of fines that serve as ammocoete rearing habitat, followed by incorporation of lamprey needs into the Trinity mainstem management programs. Passage projects are proposed in tributaries for the Buckhorn Debris Dam's existing spillway ramp (Grass Valley Creek) and diversions in Weaver Creek. To a greater extent than the Salmon Drainage, resident Brown Trout populations in the Trinity are recognized as an active predation threat. Brown Trout assessment and suppression are proposed to reduce predation on ammocoetes/macropthalmia.

South Fork Trinity

In the South Fork Trinity, extensive bedload manipulation by legacy and ongoing hydraulic and gravel mining operations, as well as extensive logging followed by the 1964 flood which destabilized hill slopes and introduced fine sediment, have resulted in major changes to channel structure. Mainstem pools that historically provided deep, cool resting areas in the summer have filled in and channel depth is generally shallower, resulting in higher summer temperatures. Primary implementation goals focus on restoration of natural channel morphology to reduce temperature and deepen channels, in order to improve habitat for holding adults. As in much of the RMU, unregulated water withdrawals and associated environmental impacts are also a particular concern in the South Fork Trinity (see above: General conservation needs). While passage is not a widespread problem in the South Fork Trinity, implementation projects are proposed for low head dams in the Hayfork drainage, its largest tributary.

Eel Basin:

Unregulated water withdrawals are a particular concern throughout the Eel Basin (see above: General conservation needs). Additional project identification and priorities will depend on the outcome of general survey and assessment of potential instream barriers (including low-head dams, diversions and culverts). Specific priorities within individual HUCs are reviewed below.

Lower Eel

In the Lower Eel, extensive bedload manipulation by legacy and ongoing hydraulic and gravel mining operations have resulted in major changes to channel structure. Mainstem channels are widened and shallower, with lower flow and less shading than historically present, resulting in higher summer temperatures and WQ issues associated with algal blooms. Primary implementation goals focus on restoration of natural channel morphology to reduce temperature, increase flow velocities and deepen channels, thereby improving habitat for ammocoetes and holding adults.

Middle Fork Eel

In the Middle Fork Eel, low water levels in Round Valley and the Round Valley Indian Reservation, resulting in desiccation of stream beds and loss of ammocoete habitat, are concerns. The Middle Fork Eel is otherwise relatively undeveloped. Proposed projects include assessment of lamprey distribution and conservation needs in Round Valley drainages.

South Fork Eel

Diversion of flows in upper Cahto Creek (a headwater tributary) above Laytonville Rancheria result in annual desiccation of the stream, loss of ammocoete habitat, and mortality of over-summering adults. Proposed projects include assessment of impacts to lampreys, coordination with stakeholders and landowners, and regulatory enforcement.

Upper Eel

The principal implementation focus on the upper Eel is on dams and diversions in the upper watershed, including: 1) Scott Dam at Lake Pillsbury, which has no fish ladder, blocks 36 miles of mainstem habitat, and reduces downstream sediment transport, 2) the Van Arsdale fish ladder (12 mi below Scott Dam), and 3) the Potter Valley project diverts a substantial amount of water out of the Eel Basin, exacerbating low summer flow conditions and WQ/temperature conditions downstream and potentially entraining lampreys. Projects include passage improvements and study of lamprey movements at Van Arsdale (Figure 5), assessment of passage (upstream and downstream) opportunities and habitat suitability above Scott Dam, and assessing entrainment at the Potter Valley diversion.

Figure 5. Van Arsdale Dam on the Eel River. The dam and fish ladder restricts passage of Pacific Lamprey to upstream reaches and is being used to study lamprey passage capabilities and test lamprey specific passage facilities.

Coastal:

With the exception of the Smith drainage, unregulated water withdrawals are a particular concern throughout the coastal subarea (see above: General conservation needs). Additional project identification and priorities will depend on the outcome of general survey and assessment of potential instream barriers (including low-head dams, diversions and culverts). Specific priorities within individual HUCs are reviewed below.

Smith

The Smith HUC is one of the least altered in California, and there are few major threats to lampreys (Figure 6). The principal implementation project in the drainage is assessment and modification of the Rowdy Creek fish hatchery weir to facilitate lamprey passage. This project will provide anadromous lamprey access to the entire Rowdy Creek watershed (ca. 10 mi of mainstem), possible outreach opportunity for public observation of migrating lampreys, and a population monitoring site.

Figure 6. The Smith River is one of the least altered rivers in California and one of the few without a major dam.

Mad-Redwood

Principal projects in the Mad-Redwood HUC are associated with assessments of possible WQ effects in the Mad River, the operation of the Arcata Water Treatment Plant (Mad) and the impacts of Ruth Lake flow management on downstream reaches.

Mattole

Coarse grain bedload has changed the morphology of the Mattole watershed and sediment storage has affected channel morphology, limiting availability of ammocoete rearing habitat. The Mattole basin is also subject to large numbers of small-scale water diversions that impact summer flow conditions. Assessment of habitat availability and flow impacts are high priorities and will guide future projects.

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Appendices

Appendix A. Stakeholder implementation meetings and workshops.

Meeting Type	Location	Date
Risk assessment	Eureka	Sep. 1-2, 2009
	Wietchpec	Oct. 14, 2009
Implementation plan	Wietchpec	Feb. 8, 2013
	Weaverville	Mar. 5, 2013
	Yreka	Apr. 17, 2013
	Van Arsdale	May 20, 2014
	Round Valley	May 21, 2013
	Laytonville	May 22, 2013
	Arcata	May 23, 2013
	Arcata	May 24, 2013
	Arcata	Jun. 7, 2013
	Sacramento	Mar. 26, 2014
	Eureka	Apr. 3, 2014
Lamprey summit	Portland	Jun. 20-21, 2012
Workshop - lamprey identification	Arcata	Mar. 17, 2006
Workshop - roads	Trinity Lake	Oct. 22, 2012
Workshop - fish passage design and engineering	Ukiah	Feb. 6, 2013
Workshop - emigration monitoring	Arcata	Jan. 22, 2014
	Yreka	Feb. 19, 2014

Appendix B. Data fields and criteria / coding used in Implementation tables.

HUC IDENTIFIER

FID - Feature ID ESRI
HUC - USGS Hydrologic Unit Code Levels 1-4
Name - HUC Name (USGS)

THREAT

Threat_Category:

- Passage
- Dewatering/Flow
- StreamDegradation
- Water Quality
- Predation
- Population
- Other

Subcategory- depends on threat category

- T_Scope- from Calif. Conservation Assessment (Goodman & Reid 2012)
- T_Severity- from Calif. Conservation Assessment (Goodman & Reid 2012)
- T_Overall- from Calif. Conservation Assessment (Goodman & Reid 2012)
- Threat- brief description of the threat addressed.

ACTION and RATIONALE

Description- short description of proposed action
Type- type of action proposed

- Assessment - assessment of potential threats or project needs.
- Coordination - including, outreach, collaboration and incorporation of lampreys into existing conservation efforts.
- Research - information needs that directly relate to their conservation needs or are needed to assess general threats.
- Survey/monitor - distribution of lampreys, suitable habitat, monitor populations or mapping of point threats (e.g., diversions, barriers).
- Instream - on the ground projects
- Rationale- rationale for action or benefit to lampreys
- Habitat gain- in linear miles of suitable habitat
- Adult- lifestage addressed (checked)
- Juv- lifestage addressed (checked)
- Larvae- lifestage addressed (checked)

SCALE and LOCATION

Scale- area impacted or addressed by action:

- Point (Lat/Long)
- Stream
- Mainstem
- Watershed
- HUC
- Basin
- Subregion
- Region - CA

Location - description, as specific as possible, depends on scale
Lat - Decimal degrees NAD83
Long - Decimal degrees NAD83

PRIORITIZATION

Scale of threats addressed

4 - Regional: Action addresses threat in >50% of region (action's impact, not overall threat)
3 - Multi-HUC: Action addresses a threat in multiple HUC's (<50% of region)
2 - HUC: Action addresses a threat in a single HUC
1 - Drainage: Action addresses threat within a drainage, reach or site, w/o broader impacts

Scope of threats addressed

4 - High: 71-100% of total population, occurrences, or area affected
3 - Medium: 31-70% of total population, occurrences, or area affected
2 - Low: 11-30% of total population, occurrences, or area affected
1 - Insignificant: <10% of total population or area affected

Severity of threats addressed

4 - High: 71-100% degradation or reduction of habitat/habitat function, and/or 71-100% reduction of population within scope
3 - Medium: 31-70% degradation or reduction of habitat/habitat function, and/or 31-70% reduction of population within scope
2 - Low: <30% degradation or reduction of habitat/habitat function, and/or <30% reduction of population within scope
1 - Unknown or n/a: Severity of threat unknown, or assessment and severity not applicable

Effectiveness of action

4 - High: Removes or causes threat to be insignificant; or provides all information needed to address threat (ie. Assessments, Coord., Research, Survey)

3 - Medium: Substantially reduces threat; or provides substantial information/collaboration
2 - Low: Has some effect on threat, but does not reduce it substantially; or provides minimal information/collaboration
1 - Insignificant: Minimally effective or not targeted at a known threat

Feasibility

Technical difficulty
4 - Simple: Utilizes simple technology or readily achievable methods
3 - Moderate: Moderately complex, but utilizes existing technology and standard methods
2 - Difficult: Requires high level of engineering, assessment, development or multiple stakeholder support development
1 - Unfeasible: Not likely to be possible at this time (5 years) due to excessive technical difficulty or complicated economic or political issues

Duration to implement
4 - Short: 0-2 years
3 - Medium: 3-5 years
2 - Long: > 5 years
1 - Extended: extended time frame or perpetual

Readiness
4 - Underway: Already underway or funded
3 - High: Can be initiated in the next two years.
2 - Medium: Could be initiated in the next 3-5 years.
1 - Low: May take five or more years for additional assessment and planning

Cost
4 - Inexpensive: $ < 10 k
3 - Moderate: $ 10-50 k
2 - Expensive: $ 50-250 k
1 - Very Expensive: $ 250 k - millions

Funding Source
4 - Funded: Funding has been obtained
3 - Identified: Appropriate funding sources identified and likely to participate
2 - Unspecified: Various appropriate funding sources exist but have not been selected
1 - Uncertain: Funding is uncertain

Partner participation
4 - High: All potential stakeholders are supportive
3 - Medium: Necessary stakeholders are supportive
2 - Low: Additional stakeholders need to be incorporated

1 - Problematic: Necessary stakeholders are not supportive

Prerequisites: Brief description of additional actions needed.

Additional Benefits

Prerequisite for other actions: Is action necessary prior to other implementation actions?
1 - Yes
2 - No

Additional benefits
4 - High: Will have substantial benefits beyond the specific goals of the action (e.g., outreach, technology, precedent setting)
3 - Medium: Will provide additional benefits to conservation efforts outside the drainage
2 - Low: Localized benefits to species or stakeholders
1 - Insignificant: Benefits restricted to action purpose only

Public awareness
4 - High: High public awareness and positive outreach benefit
3 - Medium: Increased stakeholder awareness and benefit outside of action area
2 - Low: Unlikely to come to attention of public outside action area
1 - Insignificant: Will probably not be noticed by anyone except those carrying out the action

Status

Status
- 'No status'
- Proposed
- Funded
- Underway
- Ongoing
- Completed

Work in Progress: Brief description of current work underway or completed

Implementing Entity: Lead entity, and partners
Contact: Primary contact for threat or action
Cost: Approximate (this is difficult)
Funding Source: Current or potential
Funds available: Percent (%) of total cost
Stakeholders: Involved/effected parties - not necessarily implementer or funder
Notes:

Appendix C. Proposed implementation tasks and needs - North Coast.

The Implementation Database is intended as a living document that will be updated as we develop new information and improve our understanding of lamprey conservation status and as implementation progresses and the status of individual projects changes. A current version of the Implementation Database is maintained at the Arcata USFWS Field Office. Interested stakeholders can contact us either for electronic access to the implementation database, to provide updated information or to recommend additional projects.

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