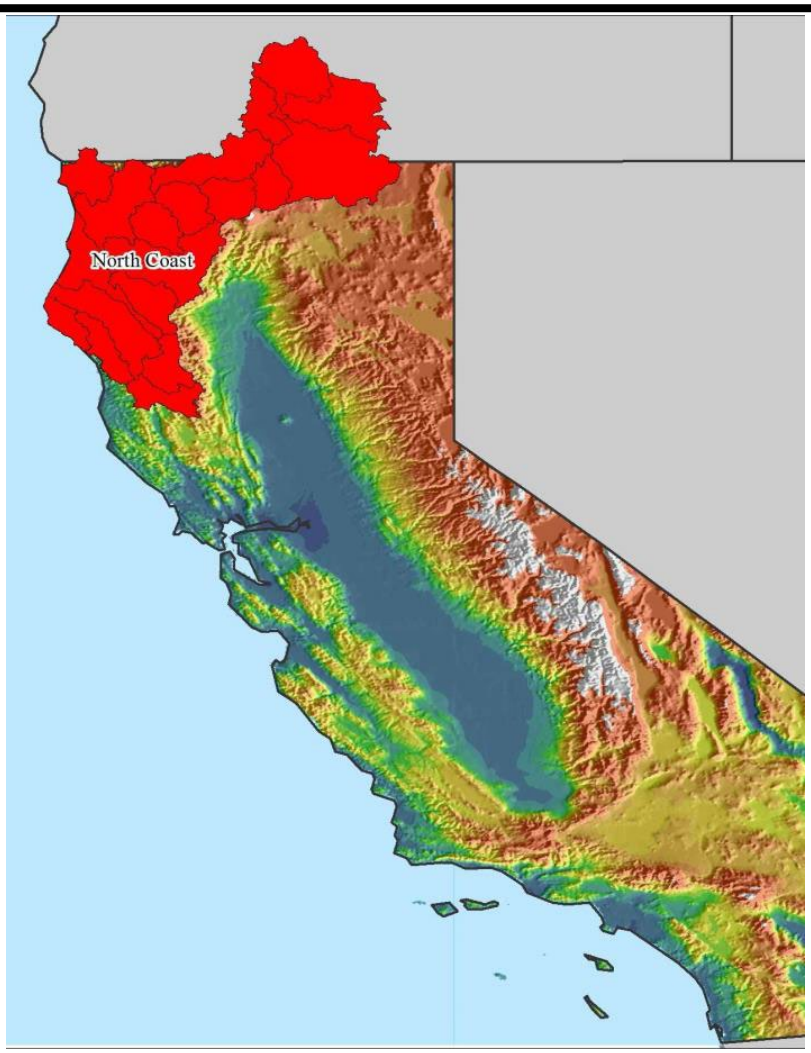
U.S. Fish & Wildlife Service

Arcata Fisheries Technical Report TR 2022-41

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

Josh Boyce, Damon H. Goodman and Stewart B. Reid



U.S. Fish and Wildlife Service
Arcata Fish and Wildlife Office
1655 Heindon Road
Arcata, CA 95521
(707) 822-7201

August, 2022

Funding for this study was provided by the U.S. Fish and Wildlife Service Arcata Fish and Wildlife Office, with additional support provided by the Service's Pacific Southwest Region Fish and Aquatic Habitat Program Office.

Disclaimers: The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the Federal Government.

This plan was developed using information collected through: (1) regional stakeholder meetings hosted throughout the North Coast Regional Management Unit in 2009-2014, (2) subsequent discussions with various stakeholders, and (3) the authors' experience. New information, as it becomes available, will be incorporated into subsequent revisions of this plan and posted on the U.S. Fish and Wildlife Service Arcata Fish and Wildlife Office website.

The Arcata Fish and Wildlife Office Fisheries Program reports its study findings through two publication series. The **Arcata Fisheries Data Series** was established to provide timely dissemination of data to local managers and for inclusion in agency databases. The **Arcata Fisheries Technical Reports** publishes scientific findings from single and multi-year studies that have undergone more extensive peer review and statistical testing. Additionally, some study results are published in a variety of professional fisheries journals.

key words: Pacific Lamprey, conservation measures, NatureServe, limiting factors

The correct citation for this report is:

Boyce, J., Goodman, D.H. and S.B. Reid. 2022. Regional Implementation Plan for Measures to Conserve Pacific Lamprey (*Entosphenus tridentatus*), California - North Coast Regional Management Unit. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2022-41, Arcata, California.

Table of Contents

List of Figures

List of Tables

Acknowledgements

This assessment was prepared in coordination with the regional USFWS Western Lamprey Conservation Team (Luzier et al. 2011) and the invaluable assistance of numerous local stakeholders. The California Lamprey Conservation Team gratefully acknowledges the following individuals who participated in local stakeholder meetings and/or provided data, information and insight on the Pacific Lamprey in California:

Agency	Individual
Bear River Band of Rhonerville Rancheria	Elijah Sanderson
	Enka Collins
	Little Runningbear
	Thomas Wallace
Blue Lake Rancheria	Jacob Pounds
	Michelle Fuller
Cahto Tribe Laytonville Rancheria	Fred Simmons
	Sonny Elliot
California Department of Fish and Wildlife	Allan Renger
	Amy Debrick
	Barbara Hagedoun
	Berlynna Heres
	Bill Chesney
	Caitlin Bean
	Chris Adams
	Chris Diviney
	Dave Kajtaniak
	Donn Rehberg
	Gayle Garman
	Gordon Leppig
	Jennifer Bull
	John Hileman
	Justin Garwood
	Lauren Romero
	Mary Daniels
	Michael Sparkman
	Michael Bradford
	Michelle Gilroy
	Mike Vanhattem
	Scott Harris
	Scott Bauer
	Seth Daniels
	Steel Sims
	Steven Stenhouse
	Tony LaBanca
CalTrout	Curtis Knight
CalTrans	Susan Leroy
Del Norte County	Jeff Daniels
	Kyle Hampson
	Lee Dutton
	Ludel McNamer
	Martin Luttrell
Five Counties Salmonid Conservation Program	Claire Lindstrand
	David Colbeck
	Mark Lancaster
	Sue Rhodes
Green Diamond	Charles Holt
	Kieth Lackey
	Matt Nannizzi
	Pat Righter
	Ryan Bourque
	Teal Dimitrie
Hoopa Valley Tribe	Aubrey Loren
	Billy Matilton
	Daniel Jordan
	David Ruiz
	Eric Matilton
	George Kautsky
	James Rickaby

Acknowledgements continued.

Agency	Individual
Hoopa Valley Tribe	Mike Orcutt
	Paul Petros
	Sean Ledwin
	Thomas Masten
	William Gray
Humboldt Baykeeper	Beth Werner
Humboldt County	Adrian Wantt
	Art Reeve
	Ben Fleek
	Denton Carrick
	Douglas Fini
	Jeff Klingal
	Jim Poletski
Humboldt County	Johnny Rodriguez
	Marty Messanger
	Michael Layton
	Paul Donoho
	Samantha Smith
	Scott Carns
	Todd Theuerkauf
	Wayne Tomasow
Humboldt State University	Andrew Kinziger
Karuk Tribe	Alex Corum
	Emilio Tripp
	Harold Mitchell Jr.
	J.J. Reed
	Ken Brink
	Mike Polmateer
Karuk Tribe	Ronald Reed
	Toz Soto
McBain and Trush	Bill Trush
Mendocino County	Alex Straessle
	Michael Perry
	Sean Leslie
	Stephen Swingle
	Steven Archuleta
	Walter Crain
NRCS	Tim Viel
NCRC	Julie Schreiber
Novo Aquatic Sciences	Steven Novotny
Quartz Valley Rancheria	Crystal Bowman
	Rebekah Slusi
Redwood National and State Parks	David Anderson
	Keith Bensen
Round Valley Indian Tribes	Joe Dukepoo
	Stephanie Boggs
	Warren Mitchell
Salmon River Restoration Council	Josh Saxon
	Sophie Price
	Betsy Stapleton
Scott River Watershed Council	Charnna Gilmore
	Glenn Hall
Siskiyou County	Keith Towne
	Kelly Eastlick
Siskiyou County	Matthew Solus
	Nate Dooley
	Rob Jackson
	Scott Burkett
	Scott Waite
	Tom Morrison
S.F. Eel River Salmonid Restoration Federation	Katrina Nystrom

Acknowledgements continued.

Agency	Individual
Stillwater Sciences	Abel Brumo
Mattole Salmon Group	Keytra Meyer
Trinity Associates	Aldaron Laird
Trinity County	Benji McClellan
	Craig Lindsey
	Dillon Fry
	DJ Fullerton
	Gary Gillihan
	Jan Smith
	Judy McLaughlin
	Ted Wilson
Trinity County RCD	Alex Cousins
Trout Unlimited	Ron Ward
BLM	Dave Fuller
USBR	Michele Gallagher
USFWS	Andrew Goodman
	Damion Ciotti
	Ernest Chen
	Greg Gray
	Javier Linares-Casenave
	Joe Polos
	Mark Magneson
	Micheal Sundman
	Nancy Finley
	Nicholas VanVleet
	Nicholas Hetrick
	Philip Colombano
	Randy Brown
	Steve Gough
	Tom Shaw
	Vina Frye
U.S. Forest Service	Bill Brock
	Bobbie DiMonte-Miller
	Eric Wiseman
U.S. Forest Service	Jason White
	Joeseph Furnish
	Karen Kenfield
	Lee Morgan
	Leroy Cyr
	Maija Meneks
	Michael Kellett
	Rodney Nakamoto
	Samatha Chilcote
U.S. National Oceanic and Atmospheric Administration	Don Flickinger
	Eric Theis
	Nathan McCann
The Watershed Research and Training Center, Hayfork	Cindy Buxton
	Josh Smith
Wiyot Tribe	Andrew Antonetti
	Briannon Fraley
	Cheryl Seidner
	Dave Hillemeier
	Eddie Koch
	Gil Calleja
	James Ray
	Jeremy Alameda
	Josh Jimenez
	Keith Hustler Jr.
	Larry Alameda
	Luke Walker
	Nick Folkins
	Robert Ray Sr.
	Scott Silloway
	Vince DiMarzo
	Stephen Kullman
	Steven Nova Jr.
	Tim Nelson
Yurok Tribe	Barry McCovey Jr.
	Keith Parker
	Tony Heacock
	Mike Belchik
	Shane Quinn

Acronym and Symbol List

BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
CalTrans	California Department of Transportation
CDFG	California Department of Fish and Game
DO	Dissolved oxygen
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FY	Fiscal Year
GIS	Geographic Information System
HUC	Hydrologic Unit Code (USGS)
IUCN	International Union for Conservation of Nature
MOA	Memorandum of Agreement
mtDNA	Mitochondrial DNA
NMFS	National Marine Fisheries Service (NOAA)
NOAA	National Oceanographic and Atmospheric Administration
P.G.&E	Pacific Gas and Electric Company
PLCI	Pacific Lamprey Conservation Initiative
RKM	River Kilometer
RM	River Mile
RMU	Regional Management Unit
SWCD	Soil and Water Conservation District
USACE	U.S. Army Corp of Engineers
USBR	U.S. Bureau of Reclamation
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WQ	Water quality

Page intentionally blank.

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

Josh Boyce[1], Damon H. Goodman [2] and Stewart B. Reid [3]

[1] *U.S. Fish and Wildlife Service*
Arcata Fish and Wildlife Office
1655 Heindon Road, Arcata, California
Josh_Boyce@fws.gov

[2] *California Trout*
701 S. Mt. Shasta Blvd., Mount Shasta, CA 96067
DGoodman@CalTrout.org

[3] *Western Fishes*
2045 East Main Street
Ashland, OR, 97520
WesternFishes@AshlandCreek.net

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 in the Assessment and Template for Conservation Measures in California (Goodman and Reid 2012, USFWS 2019, Boyce and Reid 2022) and updates earlier implementation plans (Goodman and Reid 2015), including completed, ongoing and proposed implementation actions to aid in conservation of the species. These documents do not represent analyses required by the Endangered Species Act to determine if a species is warranted for listing as a threatened or endangered.

The Assessment and Template for Conservation Measures in California includes introductory chapters describing the overall assessment and conservation strategy of the PLCI, general biology of and threats to Pacific Lamprey, and methodology. Successive chapters focus on Pacific Lamprey in the California Region as a whole and in seven specific geographic subregions (Regional Management Units - RMU's) 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

We use the combined results of viability and threats assessments in the California Assessments, review of available literature, site visits, the authors' experience with lampreys and discussions with stakeholders to develop implementation plans for each of seven RMU's (Figure 2, Appendix A); 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, 2018 and 2022 California Assessments 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 RMU's 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 to 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 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 Assessments and Implementation Plans 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 from earlier plans have been initiated or are well underway. It is our goal to continue this progress.

Implementation Planning - Methodology

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, 2018 California Assessment process (Goodman and Reid 2012, USFWS 2019). 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, 2018 and updated 2022 California Assessments are summarized herein, but the Assessments contain 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 methodology. 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 Reid and Goodman (2012; USFWS 2019, Boyce and Reid 2022). Collaborative stakeholder discussions and site visits were held in 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 discussions and workshops). Outreach and information gatherings included multiple stakeholder discussions or workshops and included over 200 different stakeholders. Stakeholder discussions 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, 2018 and 2022 threat assessments and drew upon various sources of information, including review of available literature, site visits, the authors' experience with lampreys across California and discussions with local stakeholders. For each recognized threat, actions were developed that would specifically address that threat, or would 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 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, and
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 proposed implementation tasks and contact information.

Figure 1. Map of seven California Regional Management Units (RMU's).

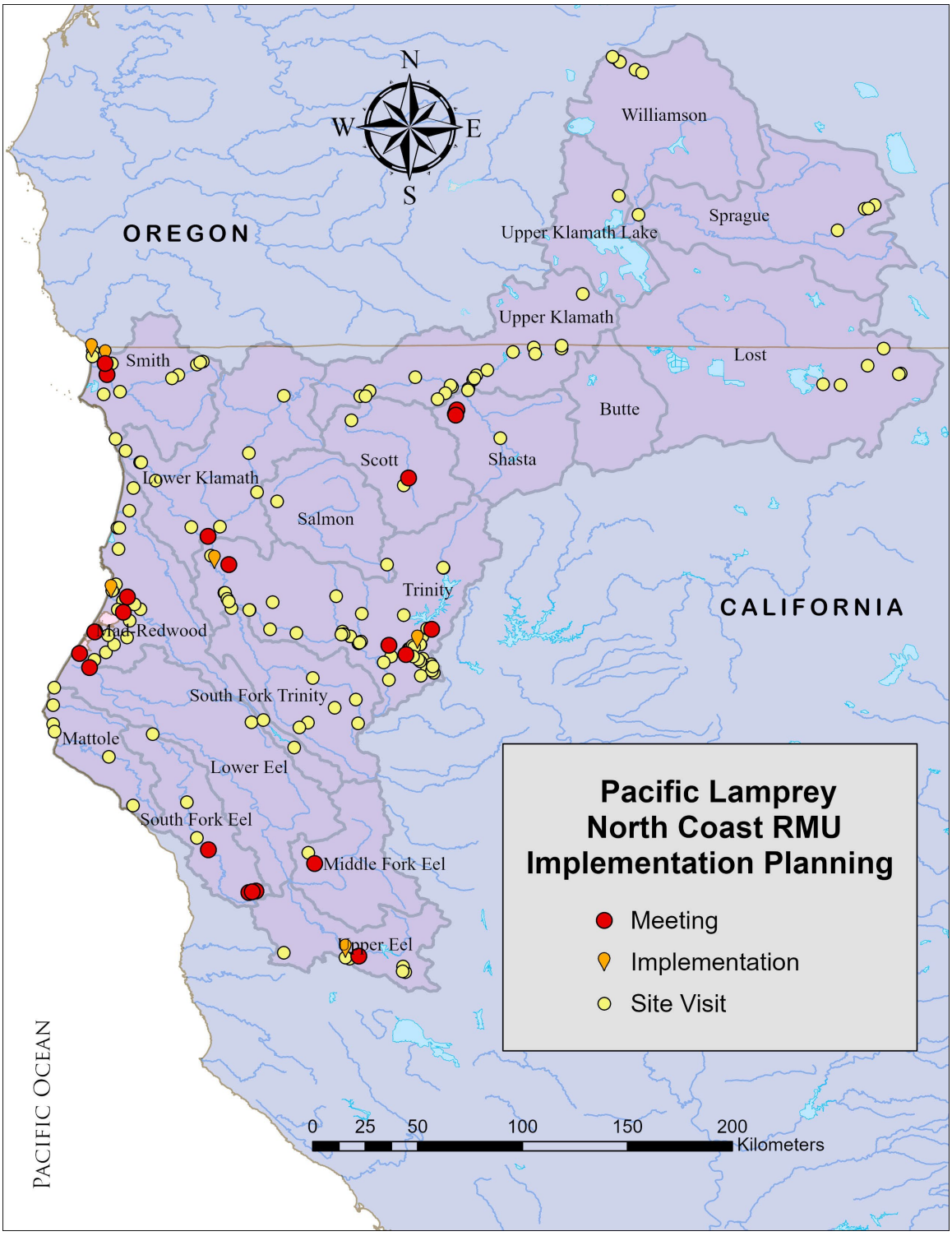


Figure 2. Map of stakeholder discussions, workshops and site visits which informed the development of the North Coast implementation plan.

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 2018 Assessment with current information, USFWS 2019).

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 (Reid and Goodman 2017).

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 (Reid and Goodman 2017). 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 Cape Horn (constructed 1907; fish ladder 1922) and Scott (constructed 1922) dams on the upper Eel River. Only the Cape Horn Dam has facilities for fish passage, although the older fishway was not suitable for lampreys. In 2017 it was modified with the addition of a lamprey-specific passage and monitoring facility under the PLCI (Goodman and Reid 2017, unpubl. data). The mainstem Klamath River dams are planned for removal in 2023, and the upper Eel River dams (Cape Horn and Scott dams) are currently under review.

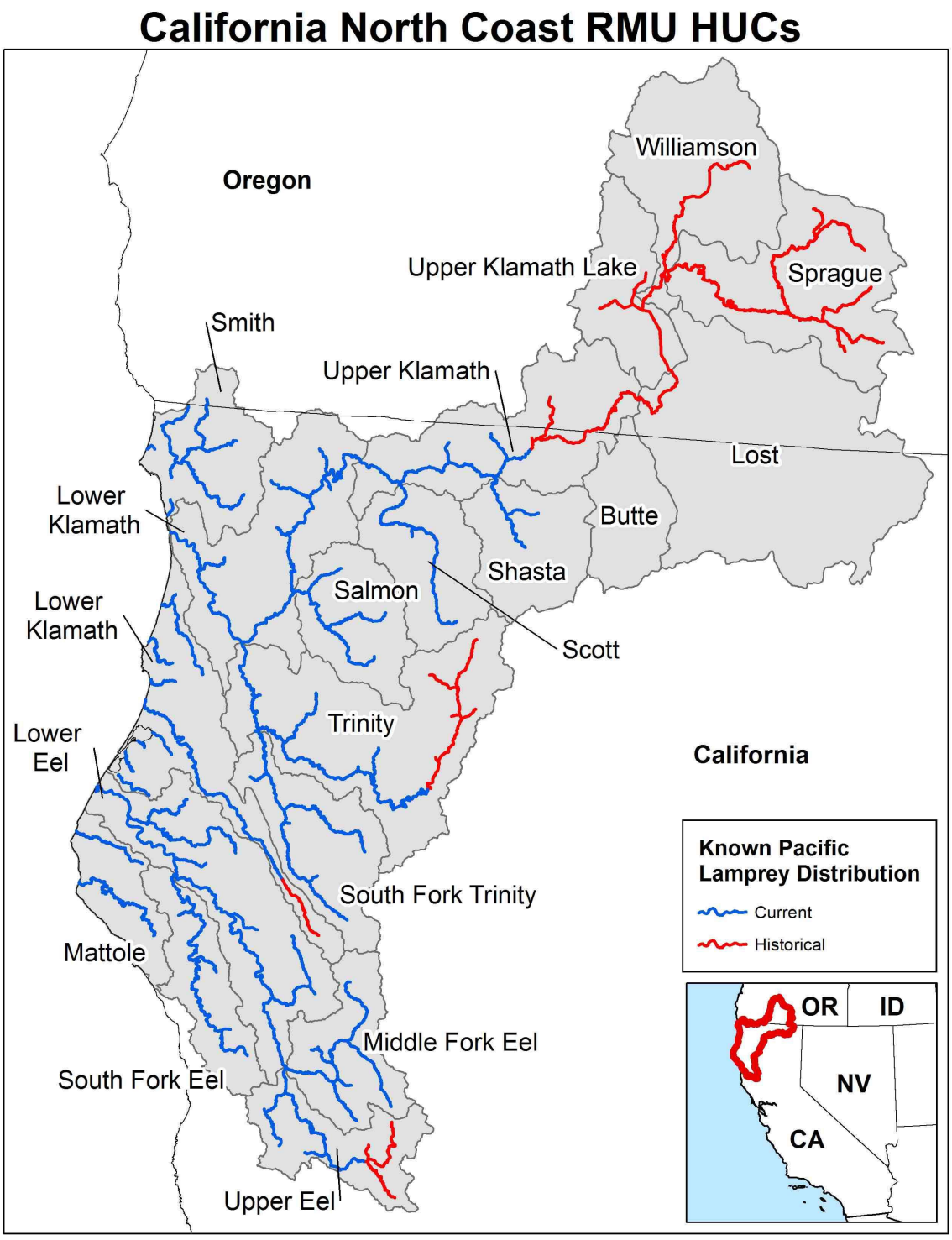


Figure 3. North Coast Regional Management Unit (RMU) and its watersheds (4th field HUCs), with current and historical distribution of Pacific Lamprey in 4th order and higher streams (Reid and Goodman 2017).

Table 1. Conservation Status Ranks and Population demographics in the 4th Field watersheds (HUC) in the CA North Coast Region. Note that historical and current occupancies are linear stream distances (4th order and above), reflecting improved distribution data since the 2012 Assessment. The Butte HUC is endorheic (NA - not anadromous). Adapted from the 2018 Assessment (USFWS 2019); note an updated assessment is expected in late 2022.

Watershed	Conservation Status Rank	Historical Occupancy (km)	Current Occupancy (km)	Ratio Current/ Historical	Population Size (adults)	Short-Term Trend (% Decline)
Klamath						
Williamson	SX	136	0	0	Extinct	-
Sprague	SX	427	0	0	Extinct	-
Upper	SX	92	0	0	Extinct	-
Lost	SX	48	0	0	Extinct	-
Butte	-	NA	-	-	-	-
Upper	S2	288	164	0.57	250-1000	50 - 70%
Shasta	S1	84	84	1	250-1000	50 - 70%
Scott	S2	139	139	1	250-1000	50 - 70%
Salmon	S2	161	161	1	1000-2500	50 - 70%
Trinity	S2	449	316	0.7	1000-2500	50 - 70%
South Fork	S2	249	249	1	1000-2500	50 - 70%
Lower	S2	373	373	1	1000-2500	50 - 70%
Eel Basin:						
Lower Eel	S2	517	517	1	1000-2500	50 - 70%
Middle Fork	S2	220	220	1	1000-2500	50 - 70%
South Fork Eel	S2	225	225	1	1000-2500	50 - 70%
Upper Eel	S2	241	160	0.66	1000-2500	50 - 70%
Coastal:						
Smith	S2	227	227	1	Unknown	50 - 70%
Mad-Redwood	S2	401	362	0.9	Unknown	50 - 70%
Mattole	S2	154	154	1	Unknown	50 - 70%

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 Cape Horn Dam, now with a lamprey-specific fishway, somewhat restricts access to another 140 km^2. Obstruction of smaller tributaries by culverts was assessed in the Eel (Stillwater Sciences 2014) and Trinity drainages (Reid 2017). However, much of this habitat is higher gradient and not utilized by lampreys.

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). Nevertheless, there is only one formal counting of lampreys in the RMU, and most estimates represent a conservative minimum adult population size for the RMU. At Cape Horn Dam (upper Eel, RM 156), 700 adults were collected at and passed over the 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. In 2016, a video monitoring station was installed in the newly installed lamprey passage facility. Counts at the station, which represent all lampreys passing the dam, have been highly variable, ranging from 4 to 11,506 (2017). 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 (Goodman et al. 2015).

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 Cape Horn 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. Even members of the general public with experience along the rivers typically remember large numbers of 'eels' in the 70's that they no longer see. These anecdotal declines are in agreement with

records from the Oregon Coast at Winchester Dam on the North Fork Umpqua River (Goodman and Reid 2012; USFWS 2019).

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 2014, 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 water quality 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 Cape Horn 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, many of which block less suitable habitat (e.g. higher gradient, seasonal, or sediment poor streams), 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 Potter Valley Project diverts a large proportion of summer flow into the Russian River Basin, reducing instream flow for a considerable reach below Cape Horn Dam. However, dewatering and eutrophication due to small-scale legal and 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 and fines 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 without extensive fine substrates. It has also changed the timing and intensity of runoff and shifted the riparian corridor from narrow and tree-lined with deeper pools to a wide, shallow and denuded channel.

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

Water quality 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 water quality 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 successfully 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

Table 2. NatureServe risk ranks, maximum threat level and principal threat rankings for Pacific Lamprey within the North Coast RMU, grouped by major drainages. The Butte HUC is endorheic (NA - not anadromous) but included for reference. NatureServe ranks: SX, Extinct; SH, Believed extinct; S1, Critically imperiled, S2, Imperiled, S3, Vulnerable, S4 Apparently secure, and S5. Maximum threat ranks: X, Extinct due to dams (prior to 1985); and A to H, substantial and imminent threat to unthreatened. Individual threat rankings for Scope and Severity: 1 to 4, Insignificant to High; U = Unknown Secure. Adapted from the 2018 Assessment (USFWS 2019); note an updated assessment is expected in late 2022.

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 - 4	3 - 3	1 - 1	4 - 3	2 - 1
Shasta	S2	C	1 - 4	3 - 2	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 - 4	3 - 2	3 - 3	4 - 2	3 - 3
South Fork Trinity	S2	C	2 - 2	4 - 2	3 - 3	4 - 2	2 - 1
Lower Klamath	S3	C	2 - 2	2 - 2	2 - 2	4 - 2	4 - 1
Eel Basin:							
Lower Eel	S2	B	2 - 2	4 - 3	3 - 3	4 - 3	4 - 2
Middle Fork Eel	S2	B	2 - 2	4 - 3	1 - 1	4 - 3	4 - 2
South Fork Eel	S2	B	1 - 4	4 - 3	1 - 1	4 - 3	4 - 2
Upper Eel	S2	B	2 - 4	4 - 3	1 - 1	4 - 3	4 - 2
Coastal:							
Smith	S3	G	1 - 3	1 - 1	1 - 1	3 - 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

(Heggenes et al. 1993). The impact of either predator on local populations is not known and may be ameliorated by downstream out-migration of juveniles 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, CDFG, 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.

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 (water quality, 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 water quality, 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.

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

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 water quality, 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 Drainage 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/ macrophthalmia.

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, outmigrating 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/macrophthalmia.

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 and a deteriorated fishway at Hayfork Falls 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, deepen channels and promote areas of fine sediments, 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 Cape Horn 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 Cape Horn Dam (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. Cape Horn 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. In 2016, a new lamprey passage and minoring system was installed, with 11,506 lampreys counted passing in 2017.

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. A lamprey passage structure and video monitor system was installed in 2020. 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.

Mad-Redwood

Principal projects in the Mad-Redwood HUC are associated with assessments of possible water quality 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.

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

Literature Cited

Boyce, J. and S.B. Reid. 2022. Pacific Lamprey (*Entosphenus tridentatus*) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. In prep.

Goodman, D.H. and S.B. Reid. 2012. Pacific Lamprey (*Entosphenus tridentatus*) Assessment and Template for Conservation Measures in California. U.S. Fish and Wildlife Service, Arcata, California. 128 pp.

Goodman, D.H., S.B. Reid, N.A. Som and W.R. Poytress. 2015. The punctuated seaward migration of Pacific Lamprey (*Entosphenus tridentatus*): environmental cues and implications for streamflow management. Canadian Journal of Fisheries and Aquatic Sciences 72(12): 1817-1828.

Goodman, D.H. and S.B. Reid. 2017. Climbing above the competition: innovative approaches and recommendations for improving Pacific Lamprey passage at fishways. Ecological Engineering 107: 224–232. https://doi.org/10.1016/j.ecoleng.2017.07.041

Hamilton, J. B., G. L. Curtis, S. M. Snedaker, and D. K. White. 2005. Distribution of anadromous fishes in the upper Klamath River watershed prior to hydropower dams, a synthesis of historical evidence. Fisheries 30:10-20.

Heggenes, J., O.M.W. Krog, O.R. Lindas, J.G. Dokk, and T. Bremnes. Homeostatic behavioural responses in a changing environment: brown trout (*Salmo trutta*) become nocturnal during winter. Journal of Animal Ecology 62:295-308.

Luzier, C.W., H.A. Schaller, J.K. Brostrom, C. Cook-Tabor, D.H. Goodman, R.D. Nelle, K. Ostrand and B. Streif. 2011. Pacific Lamprey (*Entosphenus tridentatus*) Assessment and Template for Conservation Measures. U.S. Fish and Wildlife Service, Portland, Oregon. 282 pp.

NatureServe. 2009. NatureServe conservation status assessment: rank calculator version 2.0. NatureServe, Arlington, Virginia. Online at www.natureserve.org

Nawa, R. K., J. E. Vaile, P. Lind, T. M. K Nadananda, T. McKay, C. Elkins, B. Bakke, J. Miller, W. Wood, K. Beardslee, and D. Wales. 2003. A petition for rules to list: Pacific lamprey (*Lampetra tridentata*); river lamprey (*Lampetra ayresi*); western brook lamprey (*Lampetra richardsoni*); and Kern brook lamprey (*Lampetra hubbsi*) as threatened or endangered under the Endangered Species Act. January 23, 2003.

Reid, S.B. 2017. Passage barrier assessments for lampreys in the Trinity Basin. Hoopa Valley Tribe, Pacific Lamprey Passage Project. Final Report, 14 November 2016. 21p.

Reid, S.B. and D.H. Goodman. 2017. Pacific Lamprey: Historical and Current Distribution - USFWS [ds2673]. California Dept. Fish and Wildlife, Biogeographic Information and Observation System (BIOS). https://map.dfg.ca.gov/bios/.

Stillwater Sciences. 2014. Evaluation of barriers to Pacific lamprey migration in the Eel River basin. Prepared by Stillwater Sciences, Arcata, California for Wiyot Tribe, Loleta, California.

USFWS (U.S. Fish and Wildlife Service). 2004. 90-Day finding on a petition to list three species of lamprey as threatened or endangered. Federal Register: December 27, 2004 (Volume 69, Number 2) Proposed Rules pages 77158-77167.

USFWS (U.S. Fish and Wildlife Service). 2018. Pacific Lamprey *Entosphenus tridentatus* assessment. February 1, 2019. USFWS, Washington D.C.

Appendices

Appendix A. Stakeholder implementation meetings, discussions and workshops. For map of implementation site visits, see Figure 2.

Meeting Type	Location	Date
2012 Threat assessment:	Eureka	1 Sep 2009
	Weitchpec	14 Oct 2009
Lamprey Summit:	Portland OR	20 Jun 2012
2015 Implementation planning:	Weitchpec	8 Feb 2013
	Weaverville	5 Mar 2013
	Yreka	17Apr 2013
	Cape Horn	20 May 2014
	Round Valley	21 May 2013
	Laytonville	22 May 2013
	Arcata	23 May 2013
	Arcata	24 May 2013
	Arcata	7 Jun 2013
	Sacramento	26 Mar 2014
	Eureka	3 Apr 2014
Workshops:		
Lamprey identification	Arcata	17 Mar 2006
Roads and crossings	Trinity Lake	22 Oct 2012
Lamprey passage design	Ukiah	6 Feb 2013
Emigration monitoring	Arcata	22 Jan 2014
Emigration monitoring	Yreka	19 Feb 2014
Lamprey passage design	Eureka	29 Jan 2017
Stakeholder Discussions:		
Hoopa Tribe, USFWS	Hoopa	13 May 2014
CalTrans	Cedar Creek	14 May 2014
CDFW, PG&E	Cape Horn	16 May 2014
Tolowa Tribe	Rowdy Creek	6 Mar 2015
Tolowa Tribe	Rowdy Creek	25 Sep 2015
Hoopa, Yurok, Karuk Tribes	Hoopa	8 Aug 2016
Trinity River RCD, USBR	Grass Valley, Trinity	11 Jul 2017
Scott River Water. Council, landowner	Etna, Young's Dam	21 Aug 2017
USBR	Grass Valley, Trinity	27 Aug 2018
USBR, TRRP, Yurok Tribe	Grass Valley, Trinity	24 Sep 2018
Tolowa Tribe	Rowdy Creek	8 Jan 2020
USBR, TRRP, Yurok Tribe	Grass Valley, Trinity	19 Oct 2020

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.

Please contact:
Josh Boyce, Supervisory Fish Biologist
USFWS Arcata Fish and Wildlife Field Office
1655 Heindon Road, Arcata, CA, 95521
707-825-5193 (office), josh_boyce@fws.gov

Appendix D. Proposed implementation tasks and needs - North Coast. Listed items include tasks and needs that are general to the state, as well as specific to individual HUC's within the North Coast RMU.

HUC	Threat Category	Subcategory	Action Description	Type	Status
REGIONAL					
Statewide	Dewatering/ Flow	Dewatering	Investigate ammocoete responses to fluctuating hydrographs.	Research	Ongoing
Statewide	Other	Dredging	Assess dredging impacts to lampreys in California, focusing on the lower Sacramento and San Joaquin rivers.	Assess.	Underway
Statewide	Other	Habitat	Investigate the role of beavers in lamprey life history.	Research	Ongoing
Statewide	Other	Lack of awareness	Provide outreach, training and local education to stakeholders, resource managers and community members.	Coord.	Ongoing
Statewide	Other	Lack of Coordination	Establish Lamprey Working Groups, including active stakeholders.	Coord.	Ongoing
Statewide	Passage	Culverts	Determine how lampreys move through culverts and what culvert characteristics limit passage.	Research	Completed
Statewide	Passage	Culverts	Develop passage criteria for assessments in California Fish Passage Database (PAD).	Research	Completed
Statewide	Passage	Dams, small	Develop design criteria for instream structures encountered by adult lampreys.	Research	Ongoing
Statewide	Passage	Entrainment	Determine entrainment risk from small-scale (<4") unscreened pumping stations.	Research	-
Statewide	Passage	Entrainment	Develop downstream passage/screening criteria for ammocoetes and out-migrating juveniles.	Research	Ongoing
Statewide	Passage	Entrainment	Assess potential risks of entrainment and mitigation strategies for ammocoetes and out-migrating juveniles.	Research	Ongoing
Statewide	Passage	Fish Ladders	Coordinate with other passage stakeholders to insure lamprey consideration in existing passage structures, as well as current and future projects.	Coord.	Ongoing
Statewide	Passage	General	Review PAD to provide new/modified field that are informative for lampreys.	Assess.	Completed
Statewide	Passage	General	Hold a Lamprey Passage Workshop to educate stakeholders on lamprey issues and promote sharing of experience, solutions and perspective.	Coord.	Completed
Statewide	Population	Biology	Examine the role ammocoetes play in in-stream concentration of *E. coli*.	Research	Completed
Statewide	Population	Biology	Evaluate the swimming capability of adult Pacific Lamprey.	Research	Completed
Statewide	Population	Biology	Examine the outmigration of macrophthalmia to better understand timing and behavior, especially with relation to environmental cues.	Research	Completed

HUC	Threat Category	Subcategory	Action Description	Type	Status
Statewide	Population	Biology	Examine the role ammocoetes play in stream food webs.	Research	Completed
Statewide	Population	Biology	Determine whether there are individual/population differences in maturity state and timing of in-migrating adult Pacific Lamprey.	Research	Ongoing
Statewide	Population	Distribution	Determine the probably historical range of Pacific Lamprey in California, based on tribal information, post-contact historical records, scientific collections, environmental constraints and natural barriers, as well as evidence from the current distribution.	Research	Completed
Statewide	Population	Distribution	Develop standard methods for ammocoete presence/absence surveys and assess probabilities of detection.	Research	Completed
Statewide	Stream Degradation	Education	Develop ammocoete mitigation measures for use in inwater projects to reduce mortality of ammocoetes.	Research	Ongoing
Statewide	Stream Degradation	Restoration	Assess use and design features from samonid restoration for improvements for lamprey ammocoetes in local restoration projects.	Assess.	-
Statewide	Stream Degradation	Sediment	Determine sediment habitat needs of ammocoetes	Research	Ongoing
Statewide	Stream Degradation	Sediment	Investigate ammocoete habitat needs and ecology.	Research	Ongoing
Statewide	Water Quality	Assessment	Determine impact of eutrophication and associated algal blooms on ammocoetes.	Research	-
Statewide	Water Quality	Assessment	Determine thermal and DO tolerances for adult lamprey during summer holding period.	Research	-
Statewide	Water Quality	Assessment	Determine effects of low DO on ammocoetes in fine-grained depositional rearing habitats.	Research	Ongoing
Statewide	Water Quality	Assessment	Determine effects of temperature on ammocoetes and potential impact of climate change on distribution of Pacific Lamprey	Research	Ongoing
California Coastal	Population	Distribution	Assess historical and current use of small coastal drainages by Pacific Lamprey and explore limiting factors that determine distribution.	Assess.	Completed
California Coastal	Predation	Pinnipeds	Assess impact of pinnipeds on adult lamprey in river mouths	Assess.	Underway
North Coast					
All HUCS	Dewatering/ Flow	Dewatering	Increase awareness of adverse impacts caused by small-scale diversions and nutrient inflows throughout the region and promote more responsible use of water.	Coord.	Ongoing
All HUCS	Other	Disease	Assess disease prevalence and effects on population health/survival of lampreys in the Klamath Basin.	Research	-
All HUCS	Other	Lack of awareness	Develop a lamprey exhibit at the Eureka Zoo	Coord.	Completed

HUC	Threat Category	Subcategory	Action Description	Type	Status
All HUCS	Passage	Culverts	Map and assess culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	Completed
All HUCS	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
All HUCS	Passage	Fish Ladders	Replace current fishladder into and thru the culvert with a lamprey friendly design.	Instream	Completed
All HUCS	Population	Distribution	Use telemetry to determine migration behavior and areas utilized by over-summering adult Pacific Lamprey within the Klamath River and tribs	Research	Completed
All HUCS	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries in the Eel Basin.	Survey	Ongoing
All HUCS	Population	Monitoring	Develop a monitoring program and adapt facilities to census lampreys at the Cape Horn fish ladder.	Instream	Completed
All HUCS	Population	Monitoring	Maintain long-term monitoring dataset at the Freshwater Creek weir (trib. to Humboldt Bay).	Survey/ Monitor	Ongoing
All HUCS	Population	Monitoring	Develop and implement a tribal harvest monitoring program.	Survey/ Monitor	Proposed
All HUCS	Population	Monitoring	Develop Klamath Basin population monitoring plan for out-migrating macrophthalmia utilizing existing screwtrap programs.	Survey/ Monitor	Underway
All HUCS	Population	Spawning	Determine migration timing, spawning locations and timing in principal streams.	Research	Underway
All HUCS	Predation	Non-Native Predators	Assess impact of bullheads on ammocoetes.	Assess.	-
All HUCS	Predation	Non-Native Predators	Assess impact of Brown Trout on ammocoetes/macrophthalmia.	Assess.	Completed
All HUCS	Stream Degradation	Sediment	Determine sediment habitat needs of ammocoetes	Research	Completed
All HUCS	Water Quality	Assessment	Assess impact of eutrophication and associated algal blooms on ammocoetes.	Survey/ Assess.	-
All HUCS	Water Quality	Assessment	Assess impact of mercury on ammocoetes.	Assess.	Ongoing
All HUCS	Water Quality	Assessment	Determine effects of low DO on ammocoetes in fine-grained depositional rearing habitats.	Research	Ongoing
All HUCS	Water Quality	multiple	Contaminants survey w/ ammocoetes	Survey	-
Lower Eel	Stream Degradation	Restoration	Restoration of natural channel morphology in mainstem Eel River.	Instream	-
Lower Klamath	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	-
Lower Klamath	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
Lower Klamath	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems	Survey	-

HUC	Threat Category	Subcategory	Action Description	Type	Status
			and principal tributaries within the Lower Klamath HUC4.		
Lower Klamath	Population	Monitoring	Utilize existing screw trap programs for monitoring outmigrant macrophthalmia.	Survey/ Monitor	Underway
Lower Klamath	Predation	Pinnipeds	Assess impact of pinnipeds on adult lamprey in river mouths	Assess.	Underway
Mad-Redwood	Dewatering/ Flow	Flow management	Assess role of Ruth Lake reservoir releases in maintaining suitable downstream habitat and incorporate PL into management strategies.	Assess.	-
Mad-Redwood	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	-
Mad-Redwood	Passage	Diversions	Entrainment and dewatering at Arcata treatment plant / pumps.	Assess.	-
Mad-Redwood	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
Mad-Redwood	Population	Distribution	Carry out distribution surveys to determine upstream extent in minor tributaries within the Mad-Redwood HUC4 with consideration of current limits of anadromy.	Survey	Underway
Mad-Redwood	Water Quality	Survey	Survey distribution of PL in mainstem to determine areas where WQ may be substantially affecting habitat.	Survey/ Assess.	-
Mattole	Dewatering/ Flow	Dewatering	Assess impact of water diversions on summer flow and WQ in mainstem Mattole River.	Assess.	-
Mattole	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	Underway
Mattole	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
Mattole	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries within the Mattole HUC4.	Survey	Underway
Mattole	Stream Degradation	Sediment	Survey available ammocoete habitat (fines and sands) in mainstem Mattole River. Determine need for/appropriateness of sand augmentation.	Survey/ Assess.	-
Middle Fork Eel	Dewatering/ Flow	Dewatering	Assess lamprey distribution and conservation needs in Round Valley drainages.	Assess.	-
Salmon	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	-
Salmon	Passage	Culverts	Improve Hotelling Creek road crossing	Instream	Underway
Salmon	Passage	Diversions	Assess and resolve the diversion at Little North Fork Salmon.	Instream	-
Salmon	Passage	Diversions	Assess and resolve the old diversion at Knownothing Creek.	Instream	-

HUC	Threat Category	Subcategory	Action Description	Type	Status
Salmon	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
Salmon	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries within the Salmon HUC4.	Survey	Ongoing
Salmon	Predation	Suppression	Brown Trout suppression to reduce predation on ammocoetes/macrophthalmia.	Instream	-
Scott	Dewatering/ Flow	Dewatering	Assess groundwater extraction effects on surface stream flow and lamprey habitat/populations.	Assess.	Proposed
Scott	Dewatering/ Flow	Dewatering	Incorporate lamprey needs into the Scott and Shasta Rivers Instream Flow Study Plans and Data Needs Assessment (2014).	Coord.	Proposed
Scott	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	-
Scott	Passage	Dams, small	Assess Farmers Ditch Diversion screen and passage.	Assess.	Completed
Scott	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
Scott	Passage	Diversions	Develop instream flow projects to protect lampreys in the Scott Drainage.	Coord.	Proposed
Scott	Passage	Fish Ladders	Scotts Diversion (Young's Dam) passage assessment.	Assess.	Completed
Scott	Passage	Fish Ladders	Scotts Diversion (Young's Dam) passage improvement	Instream	Funded 2022?
Scott	Population	Distribution	Use telemetry to determine areas utilized by over-summering adult Pacific Lamprey within the Scott HUC4 to support instream flow management.	Research	Ongoing
Scott	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries within the Scott HUC4.	Survey	Ongoing
Scott	Population	Monitoring	Utilize existing screw trap programs for monitoring outmigrant macrophthalmia.	Survey/ Monitor	Underway
Shasta	Dewatering/ Flow	Flow management	Manage Dwinnel Dam to incorporate lamprey habitat needs, minimum summer flow, oxygenated sediments, ensure outmigration pulse flows.	Coord.	-
Shasta	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	-
Shasta	Passage	Dams, large	Evaluate current dam and create lamprey passage for Dwinnel Dam.	Instream	-
Shasta	Passage	Dams, large	Survey above Dwinnel reservoir for resident lamprey and habitat.	Survey/ Assess.	-
Shasta	Passage	Dams, small	Assess and resolve passage/entrainment issues at the Rice/Novy seasonal flashboard dam for lamprey passage/entrainment issues.	Instream	-

HUC	Threat Category	Subcategory	Action Description	Type	Status
Shasta	Passage	Dams, small	Assess passage/entrainment issues at the Granada water diversion flashboard dam.	Assess.	Underway
Shasta	Passage	Dams, small	Resolve passage/entrainment issues at the Granada water diversion flashboard dam, if necessary, based on assessment.	Instream	Underway
Shasta	Passage	Diversions	Assess and resolve passage/entrainment issues at the Parks Creek diversion (Montague irrigation district).	Instream	-
Shasta	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
Shasta	Passage	Diversions	Develop instream flow projects to protect lampreys in the Shasta Drainage.	Coord.	Proposed
Shasta	Passage	Diversions	Incorporate lamprey needs into the Scott and Shasta Rivers Instream Flow Study Plans and Data Needs Assessment (2014).	Coord.	Proposed
Shasta	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries within the Shasta HUC4.	Survey	-
Shasta	Population	Distribution	Use telemetry to determine areas utilized by over-summering adult Pacific Lamprey within the Shasta HUC4 to support instream flow management.	Research	Ongoing
Shasta	Population	Monitoring	Utilize existing screw trap programs for monitoring outmigrant macrophthalmia.	Survey/ Monitor	Underway
Smith	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	-
Smith	Passage	Dams, small	Assess the Rowdy Creek weir for lamprey passage and provide recommendations.	Assess.	Completed
Smith	Passage	Dams, small	Modify or retrofit the Rowdy Creek weir for lamprey passage.	Instream	Completed
Smith	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
Smith	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries within the Smith HUC4.	Survey	Underway
South Fork Eel	Dewatering/ Flow	Dewatering	Assess flow management in upper Cahto Creek	Assess.	Completed
South Fork Eel	Dewatering/ Flow	Dewatering	Reduce diversion and impoundment of flow in upper Cahto Creek and restore permanent water to Cahto Creek.	Coord.	Underway
South Fork Trinity	Dewatering/ Flow	Dewatering	Assess distribution and scale of small-scale water use in South Fork Trinity	Assess.	-
South Fork Trinity	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	Completed
South Fork Trinity	Passage	Dams, small	Survey, assess and remediate low head dams in the Hayfork drainage.	Survey/ Assess.	Completed

HUC	Threat Category	Subcategory	Action Description	Type	Status
South Fork Trinity	Passage	Dams, small	Assess current passage success over Hayfork Falls and explore opportunities to improve, if necessary.	Survey/ Assess.	Underway
South Fork Trinity	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
South Fork Trinity	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries within the South Fork Trinity HUC4.	Survey	Completed
South Fork Trinity	Stream Degradation	Sediment	Investigate adult summer holding habitat/distribution and assess effects of sediment infilling of summer pools.	Research	-
Trinity	Dewatering/ Flow	Flow management	Assess effects of artificial flow regulation on out-migrating lamprey in the mainstem Trinity River.	Assess.	Underway
Trinity	Dewatering/ Flow	Flow management	Determine timing of spawning and location of lamprey spawning in the mainstem Trinity and assess impacts of peak streamflow events and restoration releases timing on redd scour.	Research	Underway
Trinity	Passage	Culverts	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assess.	Completed
Trinity	Passage	Dams, large	Assess the passage potential and constraints of transporting adult lampreys past the Lewiston and Trinity dams, and assess downstream outmigration issues for macrophthalmia.	Assess.	-
Trinity	Passage	Dams, large	Assess the passage potential and constraints of the Buckhorn Debris Dam's existing spillway ramp (Grass Valley Creek), provide passage if feasible.	Assess.	Completed
Trinity	Passage	Diversions	Assess impact of diversions in Weaver Creek.	Assess.	-
Trinity	Passage	Diversions	Map, assess and prioritize principal diversions for downstream passage, entrainment and dewatering of downstream reaches.	Survey/ Assess.	-
Trinity	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries within the Trinity HUC4.	Survey	Completed
Trinity	Population	Monitoring	Utilize existing screw trap programs for monitoring outmigrant macrophthalmia.	Survey/ Monitor	Underway
Trinity	Predation	Suppression	Brown Trout suppression to reduce predation on ammocoetes/macrophthalmia.	Instream	-
Trinity	Stream Degradation	Sediment	Evaluate sediment use by ammocoetes and sediment management strategies in the Hamilton Ponds, Trinity. Develop sediment management strategy that benefits or reduces impacts to ammocoete population.	Research	Completed
Trinity	Stream Degradation	Sediment	Assess availability of fines in the mainstem Trinity below Lewiston Dam and the opportunities to modify gravel	Assess.	Proposed

HUC	Threat Category	Subcategory	Action Description	Type	Status
			augmentation projects to include suitable particle size-ranges for ammocoete rearing.		
Upper Eel	Dewatering/ Flow	Flow management	Assess impact of Scott Dam and Potter Valley diversion flow management on lampreys.	Assess.	-
Upper Eel	Passage	Dams, large	Assess passage (upstream and downstream) opportunities and habitat suitability at/above Scott Dam.	Assess.	Ongoing
Upper Eel	Passage	Diversions	Assess entrainment at Potter Valley diversion.	Assess.	Underway
Upper Eel	Passage	Fish Ladders	Assess passage constraints for lampreys at the Cape Horn fish ladder and develop improvements.	Assess.	Completed
Upper Eel	Passage	Fish Ladders	Make modifications to the Cape Horn fish ladder to improve lamprey passage as necessary, depending on results of assessment.	Instream	Completed
Upper Klamath	Dewatering/ Flow	Flow management	Assess effects of artificial flow regulation on out-migrating lamprey in the mainstem Klamath River.	Assess.	-
Upper Klamath	Dewatering/ Flow	Flow management	Assess effects of ramping rates on ammocoetes and holding adults. Develop guidance for ramp rates to minimize impacts to ammocoetes and adults.	Assess.	-
Upper Klamath	Passage	Dams, large	Remove mainstem Klamath River dams (Iron Gate, Copco 1, Copco 2, JC Boyle).	Instream	Proposed
Upper Klamath	Passage	Dams, small	Assess and modify (if necessary) passage past Keno Dam fishladder on mainstem Klamath River.	Instream	Ongoing
Upper Klamath	Passage	Diversions	Assess seasonal (summer) diversions in Beaver Creek.	Assess.	-
Upper Klamath	Passage	Diversions	Assess seasonal (summer) diversions in Bogus Creek.	Assess.	-
Upper Klamath	Passage	Diversions	Assess seasonal (summer) diversions in Horse Creek.	Assess.	-
Upper Klamath	Passage	Diversions	Assess seasonal (summer) diversions in Seiad Creek.	Assess.	-
Upper Klamath	Passage	General	Map, assess and prioritize potential barriers in principal tributaries (3rd+ order) above Iron Gate Dam and in the Upper Klamath Lake Basin and evaluate available lamprey habitat upstream.	Survey/ Assess.	Underway
Upper Klamath	Population	Distribution	Carry out distribution surveys to determine upstream extent in mainstems and principal tributaries within the Upper Klamath HUC4 below Iron Gate Dam.	Survey	-
Upper Klamath	Population	Monitoring	Utilize existing screw trap programs for monitoring outmigrant macrophthalmia.	Survey/ Monitor	Underway
Upper Klamath	Stream Degradation	Assessment	Evaluate distribution of ammocoetes, availability of suitable habitat and potential for habitat restoration in Cottonwood Creek.	Survey/ Assess.	-
Upper Klamath	Stream Degradation	Management	Incorporate stream flow variation into hydrograph and management discussions.	Coord.	Completed

HUC	Threat Category	Subcategory	Action Description	Type	Status
Upper Klamath	Stream Degradation	Restoration	Assess use and design features from Coho restoration for improvements for lamprey ammocoetes in Seiad and Grider off channel pond restorations.	Assess.	Underway
Upper Klamath	Stream Degradation	Sediment	Work up Karuk/USFWS ammocoete habitat sampling; determine if additional information is needed; develop resource selection functions for use in 2-D habitat modeling.	Research	Underway
Upper Klamath	Stream Degradation	Water Quality	Assess sediment interface habitat quality in mainstem; dead zone Iron Gate to Scott absence of sands from upstream.	Assess.	-