Pacific Lamprey *Entosphenus tridentatus* Assessment

U.S. Fish and Wildlife Service

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DISCLAIMER

The Pacific Lamprey was written with the most current information available at the time, gathered at regional meetings hosted throughout the United States range of Pacific Lamprey in 2017 and 2018. Any new information will be incorporated into subsequent revisions of the Assessment and into the Regional Implementation Plans.

ACKNOWLEDGEMENTS

Numerous individuals representing many organizations collaborated to complete this assessment of Pacific Lamprey. Individuals who contributed to this effort are acknowledged within the individual chapters for each management unit.

Special thanks to the editorial team who led the development of the individual chapters and provided review and guidance throughout the process: Erin Butts, Jody Brostrom, Damon Goodman, Ann Gray, Ann Grote, Benjamen Kennedy, Betsy McCracken, RD Nelle, John Netto, Miranda Plumb, Jennifer Poirier, and Christina Wang.

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Overview

Pacific Lamprey *Entosphenus tridentatus* were historically widespread along the West Coast of North America; however, their abundance has declined and their distribution has contracted throughout Oregon, Washington, Idaho, and California (Luzier et al. 2009). Threats to Pacific Lamprey occur throughout much of the range of the species and include restricted mainstem and tributary passage, reduced flows, dewatering of streams, stream and floodplain degradation, degraded water quality, and changing marine and climate conditions. These threats in conjunction with declining distribution and depressed abundance affect the status of lamprey.

Pacific Lamprey are culturally important to indigenous people throughout their range, and play a vital role in the ecosystem as food for mammals, fish and birds, nutrient cycling and storage. Reductions of abundance and range of Pacific Lamprey have prompted a collaborative conservation effort by tribes, agencies, and others. This collaborative effort, through the development and implementation of the Pacific Lamprey Conservation Initiative (Initiative), is facilitating opportunities to address threats, restore habitat, increase our knowledge of Pacific Lamprey, and improve their distribution and abundance in Alaska, Washington, Oregon, Idaho, and California. The Initiative has three components: Assessment (Luzier et al. 2011; Goodman and Reid 2012); Conservation Agreement (USFWS 2012); and Regional Implementation Plans.

The Agreement called for a revision of the Assessment after 5 years. The purpose of revising the Assessment is to capture changes to conservation risk of Pacific Lamprey as restoration actions are implemented in the Regional Management Units. Partners collected updated demographic information and threats to qualitatively assess the relative risks of extirpation of Pacific Lamprey.

The same NatureServe model version and ranking procedure employed in 2011/2012 was used to re-evaluate the conservation risk of Pacific Lamprey in 2017/2018. Though elements of the NatureServe model were modified to improve the quality and accuracy of conservation factor inputs, the overall methodology remained unchanged to ensure results were comparable in terms of highlighting changes that have occurred in the five-year period between Assessments.

The revised Assessment is organized into multiple chapters. The introductory chapters (Chapter 1-4) describes new information from current literature on the biology and ecology of Pacific Lamprey and our overall assessment and conservation strategy for the species. Chapters 5-22 focuses on Pacific Lamprey in specific Regional Management Units. The RMU chapters describe the current risk rankings and any changes to population demographics and threats since the Assessment in 2011/2012. Ongoing and needed conservation actions are no longer in the Assessment RMU Chapters. They are now described in detail in the Regional Implementation Plans for each RMU (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Key Conclusions

California

NatureServe risk ranks in California Regional Management Units remained relatively stable from 2012 to 2017 and changed in only five HUCs after standardization of distribution estimate approaches between assessments. California ranks were recalculated for each HUC in the 2012 Assessment using the revised historical and current distribution analysis approach. This allowed direct comparisons between 2012 and 2017, which had updated threat severity scores. Two HUCs dropped in rank and three improved. The Smith dropped from S3 to S2 due to unresolved passage issues at the fish ladder on Rowdy Creek, although a new fishway and lamprey modifications are planned. The Lower Yuba also dropped (S2 to S1) due to passage issues, as well as a result of the refined distribution analysis. Two improved their ranks due primarily to the new distribution analysis (Gualala-Salmon and San Francisco Coastal). Finally, the Central Coastal HUC, which includes the current southern limit, improved (S1 to S2) due to passage improvements, the recent range expansion south to San Luis Obispo and successful recruitment in 2017. For 55 HUC's that are currently occupied in California, 13 are ranked as Critically Imperiled (S1), 41 as Imperiled (S2) and one as Vulnerable (S3, San Francisco Coastal). Passage and dewatering and flow management are the major threats to Pacific Lamprey in the California region.

Columbia River and Oregon Coast— The overall pattern of risk is unchanged in the 2017 Assessment. Pacific Lamprey populations at highest relative risk are those in the Upper Columbia, Snake and Mid-Columbia River Regions. All HUCs in these areas were ranked Presumed Extirpated, Possibly Extirpated or Critically Imperiled. Lower risk areas such as parts of the Willamette, the Lower Columbia River and Coastal Oregon watersheds are located downstream of major mainstem passage barriers, but were still largely ranked Critically Imperiled or Imperiled. The spatial arrangement of risk for the Columbia River Region and Oregon Coast has remained fairly homogenous. With the exception of the Clackamas Subbasin, there are no areas of low risk located in close proximity for the potential rescue/restoration of populations at high risk.

Risk ranks varied from Vulnerable (S3) to Presumed Extirpated (SX), with the majority of HUCs falling in the Critically Imperiled (S1; 48%) or Imperiled (S2; 26%) categories. Risk ranks fell (risk levels increased) in a total of 18 HUCs, with the majority of HUCs (13) moving from Imperiled (S2) to Critically Imperiled (S1). Risk ranks improved (risk level decreased) in a total of 14 HUCs. Ranks rose from Possibly Extirpated to Critically Imperiled in a total of nine HUCs in the Upper Columbia RMU and Snake Region due to new/recent information from occupancy sampling as well as successful supplementation efforts by the Nez Perce Tribe and Yakama Nation Fisheries. Improvement in other RMUs is due to increased monitoring and improved population estimates, increased population abundance, or reduced threat impact. The most notable improvement in the 2017 risk Assessment occurred in the Willamette Sub-Unit where the risk rank in the Clackamas rose from Critically Imperiled (S1) to Vulnerable (S3).), primarily due to passage and habitat improvements, combined with better information. Eight HUCs retained the ranking of Presumed Extirpated (SX) in 2017 as a result of large dams with no passage that completely block upstream migration. Principal threats to Pacific Lamprey remained consistent with those identified in the 2011 Assessment and included passage and stream and floodplain degradation.

Mainstem – Conservation Rank Status was not calculated for the mainstem Columbia and Snake Rivers since these areas are primarily seen as passage corridors for populations in other Regional Management Units. Threats were ranked for the mainstem areas and rankings were very similar to the 2011 assessment. Passage and Predation were ranked as the highest threats, but dewatering and floodplain management, stream and floodplain degradation, water quality, and climate change ranked as key threats.

Puget Sound/Strait of Juan de Fuca/Coastal Washington—The lack of demographic data in coastal Washington and Puget Sound precluded completion of risk analysis in most watersheds. Our inability to rank population factors and threats in most of the HUCs highlights the need for lamprey surveys and threat analysis. Risk assessments will be completed as new data are gathered for Puget Sound, the Strait of Juan de Fuca and the Washington Coast.

Alaska— A risk assessment was not conducted for Pacific Lamprey RMU of Alaska during 2018. Alaska has six species of lampreys. Minimal research related to these species has occurred and their full distribution, status and trends remain unknown. An assessment of needed actions and research has been compiled and can be found in the Alaska RMU chapter of this Assessment.

North Pacific Ocean - Status of Pacific Lamprey in the North Pacific Ocean RMU is unknown. The biggest threat to the marine phase of Pacific Lamprey is a lack of detailed biological information that can inform scientists, conservationists, and fisheries managers. Whereas we know some things about where Pacific Lamprey are found in the North Pacific Ocean, we do not know what particular streams they originated from or where they will return to spawn. For example, little information exists on where they go, and much less information exists on the biological history of individual lamprey, or what particular risks they face in the various areas of the ocean inhabit. Empirical data on growth rates, duration on particular prey items, details on prey switching, host impacts, and duration of this phase of their life history is needed.

1. INTRODUCTION

Importance of Pacific Lamprey

Pacific Lamprey *Entosphenus tridentatus* were historically widespread along the West Coast of North America; however, their abundance has declined and their distribution has contracted throughout Oregon, Washington, Idaho, and California (Luzier et al. 2009). Threats to Pacific Lamprey occur throughout much of the range of the species and include: restricted mainstem and tributary passage; reduced flows; dewatering of streams; stream and floodplain degradation; degraded water quality; and changing marine and climate conditions. These threats in conjunction with declining distribution and depressed abundance affect the status of lamprey.

Pacific Lamprey are culturally important to indigenous people throughout their range, and play a vital role in the ecosystem as food for mammals, fish and birds, nutrient cycling and storage. Reductions of abundance and range of Pacific Lamprey have prompted a collaborative conservation effort by tribes, agencies, and others. This collaborative effort, through the development and implementation of the Pacific Lamprey Conservation Initiative (Initiative), is facilitating opportunities to address threats, restore habitat, increase our knowledge of Pacific Lamprey, and improve their distribution and abundance in Alaska, Washington, Oregon, Idaho, and California. The Initiative has three components: Assessment (Luzier et al. 2011; Goodman and Reid 2012); Conservation Agreement (USFWS 2012); and annual Regional Implementation Plans.

Pacific Lamprey Assessment

The Pacific Lamprey Assessment and Template for Conservation Measures (Assessment) for Oregon, Washington, Idaho and Alaska was completed (Luzier et al. 2011) in 2011. The Assessment for California was completed in 2012 (Goodman and Reid 2012). Using information on population abundance, distribution, population trend, and threats to lamprey, we used a modification of the NatureServe ranking system (Faber-Langendoen et al. 2009; Master et al. 2009) to rank the risk to Pacific Lamprey relative to their vulnerability of extirpation in 15 Regional Management Units. The Assessments can be found on the USFWS lamprey webpage (https://www.fws.gov/pacificlamprey/AssessmentMainpage.cfm).

Conservation Agreement

The Pacific Lamprey Conservation Agreement (Agreement) was signed in 2012 by 33 signatories. Signatories included tribes, federal, state and local agencies and NGOs from California, Oregon, Washington, Idaho and Alaska. The goal of this Agreement is to achieve long-term persistence of Pacific Lamprey and support traditional tribal cultural use of Pacific Lamprey throughout their historical range in the United States. The intent of the parties is to achieve this goal, where ecologically and economically feasible, by maintaining viable populations in areas where they exist currently, restoring populations where they are extirpated or at risk of extirpation, and doing so in a manner that addresses the importance of lamprey to tribal peoples. The parties envision a future where threats to Pacific Lamprey are reduced to the greatest extent possible, and the historical geographic range and ecological role of Pacific

Lamprey are restored. The Agreement describes rangewide and Regional Management Unit objectives for collaborative restoration of Pacific Lamprey (USFWS 2012). The Agreement can be found on the USFWS lamprey website (https://www.fws.gov/pacificlamprey/AgreementMainpage.cfm).

Regional Implementation Planning

Regional Implementation Planning started in 2012 after the signing of the Agreement. Each of the Regional Management Unit Groups (RMUs) developed a Regional Implementation Plan that provides a 3-5 year strategy for identifying and implementing high priority conservation actions for lamprey. The plans are updated annually as projects are implemented and lamprey status in the RMU changes. The plans can be found on the USFWS lamprey website (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Lamprey Technical Workgroup

Upon the signing of the Conservation Agreement, the Lamprey Technical Workgroup (LTWG) became the technical committee serving the whole U.S. range of Pacific Lamprey, expanding its purview beyond just the Columbia Basin. The LTWG provides technical review for Regional Implementation Plans and development of best management practices such as, "Practical Guidelines for Incorporating Adult Pacific Lamprey Passage at Fishways" (https://www.fws.gov/pacificlamprey/Documents/2017.06.20%20LampreyPsgFINAL.pdf) and "Best Management Practices to Minimize Adverse Effects to Pacific Lamprey" (https://www.fws.gov/pacificlamprey/Documents/Best%20Management%20Practices%20for%20Pacific%20Lamprey%20April%202010%20Version.pdf).

Revised Assessment

The Agreement called for a revision of the Assessment after 5 years. The purpose of revising the Assessment is to capture changes to conservation risk of Pacific Lamprey as restoration actions are implemented in the RMUs. The Assessment serves as the biological modeling component of the Strategic Habitat Conservation framework. As described in Chapter 3, partners collected updated demographic information and threats to qualitatively assess the relative risks of extirpation of Pacific Lamprey at the 4th Field Hydrologic Unit Code watersheds in the RMU.

The revised Assessment is organized into multiple chapters. The introductory chapters (Chapter 1-4) describe new information from current literature on the biology and ecology of Pacific Lamprey and our overall assessment and conservation strategy for the species. Chapters 5-22 focus on Pacific Lamprey in specific Regional Management Units. The RMU chapters describe the current risk rankings and any changes to population demographics and threats since the Assessment in 2011/2012. Ongoing and needed conservation actions are no longer in the Assessment RMU Chapters. They are now described in detail in the Regional Implementation Plans for each RMU (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Accomplishments

Through the Initiative, partners have accomplished many restoration and research projects for Pacific Lamprey in the last five years. Examples of the many ongoing and completed projects include: distribution and occupancy studies; passage assessments in tributaries and mainstem habitats; habitat restoration projects and monitoring; large and small dam and diversion removals; fish ladder modifications and installation of lamprey passage structures; tide gate and culvert modifications; salinity and temperature tolerance studies; development of protocols and techniques for artificial propagation; lamprey translocation, supplementation, reintroduction and monitoring; evaluation of juvenile entrainment at irrigation diversions and other barriers and screen improvements; water quality evaluations; climate change vulnerability assessment; predation studies; habitat assessments; lamprey identification training workshops; education and outreach to stakeholders, resource managers and community members; development of regional and local lamprey working groups. Each Regional Management Unit chapter in this Assessment have tables outlining accomplishments from 2012-2017.

New Partnerships and Funding

National Fish Habitat Partnership (NFHP) (http://www.fishhabitat.org/) The Initiative became NFHP's 20th partnership in 2016. The Pacific Lamprey Fish Habitat Partnership is working with our partners and other NFHP partnerships to improve habitat and reduce threats for lamprey through our Assessment, Agreement and Regional Implementation Plan process.

The Northwest Power and Conservation Council (NPCC) Fish and Wildlife Program and ***Bonneville Power Administration*** has created the Pacific Lamprey Conservation Initiative Columbia Basin Projects program. Through BPA's cost savings program, several high priority projects identified through the Regional Implementation Plans in the Columbia Basin RMUs will be funded each year.

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

Phylogenetics

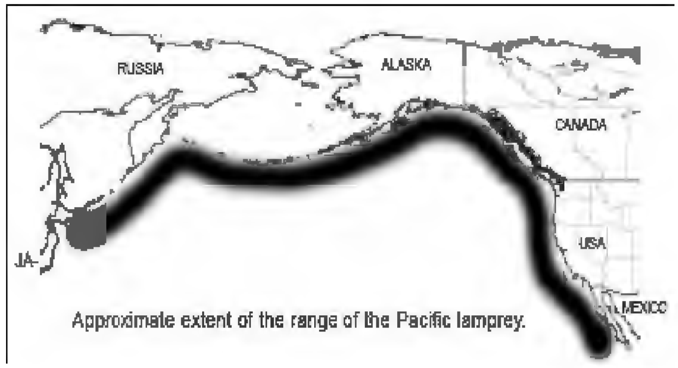
Pacific Lamprey was first described by Gairdner in 1836 (Richardson 1836). The fish are in the Class Petromyzontida, Order Petromyzoniformes, and Family Petromyzontidae. Formerly assigned to the Genus *Lampetra* (Hubbs and Potter 1971), more recent genetic and morphological analyses (Docker et al. 1999, Gill et al. 2003) have put them in the Genus *Entosphenus* (Renaud et al. 2009; Page et al. 2013). Pacific Lamprey *Entosphenus tridentatus* is one of 6 species within this genus (FishBase 2017). All lampreys are jawless fishes and considered part of a large, ancient super class (Agnatha) that date back to the late Ordovician Period (about 450 million years ago) (Purnell et al. 2001). Near the end of the Devonian Period (about 350 million years ago), most Agnathan taxa were extinct, and only the hagfishes and lampreys remain extant (Purnell et al. 2001). These modern agnathans include members that are filter feeders, scavengers, and ecto-parasites. All northern hemisphere lampreys belong to the family Petromyzontinae; Alaska species are members of the tribe Lampetrini and genus *Lampetra*. Populations in Lake Cowichan and Mesachie Lake, British Columbia, formerly included in *E. tridentatus*, are now regarded as a distinct species, Vancouver Lamprey *E. macrostoma* (Beamish 1987).

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

General Morphological Description

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

Geographic Distribution



Historical.—Their range extended from Hokkaido Island, Japan (Yamazaki et al. 2005); and around the Pacific Rim including Alaska (Vogt 1988), Canada, Washington, Oregon, Idaho (Beamish and Northcote 1989; Moyle et al. 1996; USFWS 2004a; Hamilton et al. 2005); and California to Punta Canoas, Baja California, Mexico (Swift et al. 1993; Ruiz-Campos and Gonzalez-Guzman 1996; Ruiz-Campos et al. 2000; Chase 2001; Renaud 2008). In North America, their distribution included major river systems such as the Fraser, Columbia, Klamath-Trinity, Eel, and Sacramento-San Joaquin rivers. Pacific Lamprey are the most widely distributed lamprey species on the west coast of the United States.

Current.— In Japan, Pacific Lamprey have been documented in the Naka River on Honshu Island, as well as other river systems on Hokkaido Island (Yamazaki et al. 2005). Population status in British Columbia is unranked but may be secure (Renaud et al. 2009); and status is unknown in Alaska. Anecdotal and empirical information suggests that Pacific Lamprey populations have declined or been locally extirpated in parts of California, Oregon, Washington, and Idaho (Close 2001; Moser and Close 2003; Luzier et al. 2009; Moyle et al. 2009; Swift and Howard 2009). In these states, Pacific Lamprey have declined in their distribution along all coastal streams and large rivers, including the Columbia River Basin. They are extirpated in parts of Southern California, above dams and other impassable barriers in coastal streams and larger rivers, and in the upper Snake and Columbia rivers. Although historical distribution data is still limited, the current distribution data availability has increased in Oregon, Washington, and Idaho with the development of a regional Pacific Lamprey distribution geodatabase (USFWS, 2016). The database includes data from targeted lamprey surveys, incidental observations during other surveys and in-stream work. While these data greatly increase current distribution records, they are not considered exhaustive. Data are continually added to maintain a thorough database of observations and distribution. Data availability has increased in California as well with a California distribution database populated and maintained by Reid and Goodman (2017). To see maps depicting available distribution data see the Regional Management Unit Chapters (Chapters 5-22).

Life History Characteristics

Much of what is known about the biology and life history of Pacific Lamprey are from early studies done in Canada (Pletcher 1963; Beamish 1980; Richards 1980) and in the Pacific Northwest (Kan 1975; Hammond 1979). Recently, more emphasis has been placed to gather information that characterize Pacific Lamprey life history in other parts of their range (Bayer and Seelye 1999; Chase 2001; Brumo 2006; Gunckel et al. 2006; McGree et al. 2008; Jolley et al. 2010; Clemens et al 2013; Hayes et al 2013; Moser et al 2015; Clemens et al 2016; Clemens et al. 2017). The book "Lampreys: Biology, Conservation and Control, Volume 1" (Springer Publishing, 2015) summarizes information on world lampreys, including what is currently known about their importance, biology, life history and issues affecting them. A generalized life cycle for Pacific Lamprey is depicted in Figure 2-1, and descriptions of the life stages follow.

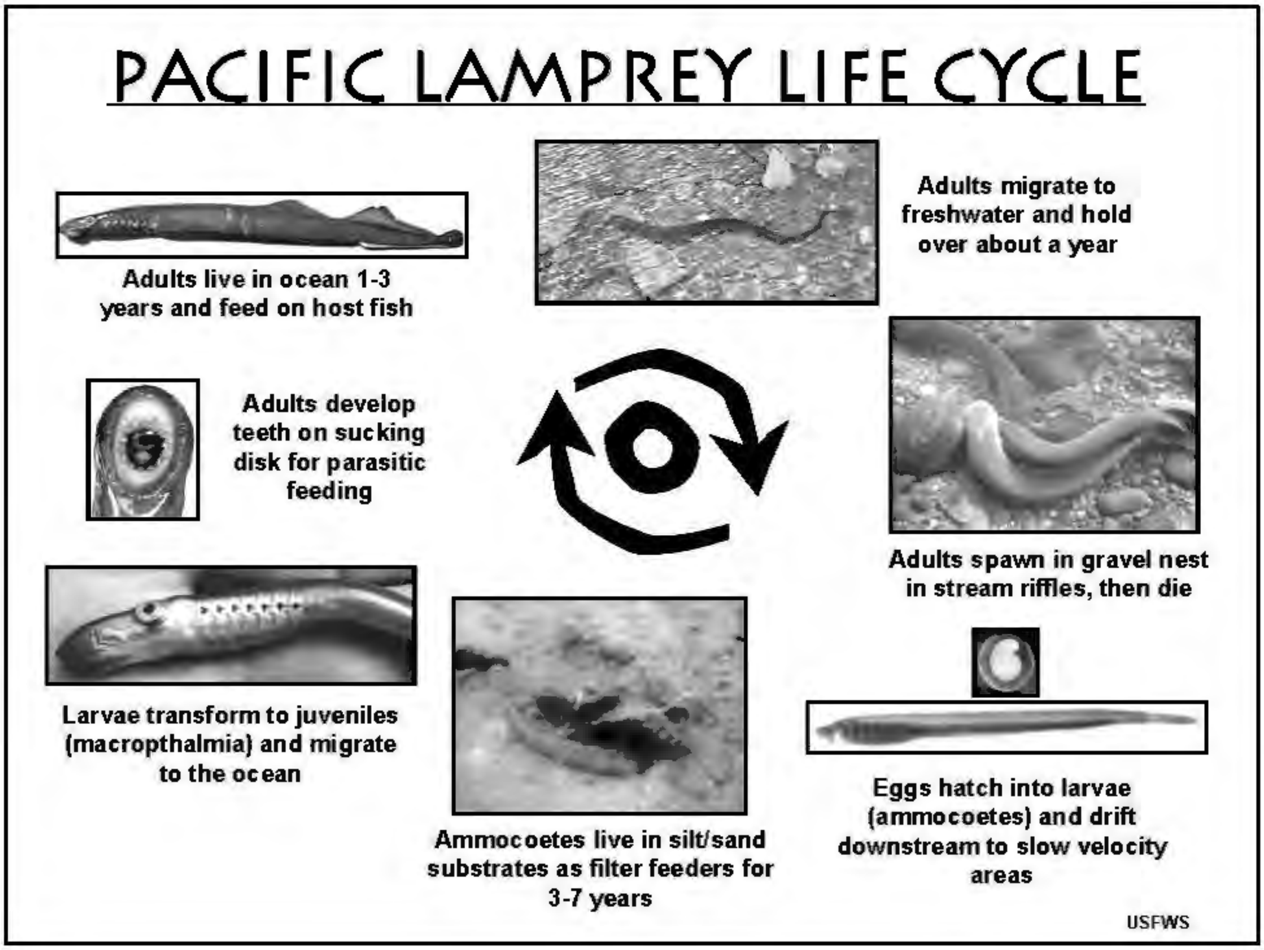


Figure 2-1. General life cycle of Pacific Lamprey, illustrating the duration and morphological characteristics of its life history stages.

Spawning/Adult.—Adult Pacific Lamprey enter freshwater and reside there anywhere from a few months (Bayer and Seelye 1999, Clemens et al. 2013, Clemens et al. 2016) to a few years prior to spawning (Whyte et al. 1993; Clemens et al. 2013; Clemens et al. 2016; Parker 2018). Timing is influenced by water temperature and streamflow (Keefer et al. 2009b) and freshwater entry generally occurs in spring (April -June, Beamish 1980), with a summer upstream migration (July-September, Luzier et al. 2006) prior to overwintering (October-March, Keefer et al. 2009b). Both ocean-maturing adults, which spawn within several weeks of entering freshwater, and stream-maturing adults which spend one year in freshwater prior to spawning have been observed in the Willamette River (Clemens et al 2013) and in the Klamath River (Parker 2018). Adults move upstream primarily at night (Moser and Mesa 2009), particularly when faced with difficult migration conditions such as high turbulent flows and predators (Keefer et al. 2013). In reservoir areas they were found to migrate during daylight (Keefer et al. 2013). Migratory distance is controlled by body size or condition of the adult, with smaller fish not migrating as far as larger fish (Keefer et al. 2009a).

Currently there is general agreement that lamprey species do not home to natal streams, but instead use migratory pheromones (bile acids) released by larvae to reach spawning areas (Goodman et al 2008; (Moser et al. 2015). Pacific Lamprey are attracted to water activated by larval pheromones (Yun et al. 2011), but on a lesser scale compared to other lamprey species (Robinson et al. 2009). This suggests that there may be other components that are important to guide adults in their longer migratory phase and distance (Moser et al. 2015).

Optimal embryo development for Pacific Lamprey occurs at water temperatures between 10 and 18 degrees C, with a sharp increase in morphological abnormalities at 22 degrees C (Meeuwig et al. 2005). Spawning has been observed at water temperature between 10 and 15 degrees C (Robinson and Bayer 2005). Latitude influences water temperature and timing (Johnson et al. 2015), with spawning generally occurring from April to July (Wydoski and Whitney 2003). However, in the Santa Clara River of southern California, spawning likely begins in January and may continue through April (Chase 2001).

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

Pletcher (1963) described Pacific Lamprey nest construction which involved rock lifting and digging by either male or females. Digging serves to loosen the bottom and line the bottom of the nest with sand for egg attachment. Nest construction and digging is carried on between spawning acts (Pletcher 1963).

Female fecundity ranges from 30,000−238,400 eggs (Kan 1975; Close et al. 2002; Wydoski and Whitney 2003). Regional differences in fecundity were found in British Columbia and were related to the distance of upstream migration (Beamish 1980). Death in adults has been observed 3−36 days after spawning (Pletcher 1963; Kan 1975; Beamish 1980).

Many factors affect survival of egg to emergence. Survival to hatching ranges from 50−60% (Close et al. 2002) and appears to be correlated with spawning stock size, water flows during spawning (Brumo 2006), and water temperature (Meeuwig et al. 2005). Brumo (2006) observed that the period of incubation ranged from 18−49 days and was dependent on water temperature. Yamazaki et al. (2003) found that eggs hatched in 11 days when water temperature was 18°C, while Scott and Crossman (1973) reported hatching in 19 days with a water temperature of 15°C. In laboratory studies, the effects of temperature on the development of larvae showed zero development at 4.85°C and greatest survival at 18.0°C (Meeuwig et al. 2005). Although egg predation by Speckled Dace *Rhinichthys osculus* has been observed (Brumo 2006), it has not been well documented for other potential predators.

Rearing/Ammocoetes.—After eggs hatch the newly emerged ammocoetes (larvae) drift downstream to favorable habitat. An appropriate river substrate is an essential environmental characteristic for the development of larval lampreys, not only because it allows for burrow construction, but also it helps maintain a vital water flux for feeding and oxygen exchange (Dawson et al. 2015). Lamprey biologists use a habitat type classification to characterize larval habitat. Type I is generally preferred if available and is located primarily in depositional zones and is predominantly a mixture of sand and fine organic matter. Type II is used less frequently and consists of shifting sand that may contain gravel. Type III consists of substrates such as hard packed gravel, hardpan clay and bedrock (Dawson et al. 2015). Though lamprey may prefer Type 1 and Type 2 habitats, they are found rearing in Type 3 habitat as well. Ammocoetes are filter feeders on detritus, diatoms and algae (Hammond 1979; Potter 1980). Pacific Lamprey larva reared in captivity showed the highest growth rate when fed algae or salmon carcass analog (Jolley et al. 2015). Downstream dispersal occurs all year, largely determined by current velocity, water levels, water temperature and larval density (Derosier et al. 2007). Movement is mostly nocturnal (Beamish and Levings 1991; Moursund et al. 2000; White and Harvey 2003).

At larger scales, larvae are most abundant where the stream channel is relatively deep (0.4−0.5 m), gradient is low (<0.5%), and the riparian canopy is open (Torgerson and Close 2004). Pacific Lamprey ammocoetes have been found residing in sediments under 16 m of water in the mainstem Columbia and Willamette rivers (Jolley et al. 2010; Jolley et al. 2011) At finer scales, larval occurrence corresponds positively with low water velocity, pool habitats, and the availability of suitable burrowing habitat (Roni 2002; Pirtle et al. 2003; Torgersen and Close 2004; Graham and Brun 2005). Ammocoetes of all sizes are known to use slow depositional areas along streambanks and burrow into fine sediments mixed with organic matter and detritus during rearing periods (Pletcher 1963; Lee et al. 1980; Potter 1980; Richards 1980; Torgersen and Close 2004; Graham and Brun 2005; Cochnauer et al. 2006). Ammocoetes remain in stream and metamorphose in 4−8 years (Beamish 1987; Russell 1986; Beamish and Northcote 1989).

Metamorphosis/Macropthalmia.—Prior to metamorphosis, a suitable water temperature regime and sufficient size/lipid reserves to provide enough energy to support all of the developmental changes that occur while the animal ceases to feed need to be present (Youson et al 1993). The stages of metamorphosis have been described for Pacific Lamprey by McGree et al. (2008) who followed ammocoetes through transformation from July to December; however, there may be regional differences in the duration of metamorphosis. Migrating macropthalmia have been collected in smolt traps and dams year round though more are thought to migrate from late fall to late spring (Close et al. 1995; Kostow 2002). Migration timing has been anecdotally correlated with rain or snow melt, distance from ocean, and elevation.

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

Ocean Phase/Macropthalmia to Adult.—Metamorphosed individuals migrate from parent streams to the Pacific Ocean (Orlov et al. 2008). The marine phase of the Pacific Lamprey is clearly an important stage of the Pacific Lamprey life cycle because it is where they attain their adult body size (Beamish 1980; Weitkamp et al. 2015) — and body size is directly proportional to the number of eggs female Pacific Lamprey produce (Clemens et al. 2010; Clemens et al. 2013).

Some topics relative to distribution and connectivity that are not well studied include when Pacific Lamprey enter into and return from marine waters, how entry to and exit from the ocean relates to feeding, recruitment to the population, dispersal at sea, and observed patterns in genetic diversity. Evidence suggests that juvenile Pacific Lamprey move downstream to the ocean in response to river discharge, particularly during late fall, winter and early spring for populations from southern British Columbia to California (Beamish 1980; Beamish and Levings, 1991; van de Wetering, 1998; Moyle 2002; Weitkamp et al. 2015). The timing of re-entry into freshwater is poorly documented due to lack of sampling during late fall and winter. However, the limited information available suggests that the reported re-entry timing as adults occurs during winter and spring (Dawley et al. 1985; Chase 2001, Moyle 2002, Moyle et al. 2009, Weitkamp et al. 2015). The timing of ocean entry and subsequent return to freshwater define the end-points for the marine residence period, and may influence migrations by Pacific Lamprey across the North Pacific Ocean.

Onset of parasitic feeding is unknown, although macropthalmia have been observed attached to salmonids in both fresh and varying concentrations of salt water (C. Luzier and G. Silver, USFWS, personal communication), presumably as they were migrating to ocean environments. Walleye Pollock appears to be the preferred prey item for juvenile Pacific Lamprey in the Strait of Georgia, whereas Pacific Hake may be the preferred prey item elsewhere on the Pacific Coast of North America (Orlov et al. 2008; Wade and Beamish 2016). Pacific Lamprey make daily vertical migrations in the water column, being shallower at night and deeper by day. These vertical migrations by Pacific Lamprey in the ocean have been linked with movements of their prey, Walleye Pollock (Orlov et al. 2008). The parasitic stage may last 20−40 months (Lee et al. 1980).

Pacific Lampreys are geographically found in their greatest concentrations in the Bering Sea, Navarin Cape, the Koryak shelf, East Aleutian Islands, and the west coast of the USA (Orlov et al. 2008). Time spent in the marine habitat is thought to be 6 months to 3.5 years (Kan 1975; Beamish 1980; Richards 1980). Pacific Lamprey are found throughout the water column. Pacific Lamprey have been found in bottom trawls at depths of 16 – 1,193 m (52 – 3,914 ft), and in the open ocean, they have been found between the surface and 1,485 m (4,872 ft; Orlov et al. 2008). However, Pacific Lamprey are most often found between the surface and 500 m (1,640 ft; Orlov et al. 2008; Wade and Beamish 2016). In the Straits of Georgia and near Vancouver Island, Pacific Lamprey were most commonly found at 31 – 100 m (102 – 328 ft), followed by 101 – 500 m (331 – 1,640 ft; Wade and Beamish 2016). Pacific Lamprey have also been found at depths of 100 – 250 m (328 – 820 ft), where they may be associated with some of their prey items, including Walleye Pollock and Pacific Hake (Beamish 1980). Recently a very large catch of adult Pacific Lamprey was made in association with a school of Walleye Pollock at a depth of 45 m (148 ft; Wade and Beamish 2016).

Adults are preyed upon by sharks, sea lions, and other marine animals during their ocean phase (USFWS 2004a). After feeding and growth, adult lamprey transition from the ocean to fresh water for spawning.

Ecology

Pacific Lamprey are an important part of the ecosystem, contributing to food web dynamics, acting as a buffer for salmon from predators, and contributing important marine nutrients to inherently nutrient-poor watersheds (Close et al. 2002; CRITFC 2011).

Larval Pacific Lamprey can make up a large portion of the biomass in streams where they are abundant, thus making them an important component along with aquatic insects in processing nutrients, nutrient storage, and nutrient cycling (Kan 1975; Close et al. 2002; Docker et al. 2015; Clemens et al. 2016). Larval lampreys process nutrients by filter feeding on detritus, diatoms, and algae suspended above and within the substrate (Hammond 1979; Moore and Mallatt 1980; Dawson et al. 2015). They are efficient at trapping food; however, they have low food assimilation rates. The material that is undigested by the lamprey is processed into fine particulate matter which is then exported from the system or taken up by other organisms such as filter feeding insects (Merritt et al. 1984). In addition, adult lamprey die after spawning, leaving the marine-derived nutrients in freshwater streams (Beamish 1980).

Pacific Lamprey appear to be a choice food for avian, mammalian, and fish predators, and at times may be preferred over salmon smolts (Close et al.1995; Stansell 2006 cited in CRITFC 2011). Ammocoetes and macropthalmia migrating downstream may buffer salmonids from predation by birds, mammals, and other fishes (Close et al. 2002). For example, lampreys accounted for 71% by volume of the diets in California gulls, ringbill gulls, western gulls, and Forster's tern in the mainstem Columbia River during early May (Merrell 1959). Past predation rates on salmon smolts by avian and aquatic predators in the Columbia River basin may have been reduced by historically large numbers of outmigrating lampreys (Close et al. 2002). Also, ammocoetes and macropthalmia become available to predators, including salmonids, during scour events, emergence, and downstream migration.

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

Population Structure

Population genetic studies on Pacific Lamprey populations indicate a high level of gene flow among and within basins (Goodman et al. 2008; Docker et al. 1999), supporting the hypothesis that Pacific Lamprey do not home to natal streams. However, varying degrees of genetic differentiation have been reported suggesting the potential for some genetic segregation in either time or space (Spice et al. 2012; Hess et al. 2013, Clemens et al. 2017). Goodman et al. (2008) investigated population structure of Pacific Lamprey from Central British Columbia to Southern California and found no significant population structure among populations or regions. Higher proportions of drainage-specific or "private" haplotypes were identified in southern regions indicating a small degree of genetic differentiation. Lin et al. (2008a) investigated the nuclear genome using among populations from Northern California to Alaska and Japan. These data also suggests significant levels of historical gene flow among populations. Docker (2010) investigated population structure of Pacific Lampreys at 21 locations between British Columbia and Southern California using microsatellite analyses. Similar to Goodman et al. (2008), she found low levels of genetic differentiation among sites. Clemens et al. (2017), however, found a high degree of temporal genetic differentiation between 2 years of adult Pacific Lamprey in the Willamette River, Oregon. These studies indicate a high level of historical gene flows among regions even on a broad scale; however, they also showed the potential for low levels of genetic differentiation at some locations. Spice et al. (2012) attributes this population structure from a species without natal homing as a consequence of limited dispersal. Although a clear understanding of the degree and mechanisms for genetic differentiation does not exist for Pacific Lamprey, it is clear that high levels of gene flow occur among broad regions, but Pacific Lamprey do not seem to be completely panmictic across their range.

Threats/ Reasons for Decline and Current Restoration Activities

Pacific Lamprey face a variety of threats to their various life history stages, and no single threat can be pinpointed as the primary reason for their apparent decline. Threats include artificial barriers to migration, poor water quality, predation by native and nonnative species, stream and floodplain degradation, loss of estuarine habitat, decline in prey, ocean conditions, dredging, dewatering, and climate change (Jackson et al. 1996; Close et al. 1999; BioAnalysts, Inc. 2000; Close 2000; Nawa et al. 2003; Clemens et al. 2017; Schaller et al. 2017).

There are a number of ongoing aquatic conservation and restoration activities that are directed at Pacific Lamprey or for other fish species that indirectly help address the threats to lamprey. The Assessment approach is to provide for coordinated conservation efforts throughout the range of Pacific Lamprey, inclusive of the other federal, state, tribal, county, and non-governmental conservation and restoration measures. We briefly summarize the threats and some conservation and restoration activities that address these threats below, as well as in the individual regional chapters later in this document. More information on threats and the details of specific, ongoing and planned conservation and restoration activities are provided in the annual Regional Implementation Plans (RIPs) developed for each regional management unit.

Passage (dams, culverts, water diversions, tide gates, other barriers).—Artificial barriers impact distribution and abundance of Pacific Lamprey by impeding upstream migrations by adult lamprey (LTWG 2017) and downstream movement of ammocoetes and macropthalmia (Close et al. 1995; Vella et al. 1999; Ocker et al. 2001; Lucas et al. 2009). Upstream adult migrations are blocked by dams without suitable passage alternatives or attraction to fish ladder entrances (Moser et al. 2002). Fish ladders and culverts designed to pass salmonids may not provide upstream lamprey passage, particularly if they have sharp angles that lamprey cannot attach to (Keefer et al. 2010) and high water velocities (Moser et al. 2002; Mesa et al. 2003). Culverts and other low-head structures that have a drop at the outlet are impassable for a variety of reasons including high velocities or distance, insufficient resting areas, and lack of suitable attachment substrate (CRBLTWG 2004). Once upstream passage is no longer possible, Pacific Lamprey populations persist for only a few years above impassable barriers before becoming locally extirpated (Beamish and Northcote 1989).

Juvenile outmigrant lamprey (macropthalmia and ammocoetes) typically travel deeper in the water column (no air bladder) compared to salmonids; thus, the use of spill to provide passage for lamprey is likely unsuccessful (Moursund et al. 2003); however, recently constructed surface collectors on the Clackamas in Oregon have some success in collecting downstream migrants near the surface (PGE 2018). Downstream migrating juvenile lamprey are often entrained in water diversions or turbine intakes (Moursund et al. 2001; Dauble et al. 2006). Due to their size and weak swimming ability (Sutphin and Hueth 2010), ammocoetes and macropthalmia can be impinged on turbine screens (Moursund et al. 2002) and irrigation screens (Ostrand 2004), resulting in delay, injury or death.

Juvenile lampreys are not likely to be harmed by changes in pressure and shear conditions present during turbine passage (reviewed in Moser et al. 2015); however, they are vulnerable to impingement on fish screens (Moursund et al. 2001, Rose and Mesa 2012, Lampman et al 2014). The body length of juvenile lamprey also influences entrainment rates; smaller individuals (< 65 mm total length) are more susceptible to pass through the open spaces in screen material (Clemens et al. 2017). Screens with wire cloth allow more entrainment than other types of screen material (Rose and Mesa 2012; Lampman et al. 2014).

Lamprey juveniles have shown high survival through the juvenile salmonid bypass system at Columbia River mainstem dams (Moursund et al. 2003), but juvenile lamprey are often inadvertently collected and transported downstream in barges or trucks with salmonid smolts. It is unknown whether this is detrimental to lamprey (Moser and Russon 2009). However, observations made by a fish technologist on the transportation barge included rapid dewatering and resulting stranding of ammocoetes and macropthalmia, potential predation in the hold, and injuries similar to descaling of salmon smolts (M. Barrows, USFWS, personal communication).

Because they block adult anadromous fish, passage barriers affect the amount of marine-derived nutrients available to a watershed, which influence primary productivity of food sources available to ammocoetes. Passage barriers often change flow patterns, and block the downstream movement of large wood and coarse sediments, barriers also affect other threats to lamprey, such as water quality, predation, toxicity, decreased habitat availability, and stream and floodplain degradation, which are discussed in subsequent sections.

There are multiple, ongoing efforts to improve passage conditions at dams for migrating adult lamprey, including those at Federal dams on the mainstem Columbia River and other non-federal, hydroelectric dams in California, Oregon, and Washington (Keefer et al. 2012, LTWG 2017). Modifications to regular fishways to improve lamprey passage include 1) installation of lamprey passage structures that bypass the regular fishways, 2) flow reductions within the fishway, 3) rounding of sharp corners to provide for continuous attachment, and 4) screen modifications (Rose and Mesa 2012, Keefer et al. 2012, LTWG 2017). While there has been significant progress, much work remains to design structural or operational solutions to these passage obstacles and expeditiously implement appropriate solutions.

In some watersheds, translocation of Pacific Lamprey adults is used as a tool for reintroduction, augmentation (e.g. Ward et al. 2012), and as an interim measure while primary limiting factors such as passage are addressed in the longer term. Translocation can be defined as the movement of wild-caught fishes from one place to another within their known range (George et al. 2009), and is applied when freshwater habitats have been restored but cannot be re-colonized naturally.

Many small passage barriers (e.g. culverts, small dams) are addressed through site-specific actions identified in recovery plans for listed salmonid species, such as those for Salmon and Steelhead (from National Marine Fisheries Service (NMFS)), and Bull Trout (from USFWS). These actions include installation/improvements to fishways where present, the removal of dams, and or culvert modifications or replacement. When such actions are implemented, they typically can incorporate lamprey passage in the design phase for little or no extra cost; however, additional information and guidance to ensure lamprey passage is incorporated is needed. There are also evaluations of improved tide gate designs to address salmon and Steelhead threats that may also benefit lamprey passage.

Numerous regional inventories (completed and ongoing) throughout the western states identify fish passage barriers and unscreened/inadequately screened water diversions that affect anadromous fish species. These inventories are used to prioritize restoration work (e.g. removal or modification) at these barriers to ensure compliance with state codes and improve fish passage conditions, which should benefit lamprey. Research has been conducted to evaluate NMFS criteria screen material (for salmon) placed in a vertical configuration in a laboratory setting to test incidence of impingement and mortality of Pacific Lamprey macropthalmia at various velocities (Ostrand 2005). Additional research conducted by USGS also evaluated the effectiveness of several common fish screen materials to prevent entrainment of Pacific Lamprey ammocoetes at irrigation diversions (Rose and Mesa 2012). These findings found that perforated plate screens offered the best protection for lamprey ammocoetes, followed by interlock and vertical bar screening. Wire cloth screens were the least protective, and should be replaced with one of the better performing materials. However, lamprey ammocoetes, especially those less than 50 mm long, were still subject to entrainment and or injury for all screen types tested, and such losses may be a major factor impacting lamprey in watersheds with many screened diversions. Fish screens in the Columbia Basin where anadromous salmonids are present must follow NMFS criteria. Screen material is only one component of required criteria. Others are approach and sweeping velocities, a bypass system, and placement that does not delay movement of fish through the diversion (Nordland 2008). These criteria have not been tested for nor determined for lamprey, and more research and monitoring needs to be done to ensure salmonid criteria screens are not impacting lamprey.

Dewatering and Stream Flow Management (reservoirs, water diversions, dredging, instream projects).— Rapid fluctuations in reservoir and stream water levels from irrigation diversions, power hydropeaking operations, and instream channel activities that isolate and dewater stream habitats can impact lamprey. These activities can strand ammocoetes in the substrate and isolate them from flowing water (J. Brostrom, USFWS; J. Crandall, Wild Fish Conservancy; E. Egbers, WDFW; personal communication; Douglas County PUD 2006 http://relicensing.douglaspud.org/documents/pud_relicensing_documents/downloads/SR/EffectofWaterLevelFluctuations.pdf).

Suitable habitat for larval lamprey is often at stream margins in areas of low velocity with fine substrate and canopy shading (Claire 2003; Pirtle et al. 2003; Graham and Brun 2005; Torgerson and Close 2004), which are the first areas dewatered when water surface elevations drop. Larval lamprey do not segregate themselves by age (King et al. 2008) so a single event can affect multiple year classes, significantly impacting a local lamprey population. Channel reconstruction or barrier removal projects targeting the restoration of salmonids can result in rapid and sometimes extensive dewatering of existing channels, thus stranding larval lamprey. Larval lamprey burrow and reside in fine and silty sediments, and may burrow deeper into the sediment during dewatering events to stay wet, which prolongs their emergence from the sediments (Hardisty 2006). While larval lamprey can rely on cutaneous respiration in the moist sediments for several days (Potter et al. 1996), these larvae will die once the habitat dries up. Salmonid salvage prior to reconstruction projects has not typically included efforts to rescue ammocoetes, which may emerge from the sediment well after salvage/rescue efforts cease and no water remains in the channel (Beals and Lampman 2016a; Lampman et al. 2015, 2016a; Liedtke et al. 2015).

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

Low flows during summer and fall can impede adult lamprey migration by restricting flow into an exposed, shallow river channel or creating a thermal block. Lamprey movement at all life stages is predominantly nocturnal (Beamish and Levings 1991; Moursund et al. 2000; Chase 2001; White and Harvey 2003); consequently, flow reductions during daylight will inhibit lamprey from moving into more suitable habitat as they will be reluctant to leave a dark, secure area.

There are some options to protect lamprey during instream water work or dewatering: 1) perform work during times when few if any lifestages of lamprey would be present, if possible; 2) collect as many lamprey as possible by netting and electrofishing and transfer them to unaffected, suitable habitats; and 3) allow larval lamprey residing in the sediments to volitionally escape from the area to be dewatered into areas not to be dewatered, by reducing water levels over several days, in combination with salvaging larvae emerging from the sediments (Clemens et al. 2017). However, these measures are time and labor intensive and the efficacy and effectiveness is unknown (Clemens et al. 2017).

There are numerous watershed planning activities in the western states that help prioritize actions to address the threats from water quantity issues for aquatic species. A specific example is the Watershed Planning Act in Washington that requires plans to balance competing resource demands. The plans are required to address water quantity by undertaking an assessment of water supply and use within the watershed. Elements that may be addressed in the plans include instream flow, water quality, and habitat. Also, water transaction programs throughout the western states have been a valuable tool to reduce water use in several tributaries by using permanent acquisitions, leases, investments in efficiency and other incentive-based approaches. Leaving water in the stream improves instream flows and temperature, and also provides more in-channel habitat, which is especially important during critical times when flows are low. These efforts will reduce the threats to Pacific Lamprey from effects of dewatering and flow management.

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

Stream and floodplain degradation refers to the simplification of river habitats. Lamprey spawn (Mattson 1949; Pletcher 1963; Kan 1975), and rear (Pletcher 1963; Potter 1980; Richards 1980; Torgeson and Close 2004; Graham and Brun 2005) in low gradient stream reaches with complex channel structure, pools, and riffles, and adjacent stream margins and side channels with finer sediment and detritus. These features are frequently found in lower gradient areas with wider floodplains, which are popular for human development. This development includes:

- Construction of dams, which has altered the natural hydrograph (changes to seasonal base flows and temperature regimes; frequency, magnitude and duration of peak flows) and eliminated coarse sediment and large wood routing, all of which are important to the creation and maintenance of complex riverine and riparian habitats.
- Channelization of rivers to reduce/redirect flooding by revetment installation, and dredging to mine gravels or deepen channels for navigation.
- Past forestry practices (log drives, removal of riparian vegetation, reduced large wood recruitment to stream habitats).
- Agricultural practices and urbanization within the floodplain (e.g. increased toxicity, bank stabilization, changes to water quality).
- Removal of riparian vegetation important for ammocoete rearing areas (Pirtle et al 2003, Claire 2003).

These practices have contributed to the loss of complex riverine and riparian habitats and likely reduced the quality and quantity of spawning and rearing habitats (USFWS 2010; Clemens et al. 2017).

Eggs and ammocoetes from many lamprey species that rear in stream substrates have been impacted by activities that remove silt and fine substrate from the stream such as excavation, mining, or dredging activities (Beamish and Yousan 1987; King et al. 2008). Excavation by heavy equipment can remove high numbers and several age classes of juvenile lamprey (King et al. 2008). Dredging activities associated with maintenance for irrigation and hydropower dams can also remove ammocoetes (J. Crandall, Wild Fish Conservancy; and E. Egbers, WDFW, personal communication). In habitats preferred by ammocoetes, these numbers can be quite significant, as densities of Pacific Lamprey have been found to be as high as 358 larvae/square foot (Harris and Jolley 2016) and 1,270 larvae/square foot (Torgersen and Close 2004). Any spoils removed from the water will remove any lamprey within them (King et al. 2008).

Current protection of fish resources in most western states is achieved in partnership with landowners, cities, counties, tribes, states, federal agencies, non-governmental organizations and others through voluntary conservation efforts and under various laws and regulations. Most of the salmon recovery plans outline activities (past, ongoing and planned) to address habitat threats from channelization, loss of side channel habitat, and scouring. While these actions and plans are targeted towards anadromous salmonids, several of the activities will benefit lamprey species. Many of the states are engaged in watershed planning processes, which provide fish, wildlife, and habitat information for land use planning purposes. There are also salmonid recovery activities (e.g., site specific restoration projects), and other conservation efforts underway throughout the states that: 1) protect intact ecosystem processes, structures, and functions; 2) restore ecosystem processes, structures, and functions; 3) reduce sources of water pollution; 4) work effectively and efficiently together on priority actions; and 5) build an implementation, monitoring, and accountability management system. While plans and reports focus on salmonids and restoring the stream and floodplain, many of the recommended future restoration activities identified will benefit lamprey species, especially if the restoration design considers and incorporates the needs of lamprey in the design, pre-planning and fish salvage efforts (Crandall and Wittenbach 2015).

For more information, see the following documents:

- A Best Management Practices document for Pacific Lamprey was issued in 2010 by the USFWS and the U.S. Forest Service (USFWS 2010), so that protection measures for lamprey can be incorporated into any stream disturbing activity (e.g., aquatic habitat restoration, prescribed fire, recreational development, grazing, gravel extraction/mining, water diversions, etc.)
- Pacific Lamprey Habitat Restoration Guide (Crandall and Wittenbach 2015): (http://www.methowsalmon.org/Documents/PacificLampreyRestorationGuide_web.pdf), Description of the biology, ecology, and cultural significance of lamprey, threats and best management practices to protect and restore populations.

Water Quality.—Pacific Lamprey tolerate a temperature range of 5°C to 25°C; spawning occurs from about 10°C to 18°C, and early development from 14°C to 19°C (Clemens et al. 2016). Clemens et al. (2016) in its review also found that temperatures of 20°C or higher were synonymous with stress, tissue damage, and potential mortality. For example, water temperatures of 22°C have been documented to result in mortality or deformation of eggs and early stage ammocoetes under laboratory conditions (Meeuwig et al. 2005). Water temperature of 22°C or higher is often a common occurrence in degraded streams during the early-to-mid-summer period of lamprey spawning and ammocoete development. Further, changes in natural temperature regimes may alter the timing of seasonal activities (migration, spawning, embryotic development) and negatively affect lamprey populations (Maitland et al. 2015; Clemens et al. 2016).

Review by Clemens et al. (2017) found that limited research has been done on the acute and chronic effects of toxicants on the behavior, physiology and overall health of Pacific Lamprey, but suggested Andersen et al. (2010) and Unrein et al. (2016) for more information. Pacific Lamprey may be exposed to toxins and contaminants, during both adult and larval lifestages. Adults may bioaccumulate contaminants while feeding in the ocean and transport those contaminants back to freshwater spawning areas, or when exposed to contaminants while migrating through river corridors designated as Superfund Sites (Clemens et al. 2017). Pacific Lamprey adults sampled in the Willamette River (the lower portion is designated as a Superfund Site) had levels of dieldrin, total PCBs and arsenic that were above acceptable tissue concentrations, and as a result, consumption restrictions were recommended to Siletz Tribal members (ODHS 2005).

Larval lamprey were found to avoid contaminated substrate where possible and often will not burrow in toxin-laden stream substrates (Unrein et al. 2016). However, several sources have found that larval Pacific Lamprey bioaccumulate fire retardants, mercury and pesticides at levels that may be deleterious to individual and population health (Bettaso and Goodman 2008; 2010; Maitland et al. 2015; Nilsen et al. 2015; Linley et al. 2016). Larval lamprey are subject to ingestion and accumulation of toxins during their prolonged freshwater residency as filter feeders in the substrate (Clemens et al. 2017). Furthermore, ammocoetes are relatively immobile in the stream substrates and multiple age classes can concentrate in areas of suitable habitat (King et al. 2008), which makes them susceptible to localized contaminant sources, chemical spills, or chemical treatment (e.g. rotenone) targeting other species.

Bettaso and Goodman (2010) investigated mercury concentrations of larval lampreys (ammocoetes; *Entosphenus* spp.) and western pearlshell mussels *Margaritifera falcata* in the Trinity River, California to determine whether these two long-lived and sedentary filter feeders show site-specific differences in uptake of this contaminant. Ammocoetes contained levels of mercury 12 to 25 times those of mussels from the same site in Trinity River (Bettaso and Goodman 2010). The Pacific Lamprey ammocoetes were also found to have 70% higher mercury levels in a historically mined area when compared to a non-mined reference reach (Bettaso and Goodman 2008). Their data indicate that ammocoetes may be a preferred organism to sample for mercury contamination and ecological effects compared with mussels in the Trinity River.

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

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

The Environmental Protection Agency has issued a comprehensive plan to reduce toxic pollution specific to the Columbia River Basin. The plan tilts toward new monitoring and research programs, but also calls for more stringent water quality standards and more restrictions on water discharges, as well as greater attention to toxics in air emissions and contaminated site cleanups. EPA and a working group developed the Columbia River Basin Toxics Reduction Action Plan (“Action Plan”, USEPA 2010). This action plan builds off the Columbia River State of the River Report for Toxics (EPA 2009) and identifies 5 major initiatives to reduce human and ecosystem exposure to toxics in the Columbia River Basin:

- Increase public understanding and political commitment to toxics reduction;
- Increase toxic reduction actions;
- Conduct monitoring to identify sources and then work to reduce toxic contamination;
- Develop a regional, multi-agency research program;

- Develop a data management system that will allow us to share information on toxics in the Basin (USEPA 2010).

The State of the River Report for Toxics and the Action Plan together create a common framework for toxics reduction and a healthier Columbia River Basin ecosystem. As noted in the plan, the success in reducing toxics depends on a commitment by all levels of government, in both the United States and Canada, tribal governments, non-governmental organizations, industry groups and the public to work together, as the problems are too large, widespread, and complex to be solved by only one organization or country. EPA continues to monitor toxics and its effects to fish and wildlife in the Columbia Basin (e.g. Herger et al. 2016). More information can be found at https://www.epa.gov/columbiariver/columbia-river-toxics-reduction-working-group.

Harvest/Overutilization.— The goal of the Agreement is to support traditional tribal cultural harvest and use of Pacific Lamprey. The non-tribal harvest for food or commercial purposes may present a threat if these activities are concentrated on rivers with low population numbers. Harvest of lamprey can change population structure and alter distribution, thus reducing population numbers. Legal harvest of adults and ammocoetes occurs in California and Alaska. It is currently illegal to sport-fish for or possess lamprey for bait in the states of Oregon, Washington, and Idaho. A non-tribal bag limit of 5 fish was imposed by CDFG for adult lamprey in 2010. These measures have restricted the harvest of Pacific Lamprey and help reduce this threat.

Predation.—Native and non-native fish, marine mammals, and birds prey upon Pacific Lamprey (Close et al. 1995; Moyle 2002) and may pose a threat to lamprey abundance, particularly in altered habitats. As Pacific Lamprey migrate through reservoirs and their associated dams, they may be more susceptible to predation. American mink, birds, raccoons, various fish, and other species feed upon ammocoetes (Semakula and Larkin 1968; Galbreath 1979; Beamish 1980; Wolf and Jones 1989). Adult lamprey are eaten by otters, sea lions, seals, and sturgeon (Roffe and Mate 1984), and northern pike in Alaska (Betsy McCracken, USFWS, personal communication). Concentrations of Stellar sea lions in recent years below Bonneville Dam in the Columbia River have been observed consuming large quantities of salmon, White Sturgeon *Acipenser transmontanus*, and Pacific Lamprey (see Tidwell et al. 2017), although the impact of predation has not been quantified. In the North Umpqua River, blue heron were often observed in areas where tagged adult Pacific Lampreys were holding below the Winchester Dam, and raccoons and mink were observed feeding on larval Pacific Lamprey during the dewatering of the Dam (Ralph Lampman, OSU, personal communication). Native fish species known to prey upon Pacific Lamprey are Northern Pikeminnow *Ptychocheilus oregonensis* and Sacramento Pikeminnow *P. grandis* (Russ Belmer, CDFG, personal communication). Non-native fishes such as bass, *Micropterus spp.*; sunfish, *Lepomis spp*.; Walleye, *Stizostedion vitreum*; Striped Bass, *Morone saxatilis*; and catfish, *Ictalurus spp.* have become established over the last century in some rivers in the western U.S.

Disease.— The impact of diseases in lamprey in all life stages is currently unknown; however, disease may influence lamprey health and reduce their ability to reproduce and survive. A study conducted by the USFWS Lower Columbia River Fish Health Laboratory analyzed adult Pacific Lamprey for a spectrum of potential pathogens from 1990−2003 (Cochnauer et al. 2006). The pathogen that causes furunculosis, *Aeromonas salmonicida,* has been detected in lamprey in the Columbia River Basin (Cummings et al. 2008; Clemens et al 2009; CRBLTWG 2011) and western Oregon. The causative agent for bacterial kidney disease (BKD), *Renibacterium salmoninarum*, was also found in Pacific Lamprey sampled in the ponds at Entiat National Fish Hatchery in Washington (J. Evered, USFWS, personal communication). As a measure of the possible risks associated with introducing wild lamprey into existing fish culture facilities, Kurath et al. tested ammocoetes for susceptibility to infection and mortality caused by experimental exposures to the fish rhabdovirus pathogens infectious hematopoietic necrosis virus (IHNV) and viral haemorrhagic septicaemia virus (VHSV). There was no evidence of infection, replication, or persistence of the viruses, suggesting that larval Pacific lamprey are highly unlikely to serve as hosts that maintain or transmit these viruses (Kurath et al. 2013).

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

Lack of Awareness.—A lack of awareness and understanding of Pacific Lamprey can have negative and unintended impacts to Pacific Lamprey. Information on their distribution, preferred habitat use, ecological role, and best management practices to protect and conserve lamprey are often inadvertently overlooked. Thus, in-channel activities, including those to restoring habitat or passage for other species, can negatively impact lamprey. For example, dewatering a stream to replace a culvert may strand ammocoetes, and use of heavy equipment to dig out channels can remove ammocoetes (Streif 2009; USFWS 2010). To date, Pacific Lamprey have rarely been included in the analysis of impacts of land management activities, such as stream alteration or channel dredging, simply because their presence and distribution is not widely known. Until the early 2000s, Pacific Lamprey were not considered in hydropower operations, fish passage, and relicensing of hydropower dams. Identifying and overcoming funding bias and barriers to lamprey-friendly salmon restoration work is needed, including incorporating lamprey needs at initial restoration design phases. Also, the negative impacts of Sea Lamprey from the Great Lakes have given all lamprey species a bad reputation. We continue to gain a better understanding of the role of Pacific Lamprey as an important component of the ecosystem. To combat negative perceptions that many people have toward lamprey, information on the ecological and cultural benefits of native lamprey needs to be disseminated.

***Ocean Conditions*.—**Given that Pacific Lamprey spend up to several years at sea prior to returning to freshwater to reproduce, it follows that direct and indirect actions to the ocean environment may significantly influence the population. Actions that greatly effect lamprey, their prey species, or that alter the pelagic or substrate habitats to depths up to 500 meters may alter population demographics (Orlov et al. 2008, Murauskas et al. 2013; Wade and Beamish 2016). Nevertheless, additional research, evaluation and monitoring will be needed to determine how actions are reflected in the population.

***Climate Change.*—**Climate change may exacerbate many of the threats listed above, especially flow, ocean conditions, water quality, diseases, predation, and stream conditions. Across the 20th century, the mean annual air temperature has risen by between 0.3°C and 0.6°C (IPCC 1996), and predictive models forecast continued increases in mean global temperatures (Kerr 1997; McCarty 2001). These increases in global climate temperatures during the 20th century have been linked to threats to species and populations, and it is theorized that these impacts will be accelerated given the current predictive models of future climate change (McCarty 2001). Ultimately, species adapted to current local conditions will face a set of ecosystem changes that can induce changes in the latitudinal and altitudinal range of populations (Brander 2007), collapses of populations that are unable to adapt to changing conditions (Pörtner and Knust 2007), asynchrony of cues necessary for animal migrations (McCarty 2001), and altered timing of biological events that coincide with seasonal changes in food availability (Wiltshire and Manly 2004). Climate change alone may threaten the conservation status of many populations and species (Daufresne and Boet 2007; Pörtner and Farrell 2009). Hydrologic changes caused by climate change such as hydrograph timing and stream temperature have the potential to affect Pacific Lamprey during all life stages (Schaller et al. 2017). Consistent with the U.S. Fish and Wildlife Service's Climate Change Strategic Plan (USFWS 2010a), we have embarked on a process to assess how climate change will influence threats and how to plan science-based management actions that will help reduce the impacts on fish and their habitats (adaptation). The adaptive response to climate change is going to be a long process involving strategic conservation of freshwater and marine habitats for Pacific Lamprey. To assist in the development of such a strategy, a climate change vulnerability assessment was recently conducted for Pacific Lamprey along the west coast of the U.S. (Schaller et al. 2017). Risk was evaluated under two different carbon emission scenarios and for two time periods (mid-century 2040 – 2069 and end of century 2070-2099) to compare and contrast climate change vulnerability risk for Pacific Lamprey across the 15 river basins from northern California to the Canadian border. Using downscaled temperature and hydrology projections, a modified NatureServe Climate Change Vulnerability Index was able to consistently score the vulnerability of Pacific Lamprey to future climate change (Schaller et al. 2017). The findings revealed the patterns of vulnerability for Pacific Lamprey across their U.S. range, and are informative for guiding restoration activities.

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

3. METHODS

2011 Assessment and Template for Conservation Measures

In 2011 and 2012 the USFWS and partners conducted an assessment to evaluate the conservation risk of Pacific Lamprey across its west coast range (Luzier et al. 2011; Goodman and Reid 2012). The assessment used a modification of the NatureServe ranking model (Master et al. 2009), which ranks a series of population demographic and threats factors to calculate the relative risk of extirpation of a species at a specific geographic scale. Pacific Lamprey demographic and threats ranking information was collected for discrete 4th field HUC watersheds during a series of regional meetings. This information was summarized by larger regional area (Regional Management Unit) to assess overall patterns of risk. Results were used to identify relative strongholds or weak areas for Pacific Lamprey in order to guide the identification and prioritization of Pacific Lamprey conservation actions. A detailed description of the 2011 Assessment development and NatureServe model selection process and approach can be found in Luzier et al. (2011).

2017 Assessment Revision

The same NatureServe model version and ranking procedure employed in 2011/2012 was used to re-evaluate the conservation risk of Pacific Lamprey in 2017. Though elements of the NatureServe model were modified to improve the quality and accuracy of conservation factor inputs (see 2017 NatureServe Modifications below), the overall methodology remained unchanged to ensure results were comparable in terms of highlighting changes that have occurred in the five-year period between Assessments.

Regional Meeting Process

In California, development of the 2017 Assessment incorporated the results of stakeholder meetings, workshops, ongoing conversations with stakeholders and local biologists, site visits, survey results, unpublished reports, recent peer-reviewed literature and the experience of the PLCI team. Information gained in development of sub-regional implementation plans from 2015-2017 was also incorporated into the status assessment. Informational discussions with local biologists and stakeholders tended to be smaller group meetings and often included site visits to discuss issues of local or regional interest. In all, 46 meetings were held by the California PLCI team as part of implementation planning and assessment processes and 27 of these were held since 2012 (Figure 3-1; see regional implementation plans, Goodman and Reid 2015a-d, 2017a-c). From these discussions and information gathering, NatureServe rankings were developed by the California PLCI team in order to insure consistency in interpretation and application of methodology.

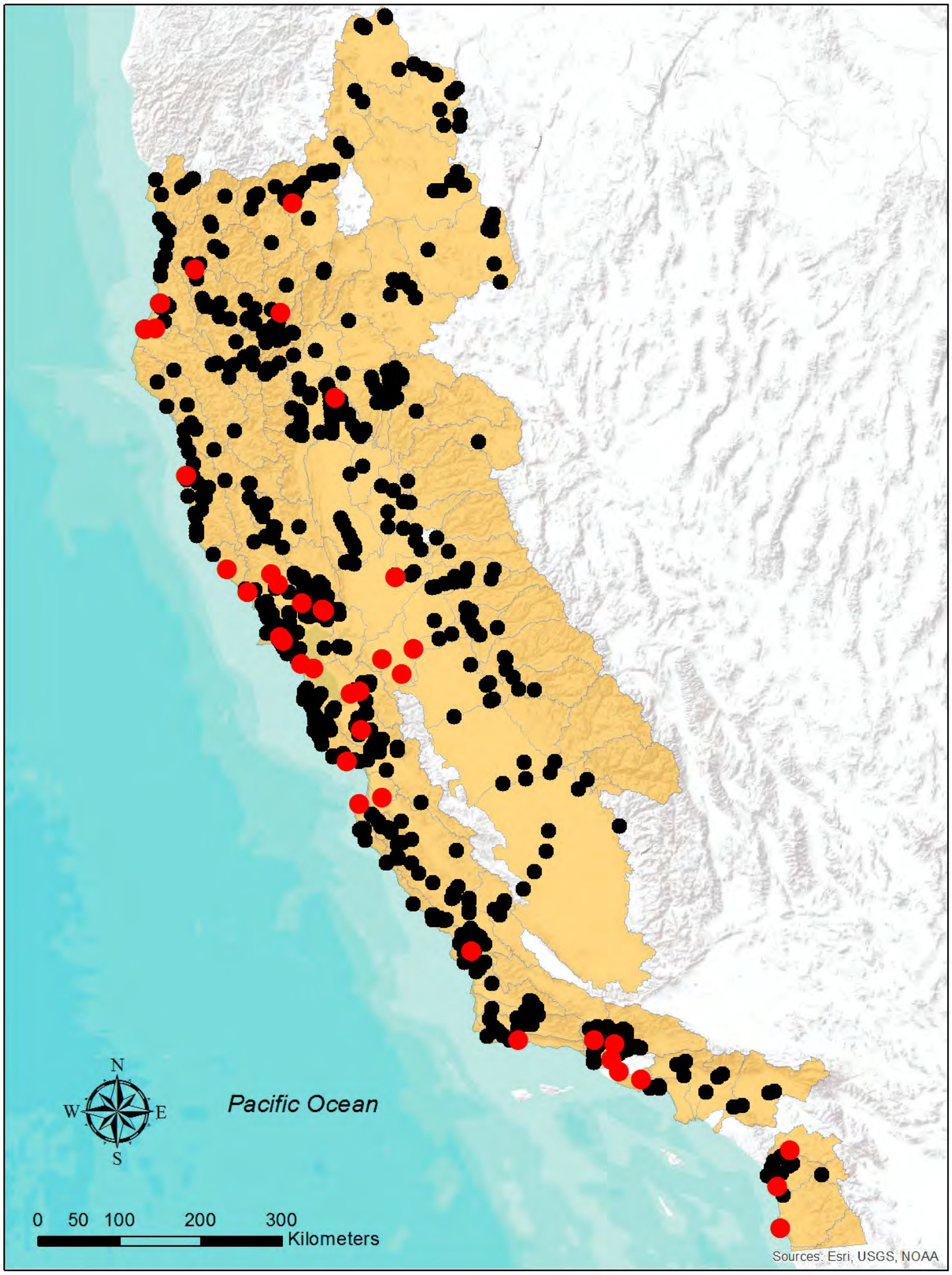


Figure 3-1. Stakeholder meetings (red dots) and site visits (black dots) conducted by the California PLCI team which were used to inform this assessment.

In Oregon, Washington and Idaho work group meetings were held in each Regional Management Unit (RMU) in 2017, either in person or by conference call. The purpose of these meetings was to collect region-specific information needed to revise the NatureServe Assessment such as:

historical and current distribution, adult abundance, short term population trend, and threats impacts to Pacific Lamprey.

Following are the dates and locations of the regional meetings in Oregon, Washington and Idaho:

February, 2017 – Willamette Sub-Unit of the Lower Columbia RMU
March, 2017 – South Coast Sub-Region of the Coastal Oregon RMU
April, 2017 – North Coast Sub-Region of the Coastal Oregon RMU; Mid-Columbia RMU
May, 2017 – Lower Columbia Sub-Unit of the Lower Columbia RMU
September, 2017 – Snake River region RMUs
October, 2017 – Upper Columbia River RMU
November, 2017 – Coastal Washington RMU
March and May, 2018 – Mainstem Snake and Columbia River RMU

Prior to work group meetings in Oregon, Washington and Idaho, RMU members and partners were provided with current Pacific Lamprey distribution maps and a standardized assessment template for each 4th Field HUC in the RMU. The template included a detailed description of the conservation factors used in the NatureServe model (described below), NatureServe ranking key (Table 3-1) as well as ranking information provided by participants during the 2011/2012 Assessment. Partners were asked to review the template and make revisions to conservation factor ranks based upon new information (e.g., spawning surveys, occupancy sampling, etc.) or professional judgement. At the meeting, attendees discussed and ranked the conservation factors for each 4th Field HUC using the NatureServe Rank Key (Table 3-1). In California, the information gathering process was inherently different. The California assessment was based on information gathered from smaller meetings with local stakeholders, and site visits often focused on specific issues and HUC or stream level geographic scales. Information was subsequently synthesized and compiled by the California PLCI team into NatureServe rankings to maintain consistency within the scope of the assessment. In addition to factors being ranked, the uncertainty for each factor was categorized based on the following scale:

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

2017 NatureServe Conservation Factors

NatureServe and its member programs and collaborators use a suite of ten conservation factors to assess the extinction or extirpation (regional extinction) risk of plants, animals, and ecosystems (or "elements" of biodiversity). Conservation factors are grouped into three general categories including: Rarity (range extent, area of occupancy, population size, ratio of area of occupancy to range extent), Trends (short-term trend) and Threats (threat impact). Ranking information for all ten conservation factors is not required to assign a conservation status rank. In 2017, we used a modified suite of seven factors to assess the relative risk of Pacific Lamprey by watershed throughout its range. These factors were selected because of our ability to collect the required information for them over the majority of geographic populations.

The seven factors used to assess Pacific Lamprey conservation risk, by category, are:

- ***Rarity Category***

  1. **Range Extent** (historical distribution) – Records of historical Pacific Lamprey distribution are incomplete or absent in most HUCs. There is a lack of fishing records, except from historical tribal fisheries, and count data at dams are mostly unavailable historically. As a result, the 2011 Assessment for Oregon, Washington and Idaho (Luzier et al. 2011) and 2017 Assessment revision, except for California (see below), used steelhead intrinsic potential (SIP) as a surrogate estimate of historical lamprey range extent in most areas where historical occupancy information was not available. The historical spawning distribution of steelhead (anadromous rainbow trout, *Oncorhynchus mykiss*) was considered a viable surrogate for lamprey distribution because steelhead use very similar habitat for spawning and both species likely co-occurred historically. Habitat-based intrinsic potential estimates for steelhead populations were developed during the NMFS recovery planning process for listed steelhead populations in the Columbia River Basin (Sheer et al. 2009). This information was used to inform the 2017 NatureServe ranking of Pacific Lamprey range extent within the Columbia River Basin, Idaho, Eastern Washington and Eastern Oregon. Additional SIP data from NOAA was used for watersheds in Southern Oregon (Agrawal et al. 2005), and the Willamette Basin (NWFSC 2008). In HUCs where SIP was limited or not available, coho salmon distribution was used in addition to SIP as a surrogate estimate for historical Pacific Lamprey range extent. Coho distribution data for the Washington Coast was obtained from the Olympic National Resource Center (2015), and information for the Oregon Coast and Lower Columbia tributaries was available from the Coastal Landscape Analysis and Modeling Study (CLAMS 2005). A small number of HUCs were lacking both SIP and coho distribution data (i.e., Washington tributaries below Bonneville Dam). In these areas, known historical and/or current distribution obtained from the Pacific Lamprey distribution database (USFWS 2016) were used as a surrogate measure of range extent. Distribution estimates based on SIP and coho distribution are considered conservative because the range extent of Pacific Lamprey may be even larger due to the fact that they are able to scale some natural barriers that block salmonids. There also may be instances where lamprey distribution could be less than that estimated from Coho distribution and SIP because of life history requirements for lamprey (e.g., lack of suitable spawning or rearing habitat).

     Although SIP and coho distribution were used to estimate the NatureServe ranking of range extent, the historical distribution depicted in RMU maps (see chapters 5–22) includes only known occurrences of Pacific Lamprey obtained from published literature, tribal accounts and state and federal agency records.

For California, the historical range of Pacific Lamprey prior to anthropogenic alterations of the hydroscape was determined specifically for Pacific Lamprey utilizing multiple sources of information, including: historical museum records, early scientific papers, ethnographic accounts, known elevational limits for Pacific Lamprey, elevational limits for closely related species of lamprey (*Entosphenus* spp.) in the regional drainages, geomorphic features (e.g. waterfalls and cascades, and stream gradient), and suitability of habitat, as well as current surveys with vouchered specimens (Reid and Goodman 2017a). The analysis was generally limited to larger streams (4th order and greater, NHDPlusV2). The exception is for smaller (3rd order) direct coastal drainages known to have been historically or currently occupied (Reid and Goodman 2016a). These drainages are included to better describe the coastal distribution, which would not have been captured at 4th order. However, note that in larger drainages Pacific Lamprey are known to occupy suitable smaller tributaries that are below the resolution considered in this analysis. Historical distribution was mapped by linear stream distance, rather than area.

2. **Area of Occupancy** (current distribution) –In Oregon, Washington and Idaho current Pacific Lamprey distribution data were primarily acquired from the Pacific Lamprey distribution database (USFWS 2016). Information in the database is provided by biologists and other partners throughout the region and comes from several different sources including: published literature, annual reports, state and federal agency records, field surveys, monitoring, fish salvage efforts, incidental, and anecdotal observations. For more information or to download the database see "Pacific Lamprey Known Observations and Distribution" on https://www.sciencebase.gov. Updates to current Pacific Lamprey distribution data were also provided by participants at regional meetings. For California, which has historical range data specific to Pacific Lamprey, current distribution data was based on unimpeded anadromous accessibility of historical Pacific Lamprey habitat (constrained by impassable dams) as well as recent vouchered specimens and lamprey-specific surveys (Reid and Goodman 2015, 2016a, 2017a, unpubl. data).

3. **Population Size** – Current abundance estimates were obtained from field experts during regional meetings. Population size was estimated from Pacific Lamprey supplementation efforts, trapping information, dam counts, and spawning ground surveys. In California, population size was generally ranked as Unknown at this time, except in a few HUCs where limited monitoring stations exist.

4. **Ratio of Area of Occupancy to Range Extent** – The ratio of current to historical distribution was added to the NatureServe ranking model in 2011 because of the uncertainty of historical distribution for Pacific Lamprey and our use of SIP and Coho Salmon distribution as surrogates. The addition of ratio lets us factor in the risk associated with rearing and spawning in less spatially diverse areas. For California the ratio of occupancy (4th order streams and above) was calculated directly from the

linear extent of current occupancy divided by the linear extent of historical habitat (Reid and Goodman 2017a).

- ***Trends Category***

5. **Short-term trend** – Short-term trend is defined as the degree of change in population size over 3 lamprey generations (27 years). Generation time for a species or population is defined as the average age of adults when they reproduce. Trends were primarily assessed via professional opinion, augmented by available, albeit limited, long-term counts of adult Pacific Lamprey from fish ladders, counting stations, and other monitoring locations (e.g., FCRPS dams, Winchester Dam, Willamette Falls, etc.).

- ***Threats Category***

6.-7. **Threat Impact** – The NatureServe ranking model characterizes threats in terms of scope and severity. Scope and severity are counted as one factor each. Threat Scope is defined as the proportion of the watershed (4th Field HUC) affected by the threat and Severity is defined as how badly and irreversibly the watershed is affected by the threat. Numeric ranking values from 0 to 4 (Unknown, Insignificant, Low, Moderate and High, respectively) were assigned to each scope and severity factor for each assessed threat in the RMU. These ranking values were derived from NatureServe characterizations (provided in Table 3-1). Rankings for each HUC were based on the professional judgement of regional meeting participants. Numeric ranks were averaged across all watersheds to obtain a single value that determined the overall magnitude of the threat for each RMU (or sub-unit of an RMU). Threat categories with an average cumulative score ≥ 2.50 were designated a high priority threat in the RMU. Major threat categories used in the 2017 Assessment are described below. All subcategories within each major threat category (e.g., the passage category includes dams, culverts, etc.) were included in scope and severity rankings.

For California, each threat sub-category was ranked within a HUC for scope and severity. The highest combined scope and severity score was applied to the principal Threat category. Certain threats were not included in overall rankings due to lack of information suitable for assessment (Disease, Climate Change), absence of evidence for substantial risk (Small Effective Population Size), or the nature of the threat that did not lend itself to ranking (Lack of Awareness). Mainstem passage was treated under passage within each HUC.

- ***Passage (dams, culverts, water diversions, tide gates, other barriers).***
- ***Dewatering and Flow Management (reservoirs, water diversions, instream projects).***
- ***Stream and Floodplain Degradation (channelization, loss of side channel habitat, scouring).***
- ***Water Quality (Water temperature, chemical poisoning and toxins, accidental spills, chemical treatment, sedimentation, non-point source).***
- ***Harvest/Overutilization.***

- ***Predation.***
- ***Disease.***
- ***Small Effective Population Size.***
- ***Lack of Awareness***
- ***Climate Change.***
- ***Mainstem Passage (if applicable).***

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

NatureServe Rank Approach

NatureServe has developed an automated rank calculator to compute and assign conservation status ranks (NatureServe 2009; Master et al. 2012). Rank values for the seven conservation factors above were collected for each 4th Field HUC at regional meetings and entered into the calculator where they are assigned a scaled point value and weighted according to influence on risk. Scores for the individual factors are pooled according to category (i.e. rarity, threats, and trends) and assigned a second weighting value. The resulting three summary scores are combined to yield an overall numeric score, which is translated into a final conservation status rank for the HUC. A more detailed description of how conservation status ranks are calculated with the 2009 version of the rank calculator can be found in NatureServe (2009). The following are the definitions for interpreting the NatureServe conservation status ranks at the subnational (S-rank) level (Master et al. 2009).

> ***SX Presumed Extirpated.—***Species or ecosystem is believed to be extirpated from the jurisdiction (i.e., nation, or state/province). Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered. (= “Regionally Extinct” in IUCN Red List terminology).
>
> ***SH Possibly Extirpated*.—**Known from only historical records but still some hope of rediscovery. There is evidence that the species or ecosystem may no longer be present in the jurisdiction, but not enough to state this with certainty. Examples of such evidence include: (1) that a species has not been documented in approximately 20–40 years despite some searching or some evidence of significant habitat loss or degradation; or (2) that a species or ecosystem has been searched for unsuccessfully, but not thoroughly enough to presume that it is no longer present in the jurisdiction.
>
> ***SU Unrankable.*** .**—**Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
>
> ***S1 Critically Imperiled*.—**Critically imperiled in the jurisdiction because of extreme rarity or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the jurisdiction.
>
> ***S2 Imperiled*.—**Imperiled in the jurisdiction because of rarity due to very restricted range, very few occurrences, steep declines, or other factors making it very vulnerable to extirpation from the jurisdiction.
>
> ***S3 Vulnerable*.—**Vulnerable in the jurisdiction due to a restricted range, relatively few occurrences, recent and widespread declines, or other factors making it vulnerable to extirpation.

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

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

The application of these calculated ranks were not used to determine conservation status of Pacific Lamprey, but rather to guide our understanding of the relative level of risk by watershed and region. For example, a HUC with an overall ranking of secure (S5) would have the lowest relative risk, while a rank of presumed extirpated (SX) would be associated with the highest relative risk. The purpose of this assessment was to re-evaluate patterns of risk amongst geographic population groupings using current population attributes and threats information to identify changes that have occurred over the last five years. Results of this Assessment will be used to guide and prioritize potential conservation measures within a watershed and geographic region. A summary of results and maps depicting the spatial arrangement of final NatureServe conservation status ranks and individual conservation factor ranks can be found in Chapter 4 and Regional Chapters 5-22.

2017 NatureServe modifications

The following modifications were made to NatureServe methods or procedures to improve the quality of ranking information.

NatureServe Rank Calculator

Three changes were made to the default conservation factor and category weighting values in the NatureServe ranking calculator to better reflect the quality of the information for Pacific Lamprey demographics, trends, and threats: 1) changed the weighting of the Rarity factors (historical distribution, current distribution, population size and ratio of current to historical distribution) so all equal 1. The information on current distribution for Pacific Lamprey is not adequate to give it double weight. 2) added a new Rarity factor, the ratio of current to historical distribution, to decrease the weight of the historical distribution factor (since most of what we have for historical is SIP). This factor was also given a weight of 1, equal to both historical range extent and current distribution. 3) changed the relative weights of the three major categories (Rarity, Trends and Threats) from 0.65, 0.2 and 0.15 to 0.6, 0.1 and 0.3. This change increases the weight for threats from standard NatureServe ranks reflecting the fact that most of our information is on threats and our trend data is more limited. A summary of the weighting and scoring values used to calculate conservation status ranks can be found in Table 3-2.

Range Extent and Area of Occupancy

The NatureServe rank model characterizes range extent (historical distribution) and area of occupancy (current distribution) as an area versus a linear metric (Table 3-1). During the 2011 Assessment, the area of lamprey distribution was visually estimated from SIP, Coho salmon, and Pacific Lamprey distribution maps. Regional meeting participants expressed concern about visually estimating the area of occupancy from a linear length of stream so during the 2017 Assessment revision we used a procedure to convert linear distances into a spatial area (Master et al. 2009; Master et al. 2012). The approach in Oregon, Washington and Idaho involved using GIS to create and overlay historical (SIP or coho distribution) and current Pacific Lamprey distribution layers with a 1 km^2 grid (see below for California). Area was obtained by counting the number of places where an occupied area of stream intersected a grid cell (see Elliot 2008;

Prescott 2008). Grid calculated occupancy values were generally more conservative than the visual estimates conducted in 2011, which resulted in a lowering of NatureServe distribution ranks in a number of HUCs. Though many ranks changed, new values were calculated directly from linear distribution layers and are likely more accurate than visual estimates. The grid approach was used to calculate range extent and area of occupancy in all Oregon, Washington and Idaho HUCs. Final grid calculated occupancy values were reviewed by RMU partners in the regional meetings or via email and modified if expert opinion warranted.

For California, range extent and area of occupancy (4th order streams and above) were calculated directly from the linear extent of both historical range specific to Pacific Lamprey and current occupancy adjusted to an area value at 1 km:1 km^2 (Reid and Goodman 2017).

Threat Categories and Threat Ranking

Several threat categories used in the 2017 (and 2011) Assessment were added or altered from those described in NatureServe (Master et al. 2009; Master et al. 2012). Many NatureServe threat categories are grouped together under a single general category hindering our ability to distinguish the most influential threat. Additionally, NatureServe categories do not encompass the wide variety of threats that may affect the different life history stages of Pacific Lamprey across the range. In the 2017 Assessment, up to 11 different threat categories (see Threats Category above) were considered for each HUC. Each threat category was composed of two elements, Scope and Severity. Numeric ranking values (high-unknown) were assigned to each Scope and Severity factor for each threat category. Following this protocol, for each HUC, we ended up with a potential total of 11 Scope ranks and 11 Severity ranks. The NatureServe rank calculator (Version 2.0) requires a single input value for Scope and a single input value for severity (in addition to population demographic information) to calculate a final conservation status rank for a given HUC. Thus, it was necessary to determine a method to generate one overall value of Scope and one overall value of Severity that represented the entire HUC.

The method used in the 2011 Assessment was to assign the highest ranking Scope value and highest ranking Severity value. The 2011 Assessment did not require Scope and Severity values to be from the same threat category (i.e., both associated with passage) and, in some cases, they were from different threat categories (i.e., passage and water quality). A preliminary assessment of this method suggested that the threat values used to calculate the conservation status rank for a given HUC may not have accurately represented the HUC and, in some cases, may have led to an inappropriately inflated threat value and reduced status rank. For example, if the threat Scope/Severity for passage, water quality and predation were high/moderate, moderate/moderate, and low/high, respectively, the overall threat Scope and Severity used in the rank calculator would have been high/high. However, it was not clear that the threat from passage being high in Scope but moderate in Severity, and the threat of predation being low in Scope but high in severity, reflected an overall threat in the HUC that was high in both Scope and Severity.

In the 2017 Assessment, Scope and Severity values from the same and most influential threat category were used as inputs to the NatureServe rank calculator. The most influential threat category was intended to represent the threat category most likely limiting the ability of Pacific Lamprey to persist in a given HUC. We reasoned that, until the threat category with the greatest influence was addressed, the other threat categories were less important and influential to the overall status rank of the HUC. This method required that we determine which of the 11 threat categories represented the most influential threat to a HUC. To accomplish this, we used the threat ranking table from the NatureServe ranking calculator (Version 2.0). Scope and Severity values for each threat category were applied to the ranking table developed by NatureServe (see Appendix). This table allowed values for Scope and Severity to be integrated such that the influence of various combinations could be ranked (A-G) and compared. The Scope and Severity value for the category with the highest rank (most influential; A>B>C…etc.) was input into the NatureServe rank calculator. For example, if the threat Scope/Severity for passage, water quality and predation were high/moderate, moderate/moderate, and low/high, respectively, the most influential threat would have been passage (with a rank of B) and the overall threat Scope and Severity used in the rank calculator would have been high/moderate. The ranking table provided an objective, consistent and repeatable way to identify which threat (and corresponding scope and severity value) could be characterized as most influential.

Applying a different Scope/Severity selection method could make it challenging to compare status ranks across time. However, we conducted a side by side comparison of both techniques using 2017 Scope/Severity data and found that while the threat ranking table was generally a more conservative approach than selecting the highest Scope and Severity value independently; the overall impact to conservation status ranks was minimal. When compared to the 2011 approach, the 2017 rank table method altered the Scope/Severity inputs of 12 total HUCs (out of 89) and may have influenced the change (improvement) in final status rank of 3 HUCs.

For California, all ranks were recalculated for each HUC in the 2012 Assessment using the revised distribution analysis and 2017 threat ranking approach. This allowed direct comparisons between 2012 and 2017.

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

Rarity 1 Factor Group

Range Extent (Historical Distribution)

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

Area of Occupancy

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

Rarity 2 Factor Group

Population Size

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

Rarity 3 Factor Group

Ratio of Historical and Current Distribution (Values in percent of historical distribution)

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

Trend Factor Group

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

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

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

Threats Factor Group

Threat Scope

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

Threat Severity

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

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

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

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

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

4. SUMMARY OF RISK ASSESSMENT RESULTS

Population demographic and threat information was collected for 12 discrete geographic regions (RMUs) across California, Oregon, Idaho and Washington (Figure 4-1). This information was used to calculate NatureServe rankings, assess the relative risk to Pacific Lamprey persistence and guide conservation measures for a majority of the regions. The following summary highlights the key changes in NatureServe Risk Ranks and threats since the completion of the 2011/2012 Assessment. The risk assessments for Alaska, Washington Coast and the Puget Sound RMUs are not complete at this time, but we provide an update on the progress that has been made in each RMU to date. A detailed summary of Assessment results are presented in the regional chapters that follow.

California

The California region includes all historically anadromous drainages that ultimately enter the Pacific Ocean along the California Coast. This includes portions of the Smith, Klamath and Sacramento drainages that extend into southern Oregon. There are seven Regional Management Units in the region and 106 potentially anadromous HUCs, not including most tributaries to the Tulare Lake Basin (southern San Joaquin Valley) or Goose Lake (Pit River headwaters), which have been isolated since the late 1800's. The region includes a wide diversity of ecological settings, from the relatively moist northern coast ranges to arid southern coastal streams and the high Sierra Nevada in the east.

The principal constraint on the current distribution of Pacific Lamprey in California is the presence of over fifty-nine large, impassable dams that collectively block 8,954 km (48%) of historical habitat in 4th order or higher streams. All but three of these dams have been in place for over fifty years, since prior to 1968. The general distribution of Pacific Lamprey in California has not changed substantially since then, with the exception of a northwards contraction of the range in southern California (Reid and Goodman 2016a, 2017a). The cause of this contraction is not known, but by 2016 the southern distributional limit had reached Big Sur (36.3° N). However, Pacific Lamprey recently recolonized the San Luis Obispo Drainage 160 km to the south, where a new lamprey passage facility had been installed in 2013 (Central Coastal Lamprey Working Group). Spawning and recruitment occurred in 2017 and has been documented again in 2018; a monitoring program of southern streams was initiated in 2011 under the PLCI and continues (Reid and Goodman, unpub. data).

The distribution of Pacific Lamprey actually appears to have increased since 2012, and we are aware of no areas where the distribution has decreased. Changes in distributions between the 2012 and 2017 assessments reflect 1) improved estimation of both historical and current distributions (Reid and Goodman 2016a, 2017a), 2) a shift from drainage area based estimation to the current linear analysis reflecting actual stream channel length (4th order and higher), which was not available in 2012, and 3) actual re-expansion of lamprey populations into previously blocked historical habitat. San Clemente Dam on the Carmel River was removed in 2015, and lampreys successfully recolonized the San Luis Obispo Drainage in 2017 following restoration of lamprey passage.

NatureServe risk ranks remained relatively stable from 2012 to 2017 and changed in only five HUCs after standardization of distribution estimate approaches between assessments. California ranks were recalculated for each HUC in the 2012 Assessment using the revised historical and current distribution analysis approach. This allowed direct comparisons between 2012 and 2017, which had updated threat severity scores. Two HUCs dropped in rank and three improved. The Smith dropped from S3 to S2 due to unresolved passage issues at the fish ladder on Rowdy Creek, although a new fishway and lamprey modifications are planned. The Lower Yuba also dropped (S2 to S1) due to passage issues, as well as a result of the refined distribution analysis. Two improved their ranks due primarily to the new distribution analysis (Gualala-Salmon and San Francisco Coastal). Finally, the Central Coastal HUC, which includes the current southern limit, improved (S1 to S2) due to passage improvements, the recent range expansion south to San Luis Obispo and successful recruitment in 2017.

For 55 HUC's that are currently occupied in California, 13 are ranked as Critically Imperiled (S1), 41 as Imperiled (S2) and one as Vulnerable (S3, San Francisco Coastal).

Of those ranked S1: five are due primarily to extremely limited distribution within the HUC caused by impassable dams, and seven have issues with smaller passage barriers that are resolvable, with three of these having additional issues with either water quality or streambed degradation. One, the Carmel River, is currently ranked as imperiled due to desiccation of the lower reaches caused by groundwater pumping. Threat scores were based on extensive implementation planning efforts (2015-2017), discussions with stakeholders throughout the state, site visits, improved understanding of lamprey biology, and completion of conservation measures.

Passage remains a primary threat to Pacific Lamprey in the California region. Not only have impassable dams severely constrained the current range, but numerous smaller barriers block or impede the upstream migration of lampreys. The barriers include smaller dams and weirs, as well as fishways that do not incorporate lamprey passage needs. Fortunately, there has been considerable progress on understanding the design features necessary to facilitate lamprey passage, identification of potential barriers, increasing awareness of lampreys, and their incorporation into passage projects (e.g. LTWG 2017). Improvement of passage has been a major focus of implementation planning and projects since 2012 and is expected to continue into the future as lampreys are incorporated into passage assessments (Goodman and Reid 2016b, 2017d).

Downstream passage of outmigrating juveniles is also recognized as a major threat, both for success of local populations and as a drain on the regional metapopulation (Goodman et al. 2015, 2017). There are two major areas of concern, entrainment and stranding. Large numbers of juveniles in the lower Sacramento and San Joaquin are entrained annually by the two major pumping projects in the delta (California Aqueduct and Delta Mendota canals), both of which lack screening suitable for lampreys. Secondly, outmigrating juveniles are periodically stranded with mass mortalities in dry lower mainstem reaches of the Carmel, Salinas and middle reaches of the San Joaquin rivers caused by the periodic inability of freshet flows to reach the ocean (Goodman and Reid 2015c, 2017b; see below for conservation measures).

Dewatering and flow management presented the most influential threats throughout the region, after passage. All Eel, Russian River and San Francisco Bay HUCs were impacted by numerous water withdrawals impacting mainstem flow. The Eel was also affected by substantial diversion of flow from the upper mainstem into the Russian River. Dewatering and flow management were also ranked moderate to high in severity throughout most currently unoccupied drainages south of San Luis Obispo, which occur in arid regions further exacerbated by urbanization, agricultural withdrawals and recent drought conditions. Flow management by large mainstem dams also impact migration cues for outmigrating juveniles and spawning of adult lamprey. Manipulation of flow in the lower Sacramento and San Joaquin by the two major pumping projects in the delta may also have substantial effects on migrating lampreys (both adults and juveniles; also see Passage).

Three HUCs north of San Luis Obispo (Carmel, Salinas, and San Joaquin-middle) are substantially impacted by total desiccation of their lower reaches, resulting in lack of access for in-migrating adults and periodic stranding of outmigrating juveniles. The periodic inability of freshet flows used by outmigrating juveniles to reach the ocean in the Carmel, Salinas and middle reaches of the San Joaquin rivers periodically cause mass emigration mortalities and is now recognized as a substantial threat, both for success of local populations and as a drain on the regional metapopulation. Carmel is currently in the process of shifting their water source away from groundwater pumping. Construction has begun on a recycled water pipeline project and installation of a large desalinization plant, as well as changes in flow management to insure channel continuity to the ocean. There is also a major restoration project underway on the San Joaquin River to improve flow and downstream passage success in the mainstem. However, at this time, all three rivers are still subject to periodic mass mortalities due to outmigration strandings.

Water quality was generally considered to be a widespread but low severity issue for lampreys. Principal exceptions where severity rose to moderate or high were in 1) highly urbanized reaches of the San Francisco and Southern Coastal RMUs (4 HUCs); 2) highly agricultural areas where there is substantial runoff into streams (3 HUCs); 3) the Klamath River, where mainstem dams, low flows and extensive upstream agricultural inputs impair water quality in the mainstem downstream of Iron Gate Dam; and 4) the Eel Drainage and Mattole (5 HUCs) where unregulated marijuana cultivation reduces summer flows, raises temperatures, and inputs contaminants and nutrients into the mainstems, promoting algal blooms. The impacts of marijuana cultivation, particularly along the north coast were not incorporated in the 2012 assessment. However, recent legalization of marijuana in California and improved regulation may influence this threat in the future.

Harvest was not considered a significant risk due to a limited tribal subsistence fishery and the 2010 CDFG establishment of a non-tribal daily bag limit of five adult lamprey. One area of potential concern is in the urbanized reaches of the San Francisco RMU, where the large homeless population may be harvesting adult lampreys (GCRCD 2005).

Predation threat was generally ranked low, except in the upper Cosumnes (a small stream with large Redeye Bass population), the Trinity (Brown Trout), and HUCs in the lower Sacramento, San Joaquin, and San Francisco bays, where concentrations of Striped Bass and Largemouth Bass at manmade structures may have substantial impacts on both adult and outmigrating juvenile lampreys.

Lack of awareness is a difficult threat to assess or quantify and was not ranked. Nevertheless, there is certainly a general lack of awareness of lampreys throughout the public, conservation and fisheries management communities in California. Many times people are unaware of the role of lampreys in the ecosystem or even their presence within a particular drainage, and in some cases there is a general antipathy towards lampreys. Lamprey needs are frequently not considered in habitat management plans, instream flow management, and stream restoration or fish passage projects focused on salmonids. This can lead to adverse effects, especially in the seasonal dewatering of ammocoete habitat or design of fish passage structures that effectively exclude lampreys due to design features such as jumps or angular edges. Increased education, outreach, coordination and inclusion in conservation planning will be essential for long-term conservation of lampreys in California and is a major component of the PLCI.

Other threats categories were not ranked due to absence of evidence for substantial risk or to insufficient information. Small effective population size was not seen as a threat in most of California's HUCs, except in southern populations. This is primarily due to the generally widespread distribution of lampreys (as evidenced by ammocoete presence) in most HUCs (below impassable barriers), evidence for considerable genetic mixing between populations, regional metapopulation dynamics, and evidence of recolonization over long distances (Goodman et al. 2008, Spice et al. 2012).

Disease was not assessed as a threat. We know very little about disease in natural lamprey populations. While it was generally recognized that disease could have a substantial effect on the success of a local population, no instance of it playing a role in the mortality or decline of a natural population was reported in any of the stakeholder assessment discussions.

Oceanic conditions and their effect on outmigrating juvenile and adult lamprey were not assessed - the assessment focused on freshwater life-stages. However, it is generally recognized that this phase of their life-history may have a substantial effect on the success of not only local populations but also the entire regional metapopulation. Areas of concern were status of the lamprey's prey-base, predation on adult lampreys by marine mammals and oceanic fishes, influence of oceanographic conditions (e.g. temperature, currents and productivity), and accumulation of heavy metals (e.g. mercury) in the food chain.

Climate Change effects were not assessed for either marine or freshwater stages of lamprey in California. It is generally recognized that climate change will affect populations, particularly in the southern portion of their range. However, Pacific Lamprey currently occupy a wide range of habitats and predicting the impacts of climatic change on their populations is difficult. Potential impacts that would exacerbate current threats included: a) continued desiccation of drainages, either directly through water use (surface diversion or groundwater pumping), or due to rising temperatures, increased aridity, or reduced precipitation, b) shifts in seasonal precipitation patterns altering migration cues (up or downstream) or passage through sandbars, and c) changes in distribution or abundance of marine prey-base.

Columbia River and Oregon Coast Regions

The Columbia River region includes all watersheds within the geographic boundary of the Willamette River Basin, watersheds that drain into the Snake River below Hells Canyon Dam (rkm 397) and watersheds that drain into the Columbia River below Grand Coulee Dam (rkm 876) to the confluence with the Pacific Ocean. The Oregon Coast region includes all coastal watersheds that drain into the Pacific Ocean from the California border, north, to the Columbia River basin boundary. Together there are five RMUs (i.e., Upper Columbia, Snake, Mid-Columbia, Willamette/Lower Columbia and Oregon Coast) and 92 total HUCs in this region.

Three HUCs located upstream of Chief Joseph and Grand Coulee Dams (Sanpoil, Kettle, and Colville) and two HUCs located above Dworshak Dam (Upper and Lower North Fork Clearwater) were excluded from this analysis due to the current lack of fish passage at these facilities.

Overall, understanding of Pacific Lamprey population factors has increased in many RMUs. Monitoring efforts in which lamprey are either the target species or information is collected during other species' monitoring, have expanded the amount of information available and quality of this information in many watersheds. Changes in NatureServe population demographic rankings between the 2011 and 2017 Assessment were generally attributed to 1) incorporating new or better quality information obtained from adult spawning ground surveys, occupancy sampling, or other targeted surveys; 2) using an improved approach to estimate historical and current distribution (see Methods); 3) actual changes within the RMU associated with increased or decreased threats scope/severity, passage improvements, supplementation efforts, etc.; and 4) professional judgement of participants that attended regional work group meetings.

Current distribution of Pacific Lamprey in Columbia River Basin and Oregon Coast watersheds has remained the same or increased since the last Assessment. The only exception was in the Little Salmon (Snake RMU), Okanogan and Similkameen Rivers (Upper Columbia RMU) where survey and screw trapping data indicates Pacific Lamprey are no longer present. The 2017 Assessment ranking of current distribution was also reduced in several watersheds within the Willamette/Lower Columbia and Oregon Coast RMUs. However, changes were a direct result of using a revised approach to calculate the numeric area of occupancy rather than a decline in lamprey range (see Methods). Improvements in distribution were attributable to 1) an improved understanding of occupancy (e.g., Imnaha, Middle Salmon-Chamberlain, Middle Salmon-Panther and Lower Middle Fork Salmon); 2) natural recolonization following the removal of a passage barrier (e.g., Hood River, White Salmon River); or 3) adult translocation or other supplementation efforts to increase abundance or reestablish the presence of Pacific Lamprey in the watershed (e.g., Fall Creek in the Middle Fork Willamette, Upper Grande Ronde, South Fork Salmon, Wallowa, Lower Yakima, Naches, Upper Yakima, Wenatchee and Methow).

NatureServe ranking of Pacific Lamprey population size was revised in many watersheds to reflect increased monitoring efforts or adult translocation. Within the Willamette/Lower Columbia and Oregon Coast RMUs, lamprey abundance was either estimated or ranked as unknown during the 2011 Assessment. The Confederated Tribes of Warm Springs have since completed annual population estimates of Pacific Lamprey adults at Willamette Falls that were used to calculate a 'rough population estimate' for each watershed in the Willamette River Basin in 2017 (see Chapter 12). Additionally, Oregon Department of Fish and Wildlife has recorded information on lamprey spawners and redds that were used to estimate a range of Pacific Lamprey population abundance in Coastal and Lower Columbia watersheds. Within the Snake River, Upper Columbia and Mid-Columbia RMUs, abundance of Pacific Lamprey has remained unchanged in most HUCs, though increases were observed in the Umatilla, Lower Yakima, Naches, Upper Yakima Wenatchee and Methow watersheds due to successful adult translocation efforts.

NatureServe risk ranks were calculated for Pacific Lamprey populations within 87 HUCs in the Columbia River region and Oregon Coast during the 2017 Assessment. Risk ranks varied from Vulnerable (S3) to Presumed Extirpated (SX), with the majority of HUCs falling in the Critically

Imperiled (S1; 48%) or Imperiled (S2; 26%) categories. Overall, risk ranks changed in 32 HUCs (36%) across the five RMUs. Risk ranks worsened (risk levels increased) in a total of 18 HUCs, with the majority of HUCs (13) moving from Imperiled (S2) to Critically Imperiled (S1). Changes in the Upper Columbia (3 HUCs) and Snake Region (1 HUC) are attributed to new/improved information obtained from occupancy surveys or declining lamprey abundance. Change in other RMUs was associated with a general lowering of population demographic ranking values as a result of better data quality (e.g., calculating versus estimating historical and current occupancy), increased information availability (e.g., ODFW abundance estimates), or the professional judgement of participants who contributed to the 2017 Assessment ranking exercise. Risk ranks improved (risk level decreased) in a total of 14 HUCs. Ranks rose from Possibly Extirpated to Critically Imperiled in a total of nine HUCs in the Upper Columbia RMU and Snake Region due to new/recent information from occupancy sampling as well as supplementation efforts by the Nez Perce Tribe and Yakama Nation Fisheries. Improvement in other RMUs is due to increased monitoring and improved population estimates, increased population abundance, or reduced threat impact. The most notable improvement in the 2017 risk Assessment occurred in the Willamette Sub-Unit where the risk rank in the Clackamas rose from Critically Imperiled (S1) to Vulnerable (S3), primarily due to passage and habitat improvements, combined with better information. Eight HUCs retained the ranking of Presumed Extirpated (SX) in 2017 as a result of large dams with no passage that completely block upstream migration.

The overall pattern of risk is unchanged in the 2017 Assessment. Pacific Lamprey populations at highest relative risk are those in the Upper Columbia, Snake and Mid-Columbia River Regions. All HUCs in these areas were ranked either Presumed Extirpated, Possibly Extirpated or Critically Imperiled. Lower risk areas such as parts of the Willamette, the Lower Columbia River and Coastal Oregon watersheds are located downstream of major mainstem passage barriers, but were still largely ranked Critically Imperiled or Imperiled. The spatial arrangement of risk for the Columbia River Region and Oregon Coast has remained fairly homogenous. With the exception of the Clackamas Subbasin, there are no areas of low risk located in close proximity for the potential rescue/restoration of populations at high risk.

Principal threats to Pacific Lamprey remained consistent with those identified in the 2011 Assessment. Changes to threat Scope/Severity scores were minimal in most categories, with most revisions likely influenced by the participants in attendance at regional meetings. Mainstem Columbia and Snake River passage is still the most serious threat impacting Pacific Lamprey in the Mid-Columbia, Snake and Upper Columbia RMUs. Lamprey in the upper most reaches of the Columbia River must pass up to nine hydroelectric dams migrating upstream as adults and downstream as juveniles. Though efforts to improve passage are ongoing (Douglas PUD 2009; Grant PUD 2009; Andersen et al. 2010; CRITFC 2011; Bureau of Reclamation 2013; USACE 2014), the physical and hydraulic conditions in and around various fishways may delay or impede passage of migrating lamprey. The combined impact of mainstem and tributary passage impediments has led to fewer Pacific Lamprey reaching Mid-Columbia, Snake and Upper Columbia watersheds, which contributed to the ranking of small effective population size as high in these RMUs. Passage within tributaries was considered a moderate threat overall in Mid-Columbia and Willamette/Lower Columbia RMUs. These regions are affected by a number of reservoir storage dams and agriculture diversions that provide little or no passage for Pacific Lamprey. Irrigation diversions are particularly problematic for juvenile lamprey as screening mesh size, material, water velocities, or other design elements may not be adequate to prevent the impingement or entrainment of larval and juvenile lampreys.

Stream and floodplain degradation was the second most prevalent threat affecting lamprey in Mid-Columbia, Willamette/Lower Columbia and Oregon Coast RMUs. Land use activities and human settlement have greatly altered the physical habitat and hydrology of many watersheds. In upland areas, historical and ongoing timber practices have deforested or altered the diversity of riparian vegetation and trees. Many watersheds are lacking mature trees that play an important role in bank stability, water quality protection, thermal cover and input of wood into channels. Within lowlands, efforts to prevent flooding and provide irrigation for crops and livestock have straightened and scoured streambeds, cutting off side channels and floodplains. Cultivation, riparian clearing and conversion of land for transportation infrastructure, crops, pastures and residential development have filled or drained wetlands, increased soil erosion and sedimentation, and promoted the establishment and spread of invasive plant species.

Water quality was ranked a moderate overall threat in Mid-Columbia, Willamette/Lower Columbia and Oregon Coast RMUs. Elevated water temperature was the primary water quality concern across watersheds. Increased temperatures may be associated with excessive solar radiation, removal of riparian vegetation, heavy water withdrawals, and flood irrigation water returns. Other common water quality concerns included low dissolved oxygen, pH extremes, sedimentation, and the presence of bacteria, heavy metals, and toxic pollutants such as insecticides or PCBs.

Dewatering and flow management was ranked a moderate overall threat in Upper Columbia, Mid-Columbia, Willamette/Lower Columbia and Oregon Coast RMUs. Low flow conditions occur naturally in many watersheds during summer months, but land use practices and consumptive water use may exacerbate such conditions. Water withdrawals for irrigation, livestock, municipal or industrial purposes leave many watersheds dewatered or with inadequate flow during summer and fall months. Flow alterations associated with large storage dams can have a major impact on natural temperature and flow regimes. These changes can negatively impact aquatic species that rely on environmental cues to trigger important developmental or behavioral events such as emergence, growth, maturation or migration. Additionally, natural and human-induced water level fluctuations can directly impact the quantity, accessibility and suitability of spawning and rearing habitat.

Climate change was a pervasive threat across RMUs, but the severity of potential impacts is not well understood and was ranked as unknown in several watersheds. Climate change is generally expected to produce changes in ambient temperature, precipitation, and streamflow patterns. Watersheds that currently experience heavy water withdrawals (for irrigation etc.) will likely see an increased demand for water that will further reduce streamflow, elevate water temperatures, and increase larval/juvenile entrainment and dewatering mortality. The potential impacts of climate change are difficult to predict and the feasibility of making tangible changes will be challenging and require large scale institutional changes.

Lack of awareness was rated a moderate threat across watersheds in the Snake, Mid-Columbia and Oregon Coast RMUs. General knowledge of Pacific Lamprey has improved considerably within conservation and fisheries management communities; however, many stream restoration and passage improvement projects are still funded and designed to benefit salmonids with little understanding of how these actions may impact lamprey. Furthermore, many people still have a negative perception of Pacific Lamprey as pests or are completely unfamiliar with the species and their ecological and cultural importance.

Mainstem Columbia and Snake Rivers

As with the 2011 assessment, no Conservation Status Ranks were assigned to the mainstem RMUs because of the lack of distinct spawning and rearing areas. Mainstem threats were evaluated for 3 sub-regions within the mainstem region: Mid-Columbia, from Bonneville Dam to the confluence with the Snake River, Upper Columbia mainstem Columbia River above the confluence with the Snake River, and Snake River which includes all mainstem habitat on the Snake River.

The threat rankings were fairly consistent with the 2011 rankings. Passage was identified as the most limiting and difficult threat maintaining a high ranking in this assessment. Although passage remained a high threat, participants in the workshop did acknowledge the substantial gains in installing Lamprey Passage Systems and other ladder modifications in multiple locations that provide successful upstream passage for adult lamprey that are able to enter these systems as improving passage conditions since 2011, but not enough to reduce the overall ranking.

Stream and floodplain degradation decreased in both scope and severity for an overall ranking of Medium compared to a High ranking in 2011. The 2017 was based on discussions among the meeting participants and the understanding of current conditions more than specific restoration projects that changed the condition. Also, it was noted that the inundation from the initial construction of the projects is somewhat static, however operations such as drawdown and turnover rates can impact this criterion I in a given year.

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

The lack of demographic data in coastal Washington and Puget Sound precluded completion of a complete risk analysis in most watersheds. A total of 6 out of 26 HUCs were assigned Conservation Status Ranks in this region compared to no rankings in the previous assessment. All 4 HUCs ranked in the Puget Sound/Strait of Juan de Fuca RMU were categorized as Critically Imperiled (S1), and the 2 HUCs in the Washington Coast RMU were categorized as Imperiled (S2) and Vulnerable (S3). Although our understanding of Pacific Lamprey status has improved since the last assessment, our inability to rank population factors and threats in most of the HUCs highlights the need for lamprey surveys and threat analysis. Risk assessments will be completed as new data are gathered for Puget Sound, the Strait of Juan de Fuca and the Washington Coast.

Sampling since 2011 indicated that Pacific Lamprey were present in many Washington Coast and Puget Sound watersheds. Occupancy was documented in 19 of the 26 HUCS evaluated, but the population size was only estimated for 3 HUCs. Pacific Lamprey were commonly found in southern Puget Sound Rivers, Hood Canal, and in several watersheds along Washington Coast including the Chehalis River.

Historical distribution for Pacific Lamprey was difficult to determine. There is a lack of fishing records, and count data from salmon smolt traps are incidental and often do not provide accurate counts or species identification. Steelhead intrinsic potential and coho salmon distribution were used as surrogates for historical range extent in many HUCs.

Alaska

A risk assessment and query of ongoing and needed actions and research was not conducted for the Pacific Lamprey RMU of Alaska during 2018. Alaska has six species of lampreys. Minimal research related to these species has occurred and their full distribution, status and trends remain unknown.

In 2005, the Alaska Natural Heritage Program (AKNHP) species tracking list ranked Pacific Lamprey as S4S5 (S4= not rare, long term concern; uncommon but not rare; some cause for long term concern due to declines or other factors; S5 = widespread, abundance, secure). Arctic Lamprey are ranked by the AKNHP as S4 (http://accs.uaa.alaska.edu/education-and-outreach/species-lists/ (AKNHP 2012)). In the Comprehensive Wildlife Conservation Strategy, the Alaska Department of Fish and Game (ADF&G) lists Pacific and Arctic Lamprey along with other species of lamprey known to occur in Alaska (River, Western Brook and Alaskan Brook) as Species of Greatest Conservation Need (SGCN).

North Pacific Ocean

In 2017, the ocean phase of Pacific Lamprey was grouped into an RMU for the first time due the recognized importance of the ocean phase in the life history of Pacific Lamprey. Pacific Lamprey gain most of their body size while in the ocean which relates directly to their level of fecundity and overall population productivity. Although some level of differentiation may exist in the ocean due to limitations on dispersal, the entire North Pacific Ocean was grouped into a single RMU. Lack of knowledge was deemed the most significant threat to Pacific Lamprey for this live history phase. We have some knowledge of the distribution of pacific lamprey, their feeding preferences, and the species that prey on them. Very little is known about how these factors influence population dynamics, individual populations, or sustainability.

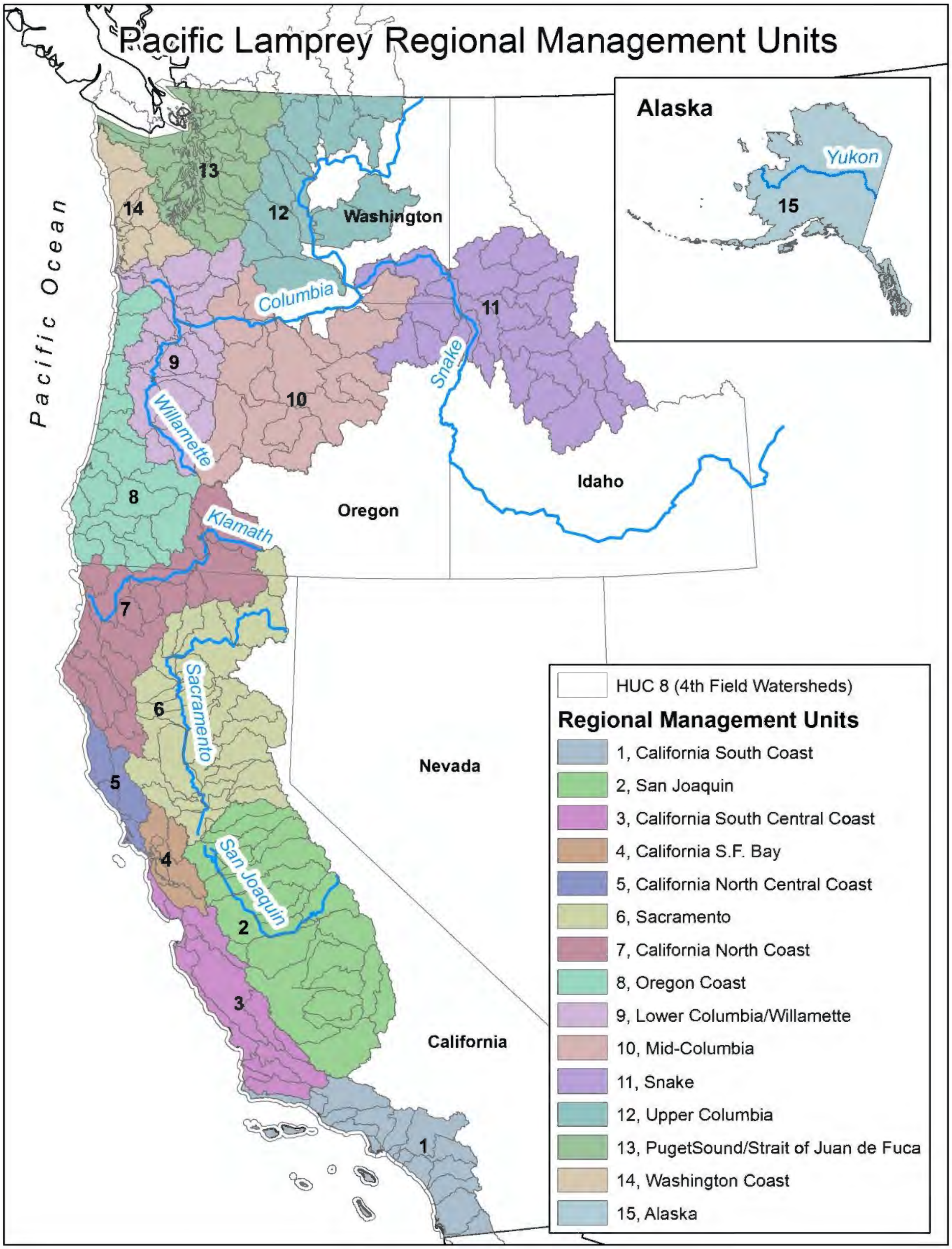


Figure 4-1. Location of 15 regional management units (RMUs) across Idaho, Oregon, Washington, California, and Alaska.

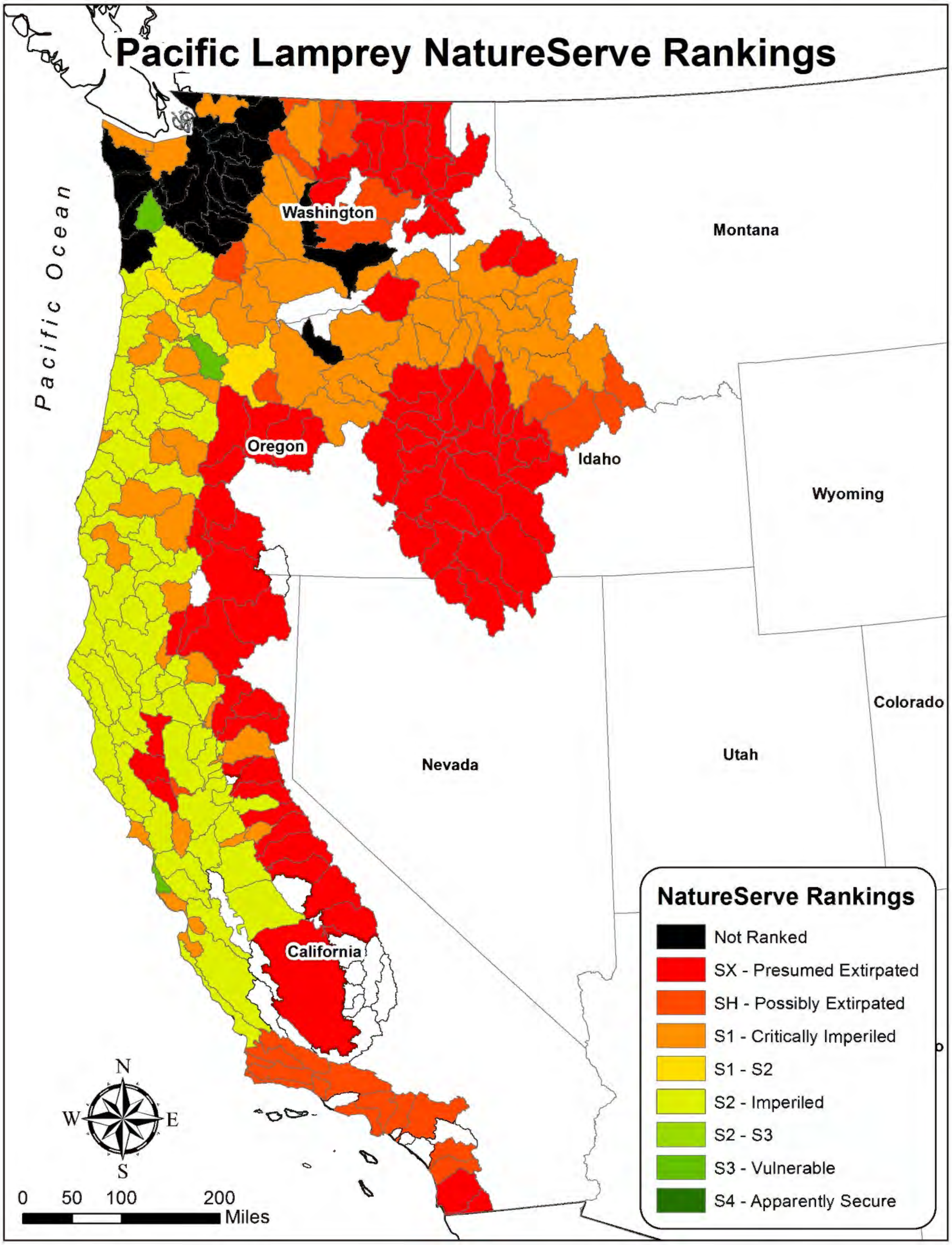
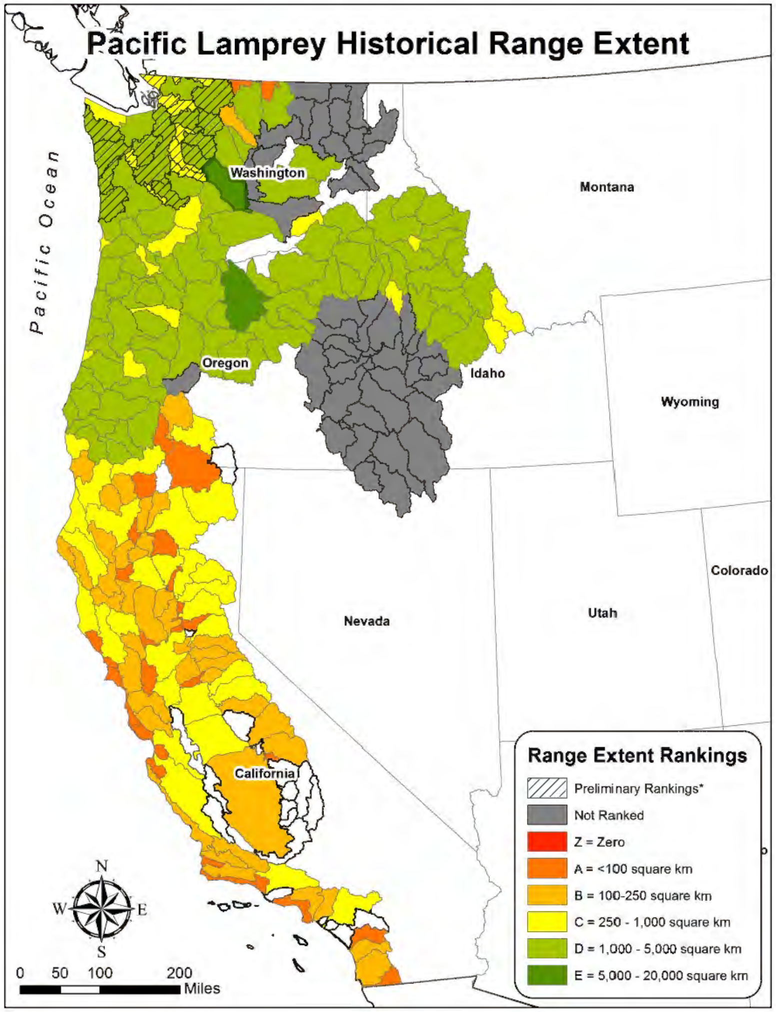
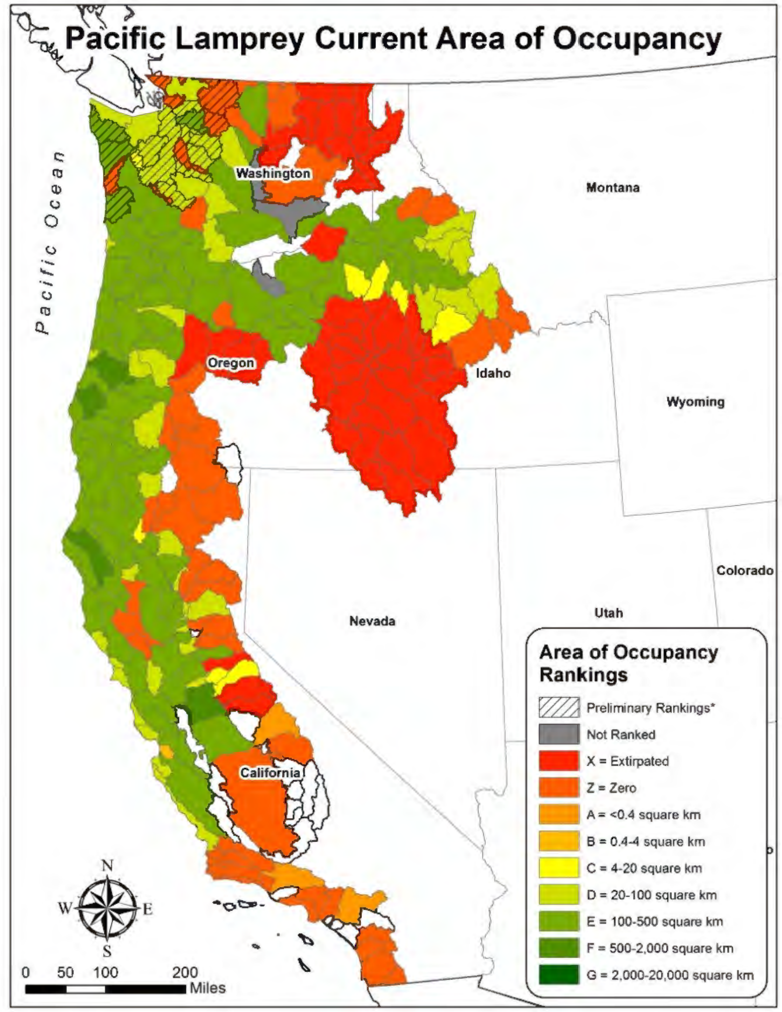


Figure 4-2. Calculated NatureServe risk ranks for Pacific Lamprey.



a)



b)

Figure 4-3. Historical Range Extent (a) and Current Area of Occupancy (b) of Pacific Lamprey.

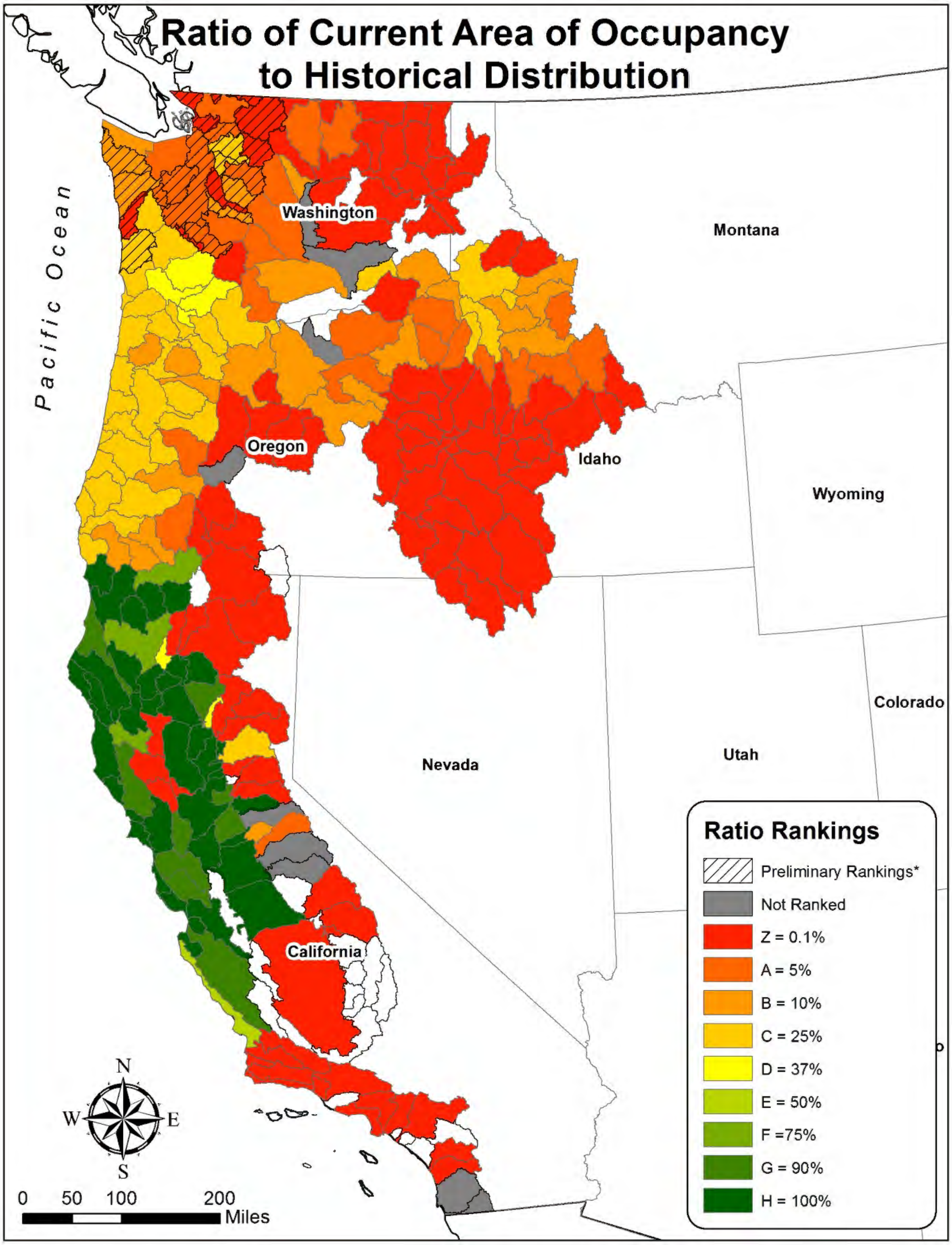


Figure 4-4. Ratio of Current Area of Occupancy to Historical Range Extent for Pacific Lamprey.

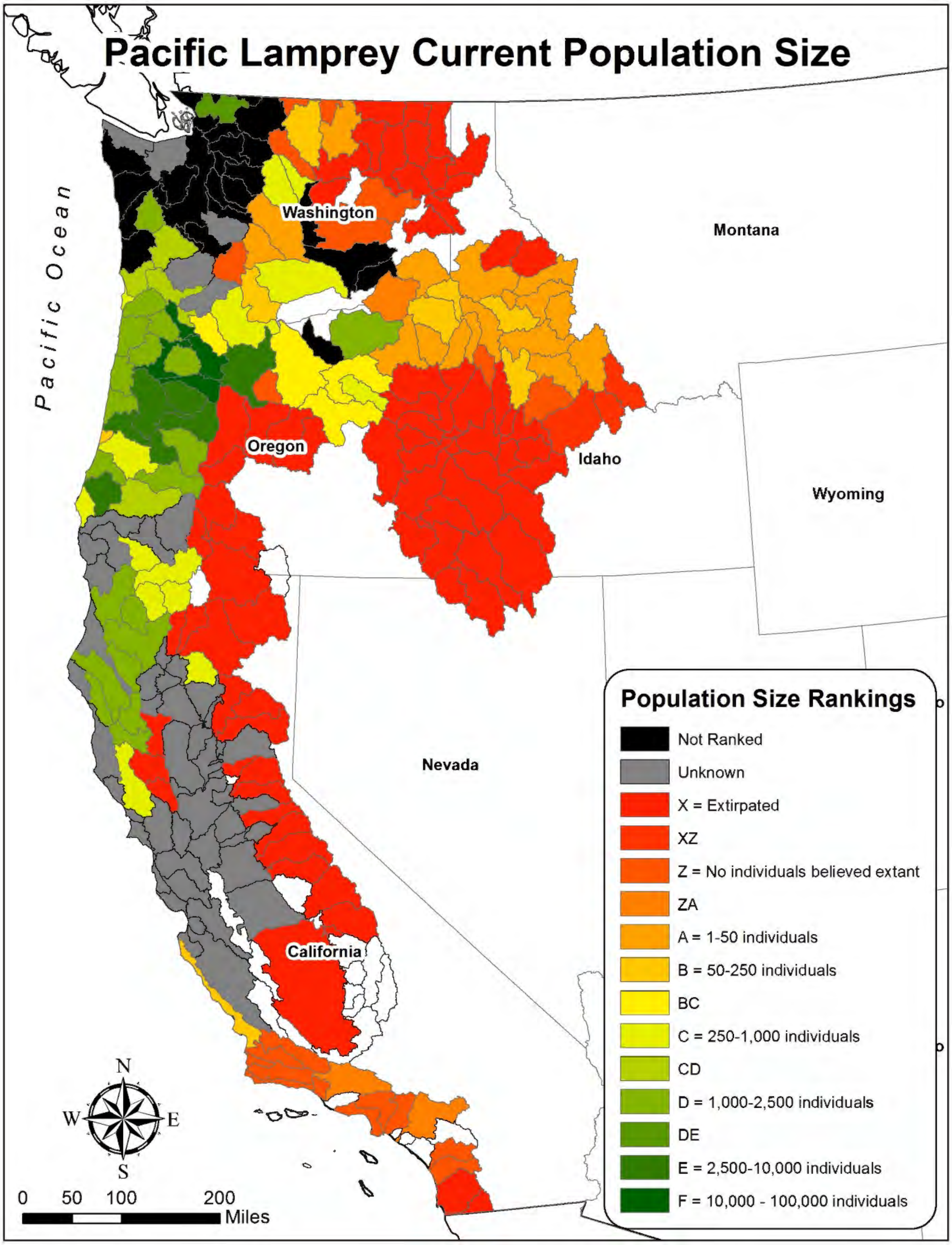


Figure 4-5. Current population size of Pacific Lamprey.

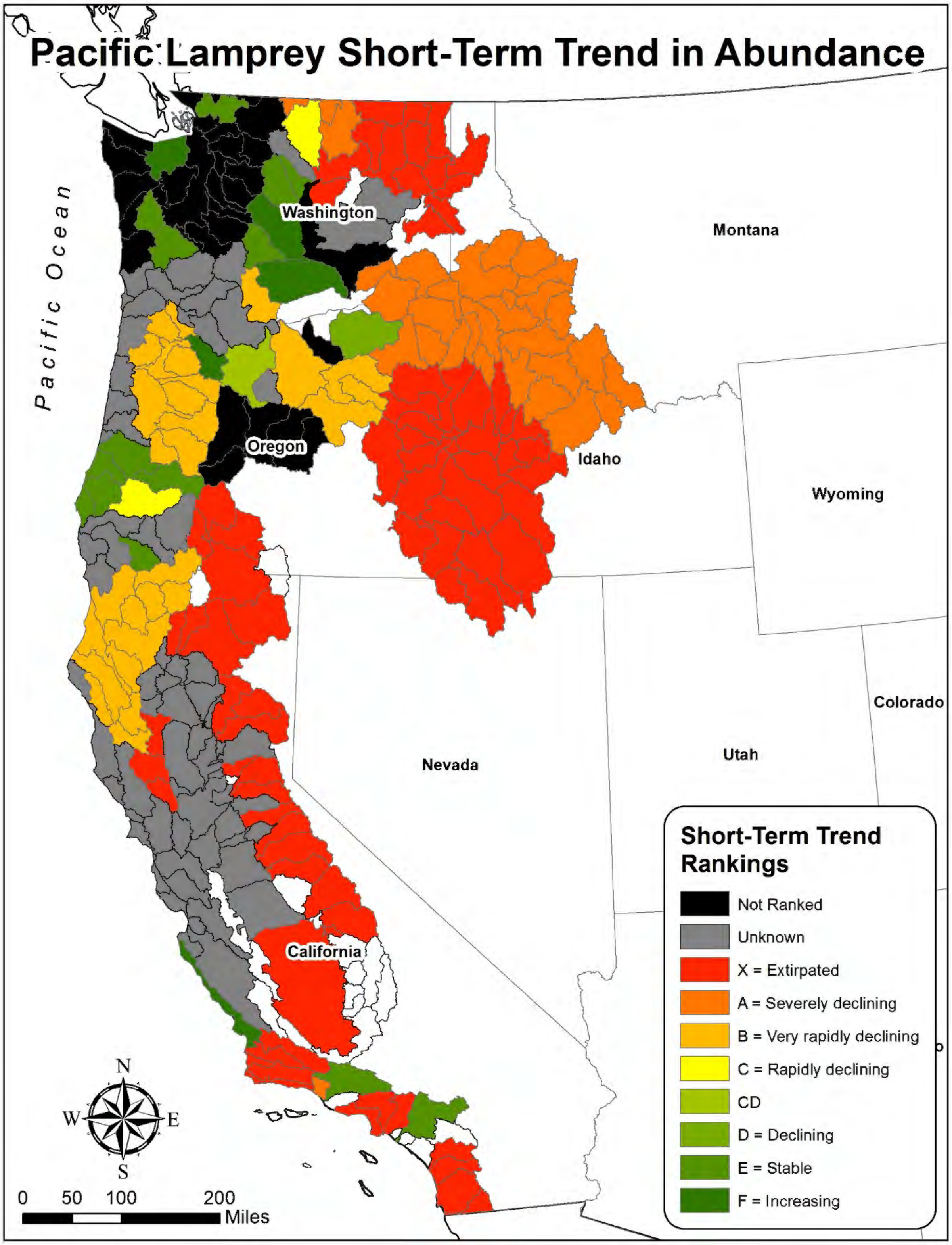


Figure 4-6. Short term trend in abundance of Pacific Lamprey.

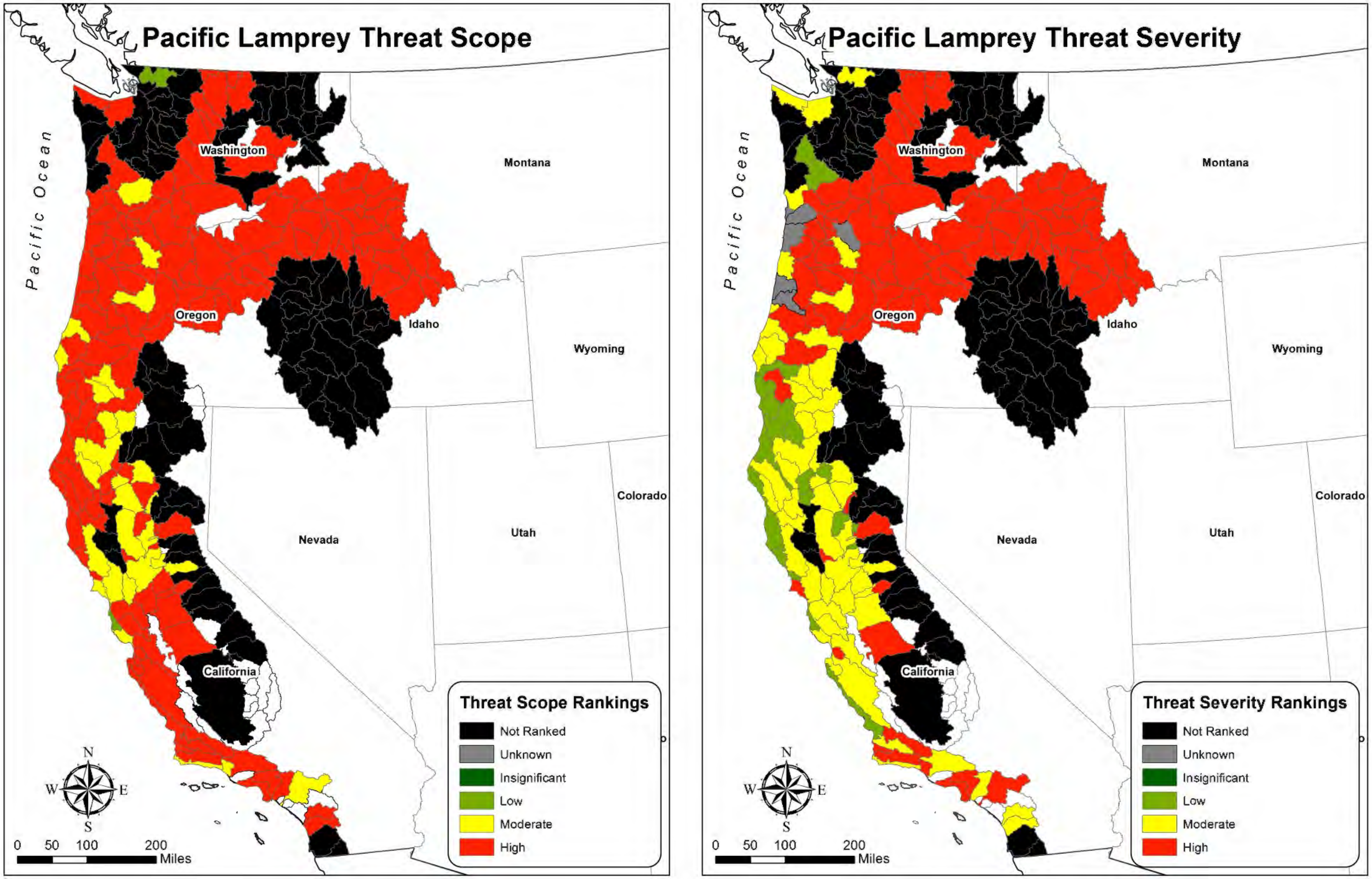


Figure 4-7. Combine threat by scope (a) and severity (b) to Pacific Lamprey.

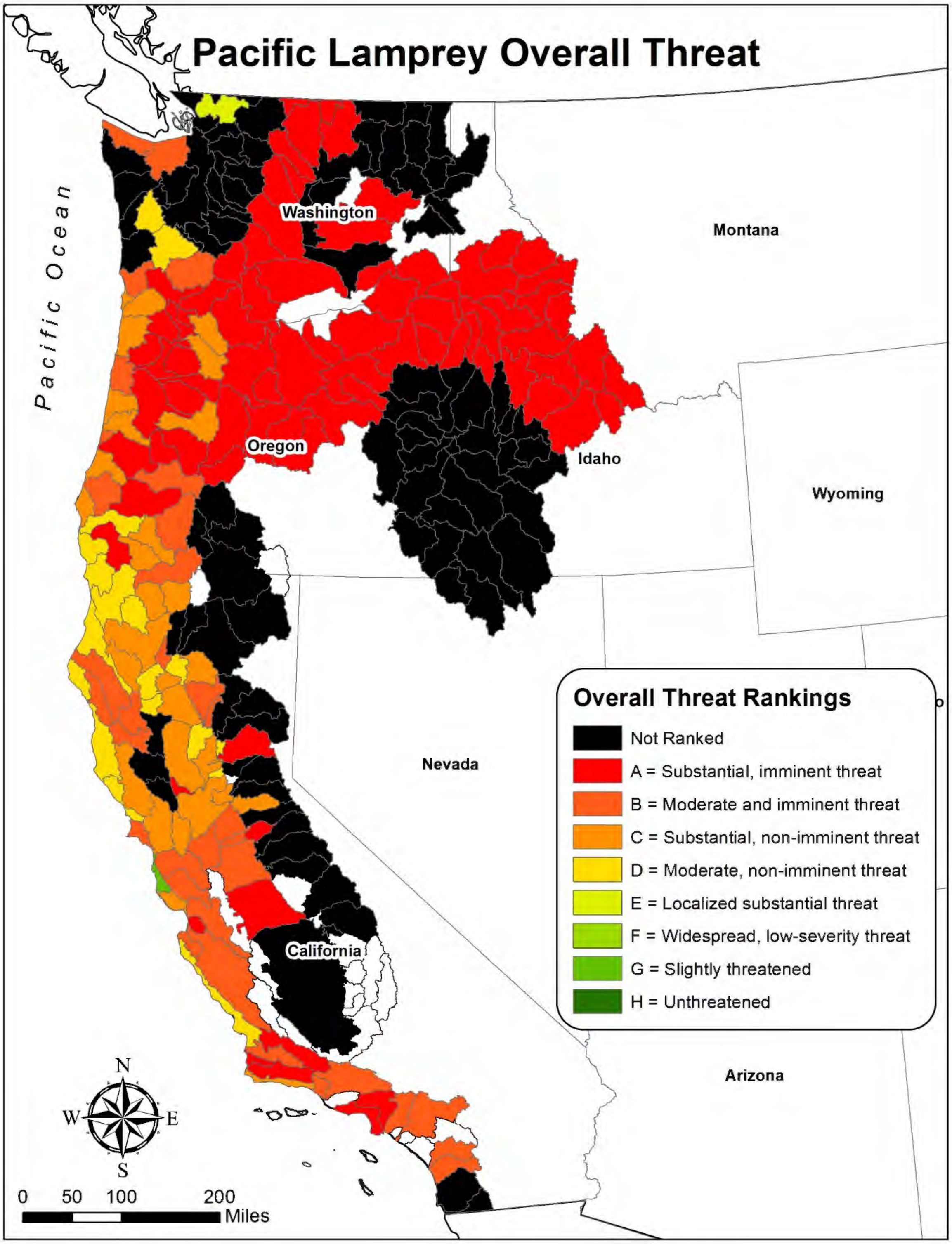


Figure 4-8. Overall threat ranking calculated from integrated Scope and Severity score of most influential threat in the HUC.

5. CA SAN FRANCISCO BAY REGION

Summary

The CA San Francisco Bay RMU (Figure 5-1) includes all drainages that enter San Francisco and its component bays from the confluence of the Sacramento and San Joaquin rivers to the Golden Gate, including the San Francisco Bay USGS accounting unit, without the outer coastal HUCs that are included in the central coastal RMUs. It includes four broader watersheds (4th field HUCS), ranging from 1,695−3,171 km^2 (Table 5-1). The RMU occupies the Central Californian Chaparral / Oak Woodlands ecoregion. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012-2017. However, our understanding of threats changed (see below). Three HUCs are categorized as S2 - Imperiled and one as Critically Imperiled (Table 5-1).
- Our understanding of distribution was substantially improved through assessment of historical and current range state-wide and continued surveys.
- Current Pacific Lamprey distribution remained generally the same in all HUCs, with a slight increase in the Napa River, following removal of a large culvert barrier.
- Population abundance of Pacific Lamprey in the CA San Francisco Bay RMU is thought to be largely unchanged since the 2012 Assessment.
- No long term count of Pacific Lamprey exists in CA San Francisco Bay RMU. Unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends and anecdotal reports from local residents (Goodman and Reid 2012).
- Passage remains the principal distributional constraint on lamprey populations in the San Francisco Bay RMU. However, considerable effort has gone into better understanding passage needs of lamprey. Passage projects are proposed under implementation plans and a number of projects are underway in the Alameda and Coyote drainages.
- Stakeholder discussions and site visits identified a potential new threat from illegal subsistence fishing by homeless population in highly urbanized streams of the Bay Area.

Threat rankings are shown in Table 5-2. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 5-3. A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the CA San Francisco Bay Region can be found in the Regional Implementation Plan for the San Francisco Bay RMU (Goodman and Reid 2017, PLCI San Francisco Bay Implementation Plan).

Table 5-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the CA San Francisco Bay Region. S1 = Critically Imperiled. S2 = Imperiled. Note that historical and current occupancies are linear stream distances (4th order and above), reflecting improved distribution data since the 2012 Assessment (Goodman and Reid 2012, Reid and Goodman 2017).

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km)	Current Occupancy (km)	Ratio Current/ Historical	Population Size (adults)	Short-Term Trend (% Decline)
Suisun Bay (Pacheco)	18050001	S1	79	65	0.82	Unknown	50 - 70%
San Pablo (Napa/Sonoma)	18050002	S2	122	122	1.00	Unknown	50 - 70%
Coyote (Coyote/Guadalupe)	18050003	S2	174	147	0.84	Unknown	50 - 70%
San Francisco (Alameda)	18050004	S2	207	169	0.82	Unknown	50 - 70%

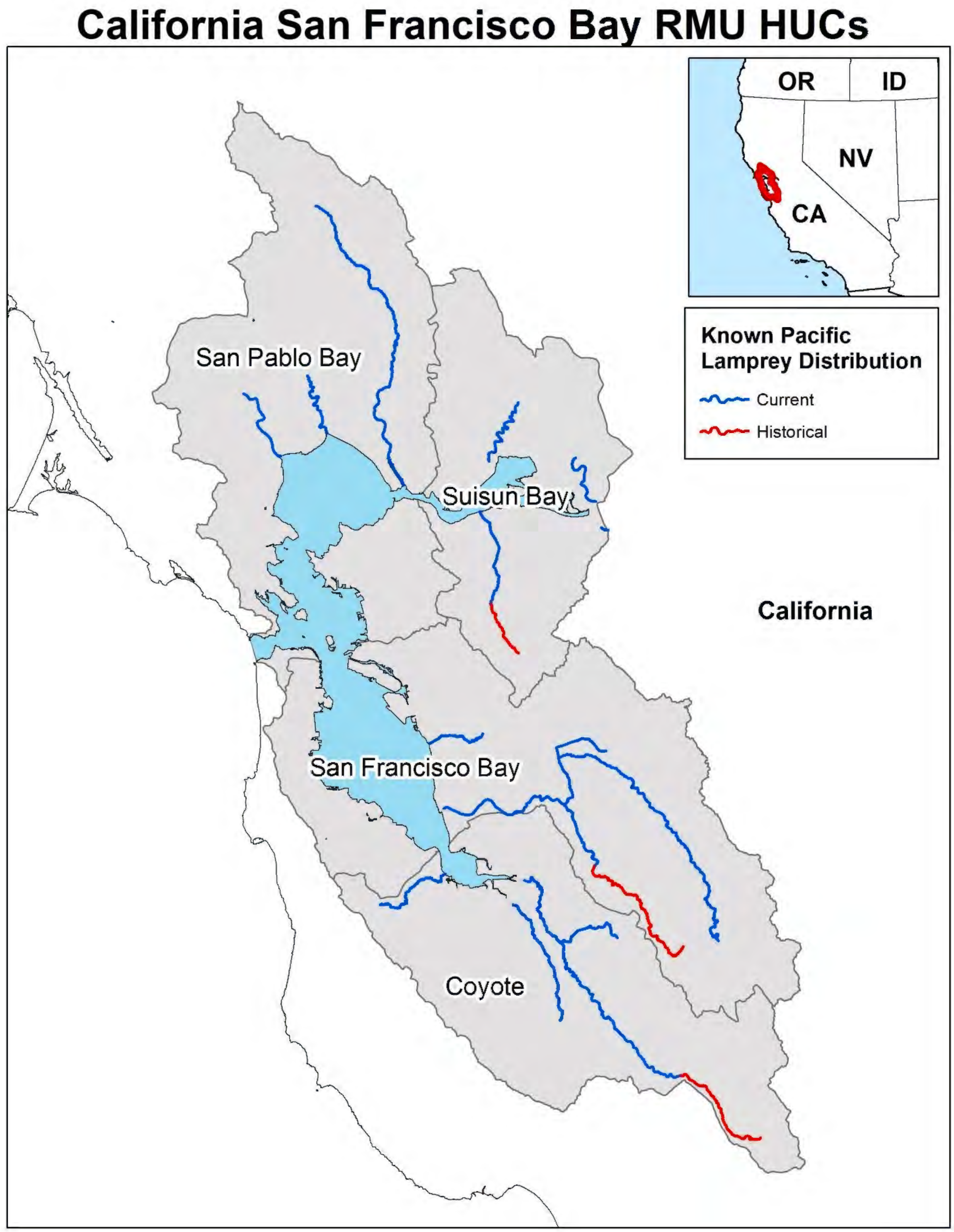


Figure 5-1. Current Pacific Lamprey distribution and location of 19 4th Field HUCs in CA San Francisco Bay RMU (Reid and Goodman 2017).

Ranked Population Status of Pacific Lamprey in the CA San Francisco Bay RMU

NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012-2017. Three HUCs are categorized as S2 - Imperiled and one (Suisun Bay) as Critically Imperiled (Table 5-1).

Pacific Lamprey are assumed to have been widely distributed and abundant historically in the larger San Francisco Bay streams, except perhaps in the higher gradient reaches of small or seasonal tributaries, based on historical records, current distribution, available habitat and lack of natural barriers. However, they probably did not occupy most smaller streams entering the Bay with drainage areas under 50 km^2, and review of historical collections from San Francisco Bay drainages finds no vouchered historical records in streams < 225 km^2, in spite of a long history of scientific collections (Leidy 2007, Reid and Goodman 2016a, 2017a). Historical freshwater records support Pacific Lamprey presence in only seven drainages (all ≥ 225 km^2): Sonoma and Napa rivers (San Pablo Bay); Pacheco/Walnut-San Ramon creeks and possibly northern Suisun creeks (Suisun Bay); Alameda Creek (San Francisco Bay); Coyote and Guadalupe creeks (Coyote).

Currently, Pacific Lamprey occupy suitable habitat, primarily in the mainstems of the seven historically occupied drainages downstream of impassable dams (Goodman and Reid 2017a). The ratio of current to historical distribution was estimated to be generally around 80% in the occupied drainages, and unobstructed in the mainstem Napa River. Changes in distributions between the 2012 and 2017 assessments reflect improved estimation of distributions (Reid and Goodman 2017) and shift from drainage area based estimation to the current linear analysis reflecting actual stream channel length (4th order and higher). We are aware of no short-term changes in actual distribution since the 2012 Assessment.

Population abundance of Pacific Lamprey in the CA San Francisco Bay RMU is unknown, but thought to be largely unchanged since the 2012 Assessment (Table 5-1). There are currently no monitoring stations for adult lamprey in the RMU. Although no long term count of Pacific Lamprey exists for the CA San Francisco Bay RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends (Goodman and Reid 2012).

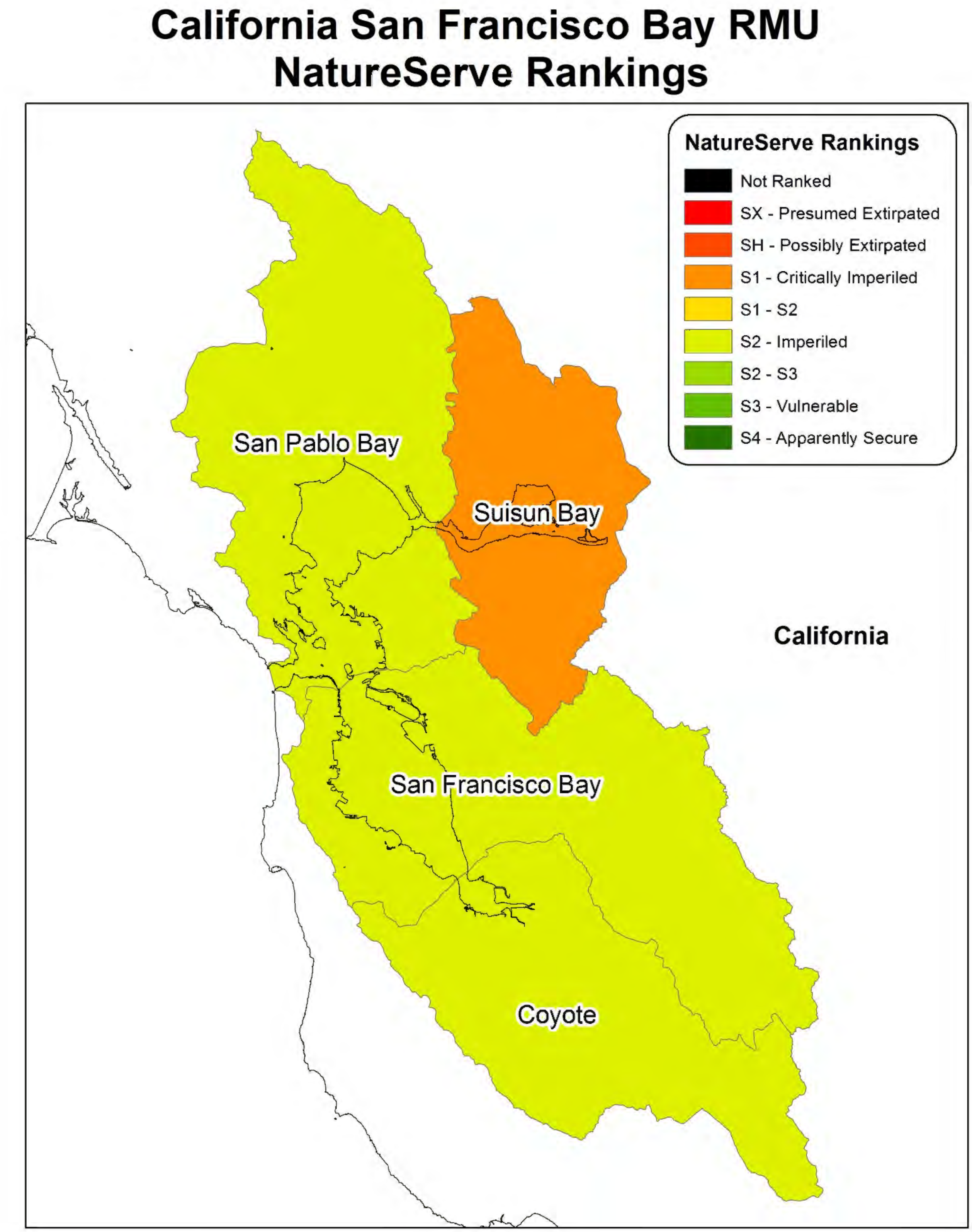


Figure 5-2. Final Conservation status ranks for the CA San Francisco Bay RMU 2017.

Threats and Limiting Factors to Pacific Lamprey in the CA San Francisco Bay RMU

Summary

Threats and limiting factors to Pacific Lamprey in the San Francisco Bay RMU are provided in Table 5-2, also discussed below. Passage remains the principal distributional constraint on lamprey populations in the San Francisco Bay RMU, however large impassable dams have reduced the distribution in 4th order and higher streams by less than 20 %. The primary threats in the San Francisco Bay RMU are the impacts of smaller, resolvable barriers dams, water quality in the highly urbanized reaches, and potential illegal harvest by homeless populations along streams in the southern tributaries to the bay.

Passage.— Major impassable barriers to passage occur in only two larger drainages (Alameda and Coyote creeks) blocking access to about 20% of habitat relatively high in the drainages. Other passage barriers are smaller but were found in most historically occupied drainages. Most may be resolvable or are currently being modified. In the Walnut Creek drainage (Suisun HUC), Walnut Creek is blocked 18 km from the mouth by a 15' drop structure and San Ramon Creek is blocked 4.3 km from its confluence with Walnut Creek, apparently blocking access to the rest of the drainage. The only major barrier in the Napa and Sonoma drainages (San Pablo HUC) blocking substantial suitable habitat is the dam on Conn Creek (Napa), blocking about 40 km of historically inhabited tributary habitat. Passage on Alameda Creek (San Francisco HUC) is substantially impeded low in the drainage at the Bart Weir by an inflatable dam (ACWD Rubber Dam #1) and further upstream by a second temporal inflatable dam (ACWD Rubber Dam #3). Fish ladders are in planning and construction phases for both. There are also three major dams in the Alameda system blocking tributaries (Calaveras, San Antonio, Laguna del Valle), although it is unclear how suitable upstream habitat would be, due to higher gradients and seasonal flow patterns. Smaller drainages in the San Francisco RMU (San Lorenzo, San Leandro and San Mateo) all have major dams blocking passage relatively low in the drainages but may not have historically held Pacific Lamprey. In the Coyote HUC, Coyote Creek itself is completely blocked by a series of major dams, starting at RKM 30. Guadalupe Creek and its tributaries are blocked by dams higher in their drainages, which may not be blocking much suitable habitat upstream, but there are also a number of smaller instream structures in the lower reaches of Guadalupe, Alamitos and Los Gatos creeks that will need to be assessed. San Francisquito, a smaller drainage (120 km^2) without historical records, also has a major dam (Searsville) blocking much of its drainage.

Changes in Scope and Severity from 2012-2017 reflect removal of a large culvert barrier on the Napa mainstem (San Pablo Bay HUC), leaving Conn Creek as the primary barrier in the drainage, and increasing Severity to 4 for impassable dams on Coyote Creek.

Dewatering and Flow Management.— Dewatering of streams (anthropogenic), resulting in reduced summer flows, is ranked as moderate in scope and severity throughout the San Francisco Bay RMU due to urbanization, extensive agriculture (e.g. viticulture) and groundwater pumping, which has become more common. Although lampreys are primarily using the mainstems and larger tributaries groundwater pumping, surface diversions and small pumps exacerbate naturally arid summer conditions making smaller streams generally unsuitable for year-round rearing. Water storage reservoirs also reduce available flow and artificially manage winter and spring flow events, reducing flow events that are crucial for outmigration of macropthalmia (Goodman et al. 2015).

There were no changes in Scope or Severity scores from 2012-2017.

Stream & floodplain degradation.— Stream degradation was generally ranked as moderate in scope and severity, primarily due to widespread channelization and down-cutting, as well as active channel constraint in urban areas. Channelization increases the energy of higher flows and reduces both habitat diversity and development of suitable depositional habitat for rearing ammocoetes.

The only change in Scope and Severity scores from 2012-2017 is in the San Pablo Bay HUC (3 to 2), reflecting channel restoration efforts in the Napa and Sonoma rivers and reassessment of direct impacts to Pacific Lamprey.

Water quality.— Water quality issues were generally ranked as widespread and moderate in severity throughout the San Francisco Bay RMU. Low summer flows and urban runoff result in high temperatures and nutrient levels, with low oxygen levels in summer refuge areas used by both adult lampreys and ammocoetes. Both agricultural and urban runoff may also be contributing to a high contaminant level in streams and sediments. The specific effects of most of these factors on lampreys is not known, however high temperatures and low oxygen in holding areas is a known cause of summer mortality.

There were no changes in Scope or Severity scores from 2012-2017.

Harvest.— As in most of California, legal harvest was not considered a major threat in the San Francisco Bay RMU (ranked Insignificant in both scope and severity). We are aware of no substantial tribal harvest in the RMU, and in 2010 CDFG established a non-tribal daily bag limit of five adult lamprey. However, illegal capture and consumption of lampreys by the large urban homeless populations, particularly in southern bay tributaries (Alameda, Coyote and Guadalupe) has emerged as a potential, but as yet unassessed, threat (GCRCD 2005).

Scope or Severity scores were adjusted to High-Unknown from 2012-2017 to account for uncertainty with regard to the potential homeless subsistence harvest, which would likely occur on in-migrating adults lower in the mainstems of the Coyote and San Francisco HUCs.

Predation.— Predation is not considered a major threat in most San Francisco Bay streams, although non-native predatory fishes are common in the mainstems and reservoirs (incl. basses, sunfishes, carp and various catfishes). The impact on local populations is not known, but was not generally considered a major threat to lamprey populations and may be ameliorated by the generally nocturnal activity patterns of lampreys and downstream migration during periods of high flow and turbidity. Sacramento Pikeminnow *Ptychocheilus grandis* are present in larger mainstems but are native. Seals and sea lions are known to feed on migrating runs of adult lampreys near the mouths of rivers, as do eagles and ospreys. However, the nature or severity of pinniped predation in San Francisco Bay has not been assessed.

Ranks for predation were changed from High in 2012 to Moderate in 2017 and scope was changed from Unknown to Moderate in all HUCs in the RMU based on an improved understanding of predation effects from other drainages. However, the need for site specific assessment of predation exists.

Lack of Awareness and Other Threats.— Increased education, outreach, coordination and inclusion in conservation planning will be essential for long-term conservation of lampreys in California and is a major continuing component of the PLCI in California (see California Introductory Chapter). The remaining threat categories were not considered in the California assessment as a whole due to lack of information (see discussion under Goodman and Reid 2012, Chap. 4 - California Regional Summary: Disease, Small Population Size, Ocean Conditions, and Climate Change).

Table 5-2. Threats to Pacific Lamprey within the CA San Francisco Bay RMU, as identified and ranked at regional meetings, site visits and further assessment of conditions. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Suisun Bay (Pacheco)	3	3	3	3	3	3	4	2	1	1	3	3
San Pablo (Napa/Sonoma)	1	3	3	3	3	2	4	2	1	1	3	3
Coyote	3	4	3	3	3	3	4	3	4	U	3	3
San Francisco (Alameda)	3	3	3	3	3	3	4	3	4	U	3	3

Table 5-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the San Francisco Bay RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
Suisun Bay	Population	Distribution surveys to determine upstream extent in the Walnut Creek drainage.	Survey	Ongoing
Suisun Bay	Population	Distribution surveys to determine upstream extent in Suisun and Green Valley creeks.	Survey	Ongoing
San Pablo Bay	Passage	Sonoma Creek, assess the Dunbar Rd. culvert for lamprey passage and upstream habitat for suitability.	Assessment	Completed
San Pablo Bay	Passage	Sonoma Creek, assess the Suttenfield dam and mainstem Sonoma for lamprey passage.	Assessment	Completed
San Pablo Bay	Passage	Napa River, remove/replace Greenwood Road culvert.	Instream	Completed
San Pablo Bay	Population	Distribution surveys to determine upstream extent in the Sonoma drainage.	Survey	Completed
San Pablo Bay	Population	Survey Napa Creek to determine causal factors if still unoccupied.	Assessment	Proposed
SF Bay	Passage	Alameda Creek, assess passage constraints for lampreys at the Lower Inflatable Dam apron, develop adaptive improvements.	Assessment	Completed
SF Bay	Passage	Alameda Creek, assess Bart Weir fishway design and develop adaptive improvements.	Assessment	Underway
SF Bay	Passage	Assess passage constraints at the pillow dam on Alameda Creek and develop adaptive improvements, if necessary, or remove.	Instream	Underway
SF Bay	Passage	Alameda Creek, assess passage at Upper Inflatable Dam.	Assessment	Underway
SF Bay	Population	Distribution surveys to evaluate presence/absence in the Alameda drainage.	Survey	Completed
SF Bay	Population	Arroyo de la Laguna drainage, evaluate habitat and distribution surveys to evaluate presence/absence and habitat suitability.	Survey	Ongoing
SF Bay	Population	Determine migration timing, spawning locations and timing in principal streams.	Research	Underway
Coyote	Population	Distribution surveys within the Coyote Creek drainage with consideration of seasonality and access.	Survey	Ongoing

HUC	Threat	Action Description	Type	Status
Coyote	Population	Distribution surveys to determine upstream extent in streams within the Guadalupe drainage with consideration of seasonality and access.	Survey	Ongoing
Coyote	Population	Distribution surveys to evaluate presence/absence in the San Francisquito drainage, including above and below Searsville Dam.	Survey	Ongoing

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Alameda County Water District	Doug Chun
	Evan Buckland
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Alameda Creek Alliance	Dave Garges
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	Dan Sarka
Calif. Dept. Fish & Wildlife	George Neillands
	Michelle Leicester
Center for Ecosystem Management and Restoration	Gordon Becker
Clean South Bay Creeks Coalition	Steve Holmes
East Bay Regional Park District	Doug Rischbieter
	Joe Sullivan
	Matthew Graul
	Peter Alexander
Friends of the Napa River	Shari Gardner
Guadalupe Coyote Resource Conservation District	Lawrence Johmann
Napa County Resource Conservation District	Jemma Williams
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Salmon and Steelhead Restoration Group	Roger Castillo
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SF Public Utilities Commission	Randall Renn
	Scott Chenue
Sierra Club & Grassroots Ecology	Kit Gordon
Sonoma Ecology Center	Caitlin Cornwall
Stoecker Ecological	Matt Stoecker
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U.S. Environmental Protection Agency	Rob Leidy
U.S. Fish and Wildlife Service	John Klochak
	Victoria Poage

6. CA SAN JOAQUIN REGION

Summary

The CA San Joaquin RMU (Figure 6-1) includes all drainages in the southern Central California Valley, including the San Joaquin and Tulare sub-basins, downstream (north) to the delta and confluence with the Sacramento, including the San Joaquin and Tulare USGS subregions and accounting units (Figure 3). Due to subregional differences in hydrology and historical use we have generally separated the San Joaquin and Tulare sub-basins within the broader San Joaquin RMU. All anadromous access to the Tulare sub-basin was lost by the 1870's due to diversion of its inflows and drainage of the lakebed for agricultural purposes, and the Tulare Basin was not analyzed further in the Assessment, with the exception of the Kings drainage (and tributary Mill Creek) that connects northwards to the San Joaquin. The San Joaquin sub-basin includes 15 watersheds (4th field HUCS), ranging from 629 - 6,921 km^2 (Table 6-1). It occupies the Central Californian Chaparral / Oak Woodlands, Central California Valley, and Sierra Nevada ecoregions. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012-2017. Most currently occupied HUCs below dams were categorized as S2 - Imperiled (Table 6-1).
- Our understanding of distribution was substantially improved through assessment of historical and current range state-wide and continued surveys.
- Current Pacific Lamprey distribution remained the same in all HUCs.
- Population abundance of Pacific Lamprey in the CA San Joaquin RMU is thought to be largely unchanged since the 2012 Assessment.
- Although no long term count of Pacific Lamprey exists in CA San Joaquin RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends and anecdotal reports from local residents (Goodman and Reid 2012).
- Passage remains the principal distributional constraint on lamprey populations in the San Joaquin RMU. However, the middle reaches of the mainstem San Joaquin River have large dry gaps that are currently under restoration.
- The primary threats in the San Joaquin RMU were entrainment by the two large diversions in the Delta and dewatering in the middle reaches of the San Joaquin mainstem. Additional concerns were dewatering and water quality in the middle reaches of the San Joaquin, as well as potential predation in the upper Cosumnes and lower San Joaquin.

Threat rankings are shown in Table 6-2. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 6-3. A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the CA San Joaquin Region can be found in the Regional Implementation Plan for the San Joaquin RMU (Goodman and Reid 2017, PLCI San Joaquin Implementation Plan).

Table 6-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the CA San Joaquin Region. SX = Presumed Extirpated. S1 = Critically Imperiled. S2 = Imperiled. Note that historical and current occupancies are linear stream distances (4th order and above), reflecting improved distribution data since the 2012 Assessment (Goodman and Reid 2012, Reid and Goodman 2017).

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km)	Current Occupancy (km)	Ratio Current/ Historical	Population Size (adults)	Short-Term Trend (% Decline)
Kings - Upper	18030010	SX	177	0	0.00	Extinct	-
Mill	18030008	SX	41	0	0.00	Extinct	-
San Joaquin - Middle-Upper	18040001	S2	295	293	0.99	Unknown	50 - 70%
San Joaquin - Middle-Lower	18040002	S2	523	521	1.00	Unknown	50 - 70%
San Joaquin Delta	18040003	S2	281	281	1.00	Unknown	50 - 70%
Calaveras / Mormon Slough	18040004	S1	68	68	1.00	Unknown	50 - 70%
Cosumnes / Lower Mokelumne	18040005	S2	185	160	0.86	Unknown	50 - 70%
San Joaquin - Upper	18040006	SX	235	0	0.00	Extinct	-
Upper Chowchilla-Upper Fresno	18040007	-	0	-	0.00	-	-
Merced - Upper	18040008	SX	218	0	0.00	Extinct	-
Tuolumne - Upper	18040009	SX	284	0	0.00	Extinct	-
Stanislaus - Upper	18040010	SX	354	6	0.02	Unknown	50 - 70%
Calaveras - Upper	18040011	S1	131	14	0.11	Unknown	50 - 70%
Mokelumne - Upper	18040012	SX	197	0	0.00	Extinct	-
Cosumnes - Upper	18040013	S2	148	148	1.00	Unknown	50 - 70%
Panoche-San Luis Reservoir	18040014	-	0	-	0.00	-	-

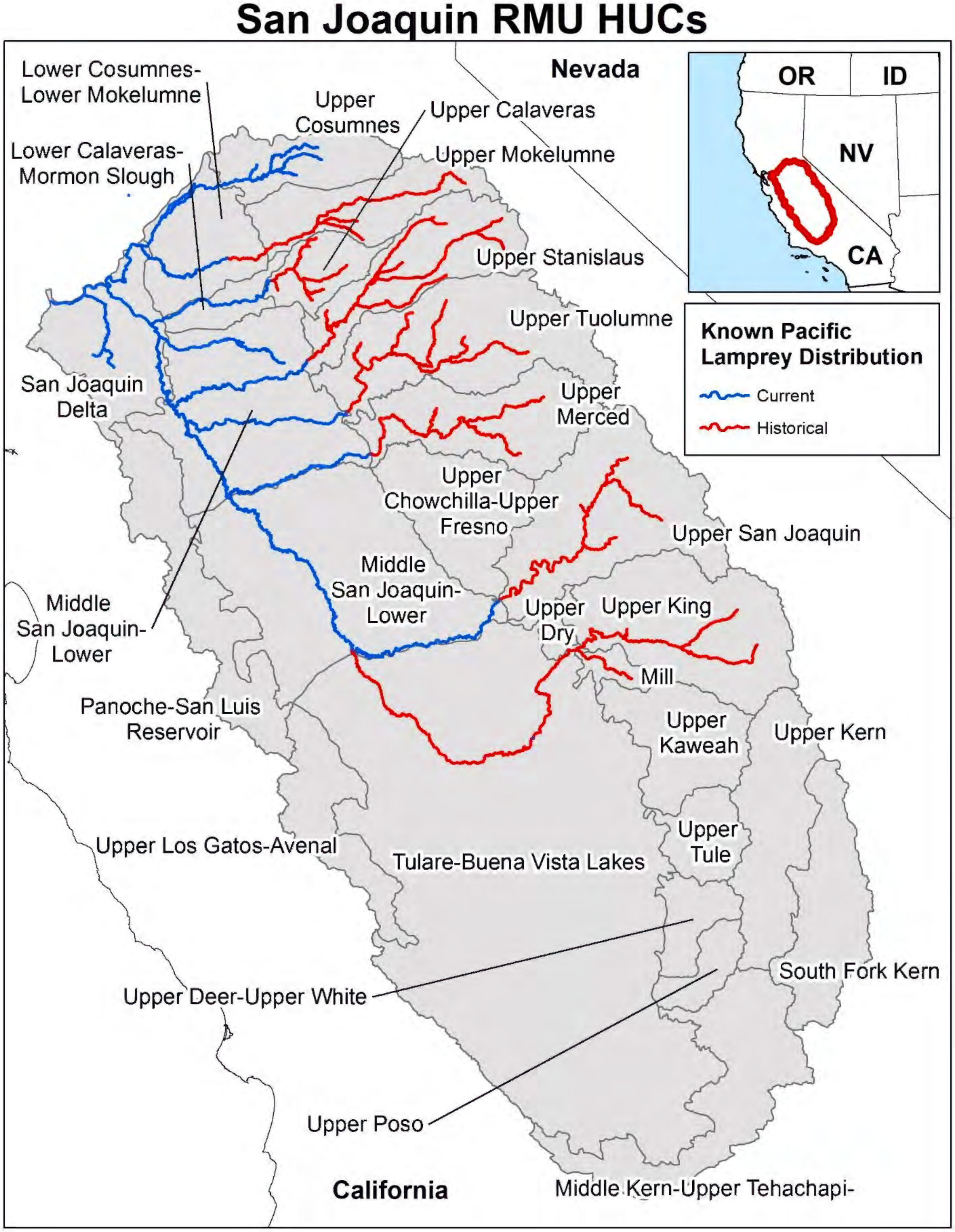

Figure 6-1. Current Pacific Lamprey distribution and location of 19 4th Field HUCs in CA San Joaquin RMU (Reid and Goodman 2017).

Ranked Population Status of Pacific Lamprey in the CA San Joaquin RMU

NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012-2017 (Table 6-1).

Pacific Lamprey are assumed to have been widely distributed and abundant historically in the San Joaquin RMU, based on current distribution, available habitat and lack of natural barriers. The principal uncertainty is whether they extended into the Tulare Lake drainage south of the Kings, for which there are no records of Pacific Lamprey or natural populations of other resident lamprey species (Yoshiyama et al 2001, Reid and Goodman 2017a).

Currently, Pacific Lamprey occupy most historical anadromous mainstem habitat in the San Joaquin RMU downstream of impassable dams (Goodman and Reid 2017a). However, the upper drainages of all major tributaries, except the Cosumnes, and their HUCs have been extirpated or nearly so by large dams (Table 6-1). The Cosumnes is the only major tributary with relatively natural flow and connectivity to the headwaters. It is a relatively small foothill drainage, which does not extend into the high Sierra. The distribution of Pacific Lamprey has remained the same in most watersheds since the completion of the 2012 Assessment. Changes in distributions between the 2012 and 2017 assessments reflect improved estimation of distributions (Reid and Goodman 2017a) and shift from drainage area based estimation to the current linear analysis reflecting actual stream channel length (4th order and higher). We are aware of no short-term changes in actual distribution since the 2012 Assessment.

Population abundance estimates of Pacific Lamprey in the CA San Joaquin RMU are unchanged since the 2012 Assessment and are still rated as Unknown (Table 6-1). This is primarily due to the lack of accurate monitoring and high apparent variability in adult run sizes. The only monitoring station in the RMU is at the Woodbridge Dam and fishway on the Mokelumne River. The site is not optimized for lamprey monitoring and is planned for passage assessment. Although no long term count of Pacific Lamprey exists in CA San Joaquin RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends and anecdotal reports from local residents (Goodman and Reid 2012).

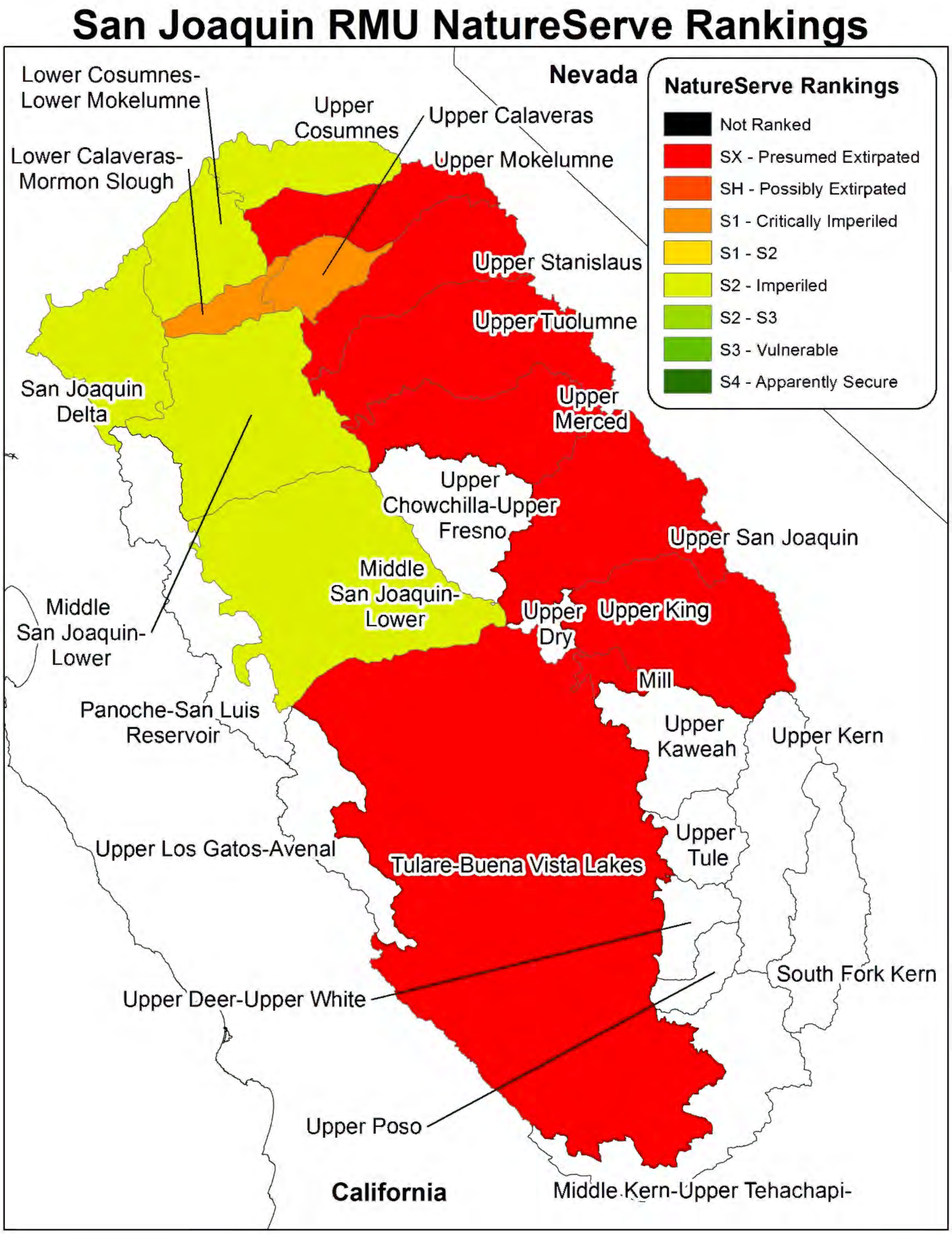

Figure 6-2. Final Conservation status ranks for the CA San Joaquin RMU 2017.

Threats and Limiting Factors to Pacific Lamprey in the CA San Joaquin RMU

Summary
Threats and limiting factors to Pacific Lamprey in the San Joaquin RMU are provided in Table 6-2, also discussed below. Passage remains the principal distributional constraint on lamprey populations in the San Joaquin RMU. The primary threats in the San Joaquin RMU were entrainment by the two large diversions in the Delta and dewatering in the middle reaches of the San Joaquin mainstem. Additional concerns were dewatering and water quality in the middle reaches of the San Joaquin, as well as potential predation in the upper Cosumnes and lower San Joaquin.

Passage.— The presence of large impassable dams along the Sierran foothills of the San Joaquin has severely limited the current range of anadromous lamprey, and much of the area lost is from the higher gradient foothill and mountain reaches that provide good water quality, spawning and rearing habitat. Under current conditions lampreys can only utilize about 65% of the RMU area, mostly on the valley floor and lower foothills. Most mainstem rivers remain accessible up to the large foothill dams. The Cosumnes River is the only river with access to its upper reaches and no major barriers. Although there is a weir in the lower river (elevation ca. 45 m), it has a fish ladder and apparent natural passage around it. There is also a natural barrier falls that apparently blocks salmonids near the Sacramento County line (elev. ca. 60 m; Yoshiyama et al. 1998), but lampreys pass it and are present in the upper Cosumnes. On the Calaveras River the New Hogan Dam blocks passage to all but 12.2 km of the upper river, while migration in the lower river and tributaries is hindered by numerous weirs and culverts. At this time, we do not think that passage above the larger storage dams is feasible, primarily due to challenges in providing outmigration opportunities to juvenile lampreys heading downstream.

A special case for passage issues (ranked as 4-U for the lower mainstem San Joaquin HUCs) is entrainment at the Tracy Pumping Facility (USBR) and Clifton Forebay Diversion Facility (CDFG) in the lower San Joaquin, which potentially impacts passage for large numbers of downstream migrating juveniles from both the San Joaquin and Sacramento drainages. Assessment of entrainment and passage effects at these facilities is currently underway (Goodman et al. 2015) and is dependent on screening efficiency, diversion timing, flow management in the complicated Central Valley water system, and downstream migration timing for juvenile lampreys.

Changes in Scope scores from 2012-2017 reflect improved distributional information and the shift from area-based to linear calculations, the two changes in Severity scores reflect a changed ranking interpretation, increasing Severity to 4 at impassable barriers.

Dewatering and Flow Management.— Stream flow is highly manipulated in the San Joaquin system, resulting in channel drying in the middle reaches of the San Joaquin and lower reaches of the Mokelumne rivers, extensive diversion into agricultural ditches, and loss of flow to state water projects. Manipulation of flow in the delta by the major pumping projects may also have substantial effects on orientation of migrating lampreys (adults and juveniles). Water storage reservoirs also reduce available flow and artificially manage winter and spring flow events, reducing flow events that are crucial for outmigration of macropthalmia (Goodman et al. 2015).

There were no changes in Scope or Severity scores from 2012-2017.

Stream & floodplain degradation.— While the San Joaquin system is highly modified, the actual threat of stream and floodplain degradation to lampreys was rated as low to moderate in the lower reaches of occupied HUCs. Channelization increases the energy of higher flows and reduces both habitat diversity and development of suitable depositional habitat for rearing ammocoetes.

There were no changes in Scope or Severity scores from 2012-2017.

Water quality.— Water quality issues were generally ranked as widespread, but low in severity throughout the RMU. The San Joaquin system, as a major agricultural area, has numerous water quality issues with eutrophication and contaminants; however, the effects on local lamprey populations have not been evaluated. The San Joaquin River itself also has considerable issues with high water temperatures and low dissolved oxygen, although again the direct impacts to the lamprey population are not understood, however high temperatures and low oxygen in holding areas is a known cause of summer mortality.

There were no changes in Scope or Severity scores from 2012-2017.

Harvest.— As in most of California, Harvest was not considered a major threat in the North Central Coast RMU (ranked Insignificant in both scope and severity). We are aware of no substantial tribal harvest in the RMU, and in 2010 CDFG established a non-tribal daily bag limit of five adult lamprey.

There were no changes in Scope or Severity scores from 2012-2017.

Predation.— Non-native predatory fishes are common in the San Joaquin Valley and foothill streams. Nevertheless, while there is certainly predation on larval and juvenile lampreys by introduced centrarchids (bass and sunfish) and catfishes, they have occupied the system since the late 1800's and were generally not considered to be a major threat to lamprey populations. A possible exception is the introduced Redeye Bass population in the upper Cosumnes, which has spread throughout the upper drainage and may pose a threat in the relatively small summer habitat of this foothill stream (Moyle et al. 2003). In the lower reaches and delta of the San Joaquin River itself, Striped Bass are abundant and represent a potential threat to lampreys. Striped Bass are large predators, capable of feeding on all stages of lampreys, including adults. They occupy the primary migration routes for adults moving upstream to spawn and juveniles outmigrating to the sea. However, the extent of predation on lampreys by Striped Bass and the actual threat this represents to the population are unresolved. Mitigating conditions may include generally nocturnal activity patterns of lampreys and downstream migration during periods of high flow and turbidity.

There were generally no changes in Scope or Severity scores from 2012-2017, except for an increase in the upper Cosumnes from Severity from 1 to 3, based on predation estimates in other areas and pending assessment of bass impacts.

Lack of Awareness and Other Threats.— Increased education, outreach, coordination and inclusion in conservation planning will be essential for long-term conservation of lampreys in California and is a major continuing component of the PLCI in California (see California

Introductory Chapter). The remaining threat categories were not considered in the California assessment as a whole due to lack of information (see discussion under Goodman and Reid 2012, Chap. 4 - California Regional Summary: Disease, Small Population Size, Ocean Conditions, and Climate Change).

Table 6-2. Threats to Pacific Lamprey within the CA San Joaquin RMU, as identified and ranked at regional meetings, site visits and further assessment of conditions. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Kings - Upper	4	4										
San Joaquin - Middle-	4	4	4	4	4	2	4	3	1	1	4	3
San Joaquin - Middle-	4	U	4	3	4	2	4	2	1	1	4	3
San Joaquin Delta	4	U	4	3	4	2	4	2	1	1	4	3
Calaveras / Mormon	4	3	2	2	3	3	4	2	1	1	2	1
Cosumnes / Lower	3	4	4	3	3	3	4	2	1	1	3	1
San Joaquin - Upper	4	4										
Upper Chowchilla-Upper	4	4										
Merced - Upper	4	4										
Tuolumne - Upper	4	4										
Stanislaus - Upper	4	4										
Calaveras - Upper	4	4	2	2	3	3	4	2	1	1	2	1
Mokelumne - Upper	4	4										
Cosumnes - Upper	2	2	2	2	1	1	4	2	1	1	3	3
Panoche-San Luis												

Table 6-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the San Joaquin RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
San Joaquin	Passage	Assess screen effectiveness for lampreys at the BOR pumping facility.	Assessment	Completed
San Joaquin	Passage	Assess screen effectiveness for lampreys at Clifton Forebay CDFW pumping facility.	Assessment	Completed
San Joaquin	Passage	Assess Clifton Forebay operations for lampreys at the CDFW facility.	Assessment	Ongoing
San Joaquin	Passage	Assess screen effectiveness and Clifton Forebay operations for lampreys at the CDFW facility.	Assessment	Underway
San Joaquin - Middle - Upper	Passage	Assess Eastside Bypass control structure, incorporate lamprey passage	Assessment	Underway
San Joaquin - Middle - Upper	Passage	Assess Eastside Bypass culvert site, incorporate lamprey passage	Assessment	Underway
San Joaquin - Middle - Upper	Passage	Assess Mariposa Bypass, at Eastside B, incorporate lamprey passage	Assessment	Underway
San Joaquin - Middle - Upper	Passage	Assess proposed fish bypass facilities for Mendota Weir to incorporate lampreys.	Assessment	Underway
San Joaquin - Middle - Upper	Passage	Assess Sack Dam, Henry Miller I.D.	Assessment	Underway
San Joaquin - Middle - Upper	Passage	Restore connectivity and flow in middle reaches of San Joaquin.	Assessment	Underway
San Joaquin - Middle - Upper	Passage	Assess San Mateo Rd. crossing culverts	Assessment	Completed
Cosumnes - Upper	Passage	Assess passability of LaTrobe Falls	Assessment	Completed

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The USFWS and 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 the California San Joaquin RMU:

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Woodbridge Irrigation District	Anders Christensen

7. CA SACRAMENTO REGION

Summary

The CA Sacramento RMU (Figure 7-1) includes the mainstem Sacramento River and all of its tributaries downstream to the confluence with the San Joaquin River, including the Upper and Lower Sacramento USGS accounting units. It includes 34 watersheds (4th field HUCS), ranging from 96–7,041 km^2 (Table 7-1). The RMU extends from the San Francisco Bay inland through California's Central Valley, east into the Sierra Nevada Mountains, northwards to Mount Shasta, and inland to the arid Goose Lake Basin (currently endorheic and not shown in tables) and western slope of the Warner Mountains. It occupies the Central California Chaparral / Oak Woodlands, Central California Valley, Sierra Nevada, Klamath Mountains, Cascade, and Eastern Cascade, slopes and foothills ecoregions. Due to differences in hydrology, habitat and threats, we have grouped the HUCs within the RMU into three sub-groupings: Upper Sacramento, East Foothills and Sierras, West Valley and Coast Range. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks changed in only 1 of 33 HUCs from 2012-2017. This was in the Lower Yuba HUC, which dropped from S2 to S1, due to revised passage ranks and distribution information.
- Our understanding of distribution was substantially improved through assessment of historical and current range state-wide and continued surveys.
- Current Pacific Lamprey distribution remained the same in all HUCs.
- Population abundance of Pacific Lamprey in the CA Sacramento RMU is thought to be largely unchanged since the 2012 Assessment.
- Although no long-term count of Pacific Lamprey exists in CA Sacramento RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends and anecdotal reports from local residents (Goodman and Reid 2012).
- Passage remains the principal distributional constraint on lamprey populations in the Sacramento RMU. There is a need to further assess and resolve, if necessary, small passage barriers throughout the RMU.
- The only new threat recognized is potential dewatering and passage issues associated with the Yolo Bypass.

Threat rankings are shown in Table 7-2. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 7-3. A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the CA Sacramento Bay Region can be found in the Regional Implementation Plan for the Sacramento RMU (Goodman and Reid 2017, PLCI Sacramento Implementation Plan).

Table 7-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the CA Sacramento Region. SX = Presumed Extirpated. S1 = Critically Imperiled. S2 = Imperiled. Note that historical and current occupancies are linear stream distances (4th order and above), reflecting improved distribution data since the 2012 Assessment (Goodman and Reid 2012, Reid and Goodman 2017). Conservation Status Rank highlighted in yellow indicate a decline (↓) or improvement(↑) in status in 2017 from 2011.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km)	Current Occupancy (km)	Ratio Current/ Historical	Population Size (adults)	Short-Term Trend (% Decline)
<u>Upper Sacramento</u>:							
Upper Pit	18020002	SX	291		0.00	Extinct	-
Lower Pit	18020003	SX	413		0.00	Extinct	-
McCloud	18020004	SX	160		0.00	Extinct	-
Sacramento headwaters	18020005	SX	127		0.00	Extinct	-
Sacramento - Upper Clear	18020112	S1	54	15	0.28	Unknown	50 - 70%
<u>East Foothills and Sierras</u>:							
Upper Cow - Battle	18020118	S1	57	57	1.00	Unknown	50 - 70%
Lower Cow - Lower Clear	18020101	S2	216	214	0.99	Unknown	50 - 70%
Mill - Big Chico	18020119	S2	286	258	0.90	Unknown	50 - 70%
Butte - Upper	18020120	S1	68	25	0.36	Unknown	50 - 70%
Butte - Lower	18020105	S2	194	194	1.00	Unknown	50 - 70%
Feather - North Fork	18020121	SX	309		0.00	Extinct	-
Feather - N.F. East Branch	18020122	SX	295		0.00	Extinct	-
Feather - Middle Fork	18020123	SX	349	1	0.00	Extinct	-
Feather - Lower	18020106	S2	215	212	0.98	Unknown	50 - 70%
Honcut headwaters	18020124	S2	29	29	1.00	Unknown	50 - 70%
Yuba - Upper	18020125	S1	426	48	0.11	Unknown	50 - 70%
Yuba - Lower	18020107	S1↓	40	40	1.00	Unknown	50 - 70%
Bear - Upper	18020126	SX	94		0.00	Extinct	-
Bear - Lower	18020108	S2	48	47	0.97	Unknown	50 - 70%
Upper Coon - Upper Auburn	18020127		0				
American - North Fork	18020128	SX	297		0.00	Extinct	-
American - South Fork	18020129	SX	199		0.00	Extinct	-
American - Lower	18020111	S2	105	91	0.86	Unknown	50 - 70%
<u>West Valley and Coast Range</u>:							
Cottonwood headwaters	18020113	S2	103	103	1.00	Unknown	50 - 70%
Cottonwood - Lower	18020102	S2	131	131	1.00	Unknown	50 - 70%
Upper Elder - Upper Thomes	18020114	S2	52	52	1.00	Unknown	50 - 70%
Sacramento - Lower Thomes	18020103	S2	467	466	1.00	Unknown	50 - 70%
Stony - Upper	18020115	SX	213		0.00	Extinct	-
Sacramento - Stone Corral	18020104	S2	213	213	1.00	Unknown	50 - 70%
Cache - Upper	18020116	SX	296		0.00	Extinct	-
Cache - Lower	18020110	SH	88		0.00	Extinct	-
Putah - Upper	18020117	SX	108		0.00	Extinct	-
Sacramento - Lower	18020109	S2	450	414	0.92	Unknown	50 - 70%

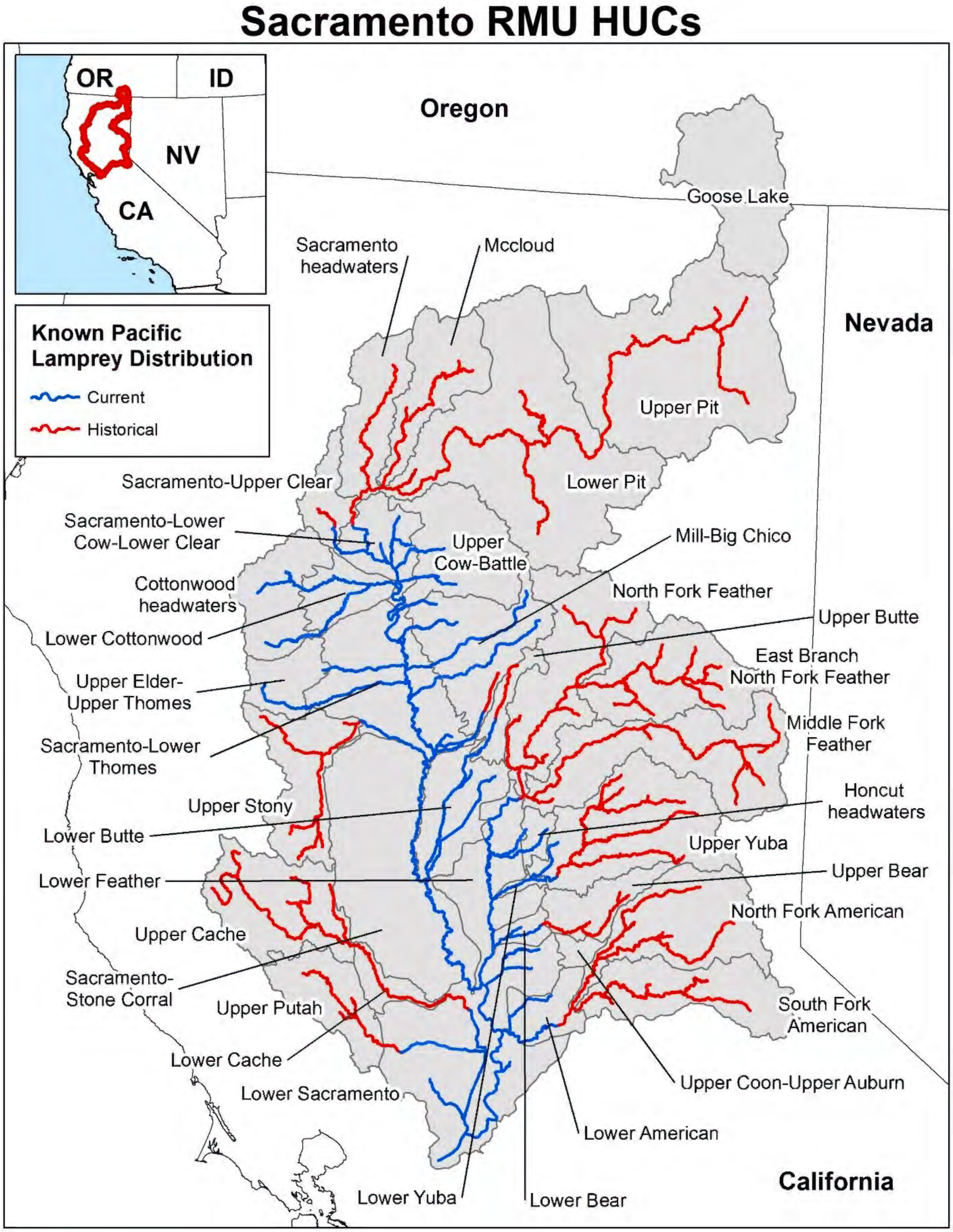

Figure 7-1. Current Pacific Lamprey distribution and location of 34 4th Field HUCs in CA Sacramento (Reid and Goodman 2017).

Ranked Population Status of Pacific Lamprey in the CA Sacramento RMU

NatureServe conservation status ranks changed in only 1 of 33 HUCs from 2012-2017. This was in the Lower Yuba HUC, which dropped from S2 to S1, due to revised passage ranks and distribution information.

Pacific Lamprey are assumed to have been widely distributed and abundant historically in the Sacramento RMU, based on current distribution, available habitat and tribal knowledge of fisheries. The principal uncertainty is how far they extended into the upper Pit River for which there are no records. However, for the purpose of this assessment we follow Reid and Goodman (2017a) and assume that they were able to utilize all suitable habitat with anadromous access. This is based on the widespread presence of resident populations of a similar species, the Pit-Klamath Brook lamprey *Entosphenus lethophagus* throughout the upper Pit and Goose basins up to 1,760 m, the absence of natural barriers, historical records of Pacific Lamprey at elevations of up to 2,140 m in Idaho (Evermann and Meek 1898) and at least 1,490 m in California.

Currently, Pacific Lamprey occupy most historical anadromous habitat in the Sacramento RMU downstream of impassable dams, except perhaps in higher gradient reaches or smaller tributaries (Goodman and Reid 2017a). However, the upper drainages of some major tributaries and their HUCs have been extirpated or nearly so by large dams (Table 7-1). The distribution has remained the same in most watersheds since the completion of the 2012 Assessment. Changes in distributions between the 2012 and 2017 assessments reflect improved estimation of distributions (Reid and Goodman 2017a) and shift from drainage area based estimation to the current linear analysis reflecting actual stream channel length (4th order and higher). We are aware of no short-term changes in actual distribution since the 2012 Assessment.

Population abundance estimates of Pacific Lamprey in the CA Sacramento RMU are largely unchanged since the 2012 Assessment and are still rated as Unknown (Table 7-1). This is primarily due to the lack of accurate monitoring and high apparent variability in adult run sizes. There are two video monitoring stations in the RMU at the Coleman Fish Hatchery weir on Battle Creek, a relatively small tributary of the Sacramento, and on the lower Yuba. These sites are not optimized for lamprey monitoring and are planned for passage assessment. However, video monitoring on Battle Creek (Upper Cow-Battle Creek HUC) has been carried out since 2009, with an average count of 395 adults and ranging from 60 in 2015 to 1,457 in 2017 (R.J. Bottaro USFWS pers. com.). These observations are limited by diurnal use patterns, seasonal monitoring that may miss lamprey migrations, turbidity issues at high flow, and the possibility that lampreys use routes other than those being monitored. Nevertheless, they provide lower limits for population size in this stream (Goodman and Reid 2012). Although no long-term count of Pacific Lamprey exists in CA Sacramento RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends and anecdotal reports from local residents (Goodman and Reid 2012).

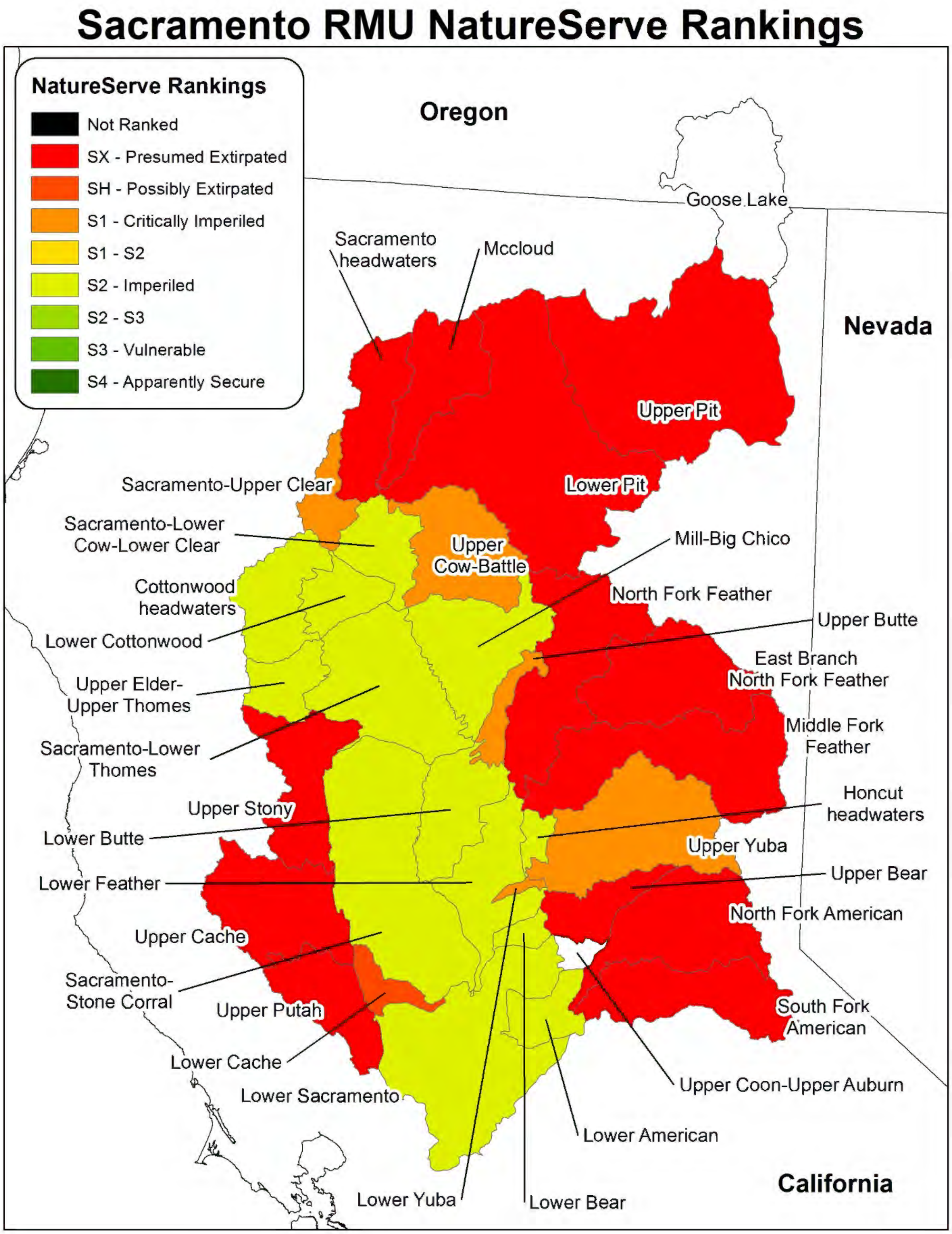

Figure 7-2. Final Conservation status ranks for the CA Sacramento RMU 2017.

Threats and Limiting Factors to Pacific Lamprey in the CA Sacramento RMU

Summary

Threats and limiting factors to Pacific Lamprey in the Sacramento RMU are provided in Table 7-2, also discussed below. Passage remains the principal distributional constraint on lamprey populations in the Sacramento RMU. The primary threat in the Sacramento RMU is entrainment by the two large diversions in the Delta. Additional concerns were dewatering and water quality in the Yuba Bypass area, as well as numerous smaller passage barriers that will require assessment and resolution.

Passage.— The presence of large impassable dams along the rim of the Sacramento Valley has severely limited the current range of anadromous lamprey (ca. 70% of total historical habitat), and much of the area lost is from the higher gradient foothill and mountain reaches that provide good water quality, spawning and rearing habitat. Nearly all habitat in the upper Sacramento HUCs has been blocked by dams, while eight out of 18 HUCs in the eastern foothills and Sierran drainages have been fully or essentially blocked (60% of historical habitat), and two HUCs in higher reaches of the Coast Ranges have been completely lost to dams (15% of historical habitat). Medium-sized diversion dams on some creeks (e.g. Battle, Cache, upper Coon and Putah creeks) also obstruct passage and may be suitable for reestablishment of passage. However, within occupied habitat, most mainstem rivers remain accessible up to the large dams, and other passage issues (e.g. culverts and smaller weirs) were generally ranked as a low threat in most occupied HUCs. At this time we do not feel that passage above the larger storage dams is feasible, primarily due to challenges in providing outmigration opportunities to juvenile lampreys heading downstream.

A special case for passage issues is entrainment at the Tracy Pumping Facility (USBR) and Clifton Forebay Diversion Facility (CDFG) in the lower San Joaquin, which potentially impacts passage for large numbers of downstream migrating juveniles from both the San Joaquin and Sacramento drainages. Assessment of entrainment and passage effects at these facilities is currently underway (Goodman et al. 2017) and is dependent on screening efficiency, diversion timing, flow management in the complicated Central Valley water system, and downstream migration timing for juvenile lampreys.

Changes in Scope scores from 2012-2017 reflect improved distributional information and the shift from area-based to linear calculations, as well as recognition of additional barriers lower in the drainages. Changes in Severity scores reflect a changed ranking interpretation, increasing Severity to Moderate at impassable barriers, and Moderate as to the impact of small barriers on the lower Yuba.

Dewatering and Flow Management.— Streamflow is highly manipulated in the Sacramento system. Threats due to flow management were generally ranked low in the upper reaches of occupied streams and moderate in the lower reaches. Threats were ranked higher in the west-side streams due to dewatering and diversion of lower reaches, where channels are usually dry or have low, warm flow in the summer and fall. Water storage reservoirs, including Shasta Reservoir on the mainstem Sacramento, also reduce available flow and artificially manage winter and spring flow events, reducing flow events that are crucial for outmigration of macropthalmia (Goodman et al. 2015). Manipulation of flow in the lower Sacramento by the major pumping projects in the delta may also have substantial effects on orientation of migrating lampreys (adults and juveniles). The Yuba Bypass floodplain project also presents issues with potential stranding as water recedes.

There were generally few changes in Scope or Severity scores from 2012-2017, except that Severity in Sacramento – Lower was raised from 2 to Unknown due to lack of information on the impacts of the Yuba Bypass and possible stranding.

Stream & floodplain degradation.— While the Sacramento system is highly modified, the actual threat of stream and floodplain degradation to lampreys was rated as insignificant to low in most occupied HUCs, with the notable exceptions of some west-side valley bottom reaches with gravel mining impacts and dredging in the lower Sacramento.

There were no changes in Scope or Severity scores from 2012-2017.

Water quality.— The Sacramento system, as a major agricultural and urban area, has numerous water quality issues with contaminants; however, the effects on local lamprey populations has not been evaluated. Threats due to water quality were generally ranked as widespread but low in severity. Threats due to higher water temperatures caused by low flow conditions were generally captured under dewatering and flow management.

There were no changes in Scope or Severity scores from 2012-2017.

Harvest.— As in most of California, Harvest was not considered a major threat in the North Central Coast RMU (ranked Insignificant in both scope and severity). We are aware of no substantial tribal harvest in the RMU, and in 2010 CDFG established a non-tribal daily bag limit of five adult lamprey.

There were no changes in Scope or Severity scores from 2012-2017.

Predation.— Non-native predatory fishes are common in the Sacramento Valley and foothill streams. Nevertheless, while there is certainly predation on larval and juvenile lampreys by introduced centrarchids (bass and sunfish) and catfishes, they have occupied the system since the late 1800's and were generally not considered to be a major threat to lamprey populations. In the lower reaches and delta of the Sacramento River itself, Striped Bass are abundant and represent a potential threat to lampreys. Striped Bass are large predators, capable of feeding on all stages of lampreys, including adults. They occupy the primary migration routes for adults moving upstream to spawn and juveniles outmigrating to the sea. However, the extent of predation on lampreys by Striped Bass and the actual threat this represents to the population are unresolved. Mitigating conditions may include generally nocturnal activity patterns of lampreys and downstream migration during periods of high flow and turbidity.

There were no changes in Scope or Severity scores from 2012-2017

Lack of Awareness and Other Threats.— Increased education, outreach, coordination and inclusion in conservation planning will be essential for long-term conservation of lampreys in California and is a major continuing component of the PLCI in California (see California Introductory Chapter). The remaining threat categories were not considered in the California assessment as a whole due to lack of information (see discussion under Goodman and Reid 2014, Chap. 4 - California Regional Summary: Disease, Small Population Size, Ocean Conditions, and Climate Change).

Table 7-2. Threats to Pacific Lamprey within the CA Sacramento RMU, as identified and ranked at regional meetings, site visits and further assessment of conditions. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Upper Sacramento:												
Upper Pit	4	4										
Lower Pit	4	4										
McCloud	4	4										
Sacramento headwaters	4	4										
Sacramento - Upper Clear	4	3	1	1	2	3	4	2	1	1	2	1
East Foothills and												
Upper Cow - Battle	3	3	3	U	1	1	4	2	1	1	2	1
Lower Cow - Lower Clear	2	3	2	3	2	2	4	2	1	1	3	1
Mill - Big Chico	4	3	3	2	1	1	4	2	1	1	3	1
Butte - Upper	3	4	2	2	1	1	4	2	1	1	3	1
Butte - Lower	3	2	2	3	2	2	4	2	1	1	2	1
Feather - North Fork	4	4										
Feather - N.F. East Branch	4	4										
Feather - Middle Fork	4	4										
Feather - Lower	4	2	3	3	2	2	4	2	1	1	3	1
Honcut headwaters	1	2	2	2	1	1	4	2	1	1	2	1
Yuba - Upper	4	4	2	2	1	1	4	2	1	1	2	1
Yuba - Lower	3	3	2	3	2	2	4	2	1	1	3	1
Bear - Upper	4	4										
Bear - Lower	3	2	2	3	2	2	4	2	1	1	3	1
Upper Coon - Upper	-	-										
American - North Fork	4	4										
American - South Fork	4	4										
American - Lower	3	3	2	3	2	2	4	2	1	1	3	1
West Valley and Coast												
Cottonwood headwaters	1	2	2	3	1	1	4	2	1	1	2	1
Cottonwood - Lower	2	2	3	3	2	2	4	2	1	1	3	1

Upper Elder - Upper	2	2	2	3	1	1	4	2	1	1	2	1
Sacramento - Lower	3	3	3	3	3	3	4	2	1	1	3	1
Stony - Upper	4	4										
Sacramento - Stone Corral	4	U	3	3	2	2	4	2	1	1	3	1
Cache - Upper	4	4	2	3	1	1	4	2	1	1	2	1
Cache - Lower	4	4	4	4	3	3	4	2	1	1	3	1
Putah - Upper	4	4										
Sacramento - Lower	3	3	3	U	3	3	4	2	1	1	4	3

Table 7-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the Sacramento RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
Sacramento headwaters	Passage	Explore possibility of including lampreys in project to evaluate hauling salmonids above Shasta Dam and trapping outmigrants.	Coord.	Proposed
Lower Cow - Lower Clear	Passage	Assess lamprey passage at the sheetpile barrier on Clear Creek.	Assessment	Completed
Lower Cow - Lower Clear	Population	Adapt or modify monitoring facilities/methods at Clear Creek weir to include lamprey.	Survey/ monitor	Proposed
Lower Cow - Lower Clear	Passage	Install lamprey passage at the sheetpile barrier on Clear Creek.	Instream	Proposed
Upper Cow - Battle	Population	Assess and modify monitoring facilities/methods at Coleman Hatchery Battle Creek fishway to validate lamprey monitoring.	Survey/ monitor	Ongoing
Upper Cow - Battle	Passage	Assess Eagle Canyon Dam and new fishway for lamprey or remove dam.	Assessment	Ongoing
Upper Cow - Battle	Passage	Assess Soap Creek Diversion Dam for lamprey passage and survey upstream.	Assessment	Ongoing
Upper Cow - Battle	Passage	Assess South Diversion Dam for lamprey passage and survey upstream.	Assessment	Ongoing
Upper Cow - Battle	Passage	Assess Wildcat Diversion and modify structure for lamprey passage or remove dam.	Instream	Completed
Upper Cow - Battle	Passage	Assess Coleman Diversion Dam for lamprey passage or remove dam.	Assessment	Ongoing
Mill - Big Chico	Passage	Assess Clough Dam siphon crossing for lamprey passage	Assessment	Completed
Mill - Big Chico	Passage	Assess fish screens to determine potential for ammocoete and outmigrant entrainment.	Assessment	Completed
Mill - Big Chico	Passage	Deer Creek, assess fishway at Upper Deer Creek Falls as potential route, as well as natural falls passability	Assessment	Completed
Mill - Big Chico	Passage	Mill Ck, Ward Dam, fish ladder and structure for lamprey passage	Instream	Completed
Mill - Big Chico	Passage	Replace fish-ladder with lamprey friendly ladder	Instream	Completed

HUC	Threat	Action Description	Type	Status
Mill - Big Chico	Passage	Establish monitoring program to detect potential upstream expansion past Lower Deer Creek Falls.	Survey/ monitor	Ongoing
Mill - Big Chico	Passage	Mill Creek, Upper Dam, fish ladder and structure for lamprey passage	Instream	Ongoing
Butte - Upper	Passage	Assess value and issues of providing passage over or removing Centerville Dam.	Assessment	Proposed
Cache - Lower	Passage	Provide lamprey passage over Capay Dam.	Instream	Proposed
Feather -Lower	Other	Provide lamprey sign and informative kiosk at Feather River Hatchery public viewing area.	Coord.	Proposed
San Joaquin	Passage	Assess screen effectiveness for lampreys at the BOR facility.	Assessment	Completed
San Joaquin	Passage	Assess screen effectiveness and Clifton Forebay operations for lampreys at the CDFW facility.	Assessment	Ongoing

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8. CA SOUTH COAST REGION

Summary

The CA South Coast RMU (Figure 8-1) includes all coastal drainages from Point Conception south to the Mexican border, including the Ventura-San Gabriel, Santa Ana and Laguna-San Diego coastal USGS accounting units. It includes 15 watersheds (4th field HUCS), ranging from 233 - 4,403 km2 (Table 8-1). The RMU occupies the Southern California Mountain and Southern and Central Californian Chaparral / Oak Woodlands ecoregions. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012-2017. All HUCs were categorized as SH - Possibly Extirpated, based on absence ammocoetes or macropthalmia - the most recent detection being 2006 in the Santa Clara (see below).
- Two HUCs (Santa Clara and Santa Ana) populations were listed as Unknown, due to sightings of 2-3 adults in 2017. Surveys are planned for 2018.
- Our understanding of historical distribution was substantially improved through assessment of historical and current range state-wide and continued surveys.
- Although Pacific Lamprey were not documented in the South Coastal RMU from 2006-2016. The potential presence of adults in 2017 and recolonization of the San Luis Obispo drainage to the north (South Central Coastal RMU) demonstrate that management for Pacific Lamprey even in currently unoccupied historical range should still aim to provide suitable habitat and passage.
- Both passage and channel desiccation remain principal distributional constraints on lamprey populations in the South Coastal RMU.
- The primary threats in the South Central Coast RMU are associated with dessication of lower reaches by diversions and groundwater withdrawals. Dry reaches block adults migrating in from the ocean, as well as creating a sink for outmigrating juveniles. The periodic inability of freshet flows used by outmigrating juveniles to reach the ocean can cause mass emigration mortalities and is now recognized as a substantial threat, both for success of local populations and as a drain on the regional metapopulation. Channel degradation and water quality are also a concern in highly urbanized reaches.

Threat rankings are shown in Table 8-2. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 8-3. A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the CA South Coast Region can be found in the Regional Implementation Plan for the South Central Coast RMU (Goodman and Reid 2015d, PLCI South Coast Implementation Plan).

Table 8-1. Population demographics and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the CA South Coast Region. SH = Possibly Extirpated. Note that historical and current occupancies are linear stream distances (4th order and above), reflecting improved distribution data since the 2012 Assessment (Goodman and Reid 2012, Reid and Goodman 2017). Note that two HUCs (Santa Clara and Santa Ana) had observations of 1-2 adults in 2017; however, reproduction has not been confirmed (see text). Five HUCs are included in table that are likely too small to have had historical populations and are not ranked (see text).

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km)	Current Occupancy (km)	Ratio Current/ Historical	Population Size (adults)	Short-Term Trend (% Decline)
Santa Barbara Coastal	18060013	SH	7	-	0.00	Extinct	100%
Ventura	18070101	SH	74	-	0.00	Extinct	100%
Santa Clara	18070102	SH	423	-	0.00	Unknown	to 70%
Calleguas	18070103	-	0	-	0.00	-	-
Santa Monica Bay	18070104	SH	20	-	0.00	Extinct	100%
Los Angeles	18070105	SH	159	-	0.00	Extinct	100%
San Gabriel	18070106	SH	124	-	0.00	Extinct	100%
Seal Beach	18070201	-	0	-	0.00	-	-
San Jacinto	18070202	-	0	-	0.00	-	-
Santa Ana	18070203	SH	357	-	0.00	Unknown	to 70%
Newport Bay	18070204	-	0	-	0.00	-	-
Aliso-San Onofre	18070301	-	0	-	0.00	-	-
Santa Margarita	18070302	SH	83	-	0.00	Extinct	100%
San Luis Rey-Escondido	18070303	SH	118	-	0.00	Extinct	100%
San Diego	18070304	SH	227	-	0.00	Extinct	100%
Cottonwood-Tijuana	18070305	SH	99	-	0.00	Extinct	100%

Figure 8-1. Current Pacific Lamprey distribution and location of 19 4th Field HUCs in CA South Coast RMU (Reid and Goodman 2017).

Ranked Population Status of Pacific Lamprey in the CA South Coast RMU

NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012 and 2017. All HUCs were categorized as SH - Possibly Extirpated, based on the absence ammocoetes or macropthalmia - the most recent detection being 2006 in the Santa Clara (Swift and Howard 2009, Reid and Goodman 2016a).

Pacific Lamprey are assumed to have been widely distributed and abundant historically in the South Coast RMU, based on recent and current distribution, available habitat and lack of natural barriers. However, historically they probably did not occupy most smaller coastal drainages less than 200 km^2 south of Point Conception or the San Jacinto, which was generally endorheic except for brief overflow events (Reid and Goodman 2016a).

Currently, no Pacific Lamprey populations are considered to exist in freshwater south of Point Conception, based on the absence ammocoetes (Reid and Goodman 2016a). The most recent detection was a single macropthalmia sighted in 2006 in the lower Santa Clara River (Swift and Howard 2009, Reid 2015, Reid and Goodman 2016a). However, there were sightings of 2-3 dead adults in both the Santa Clara and Santa Ana rivers in 2017. These two HUCs populations are listed as Unknown (Table 8-1). Ammocoete surveys are planned for 2018 and stakeholders have been advised to keep an eye out.

The potential presence of adults in 2017 and recolonization of the San Luis Obispo drainage (South Central Coastal RMU) demonstrate that management for Pacific Lamprey in currently unoccupied historical range should still aim to provide suitable habitat and passage.

Pacific Lamprey were not documented anywhere in the South Coastal RMU from 2006-2016 (Goodman and Reid 2016). There are currently no monitoring stations for adult lamprey in the RMU. However, staff at the Freeman Diversion fishway are generally on the lookout for lampreys trying to pass the ladder. An improved lamprey passage facility is under consideration at the Freeman Diversion and may include monitoring capabilities. Additional sightings are generally incidental to other activities.

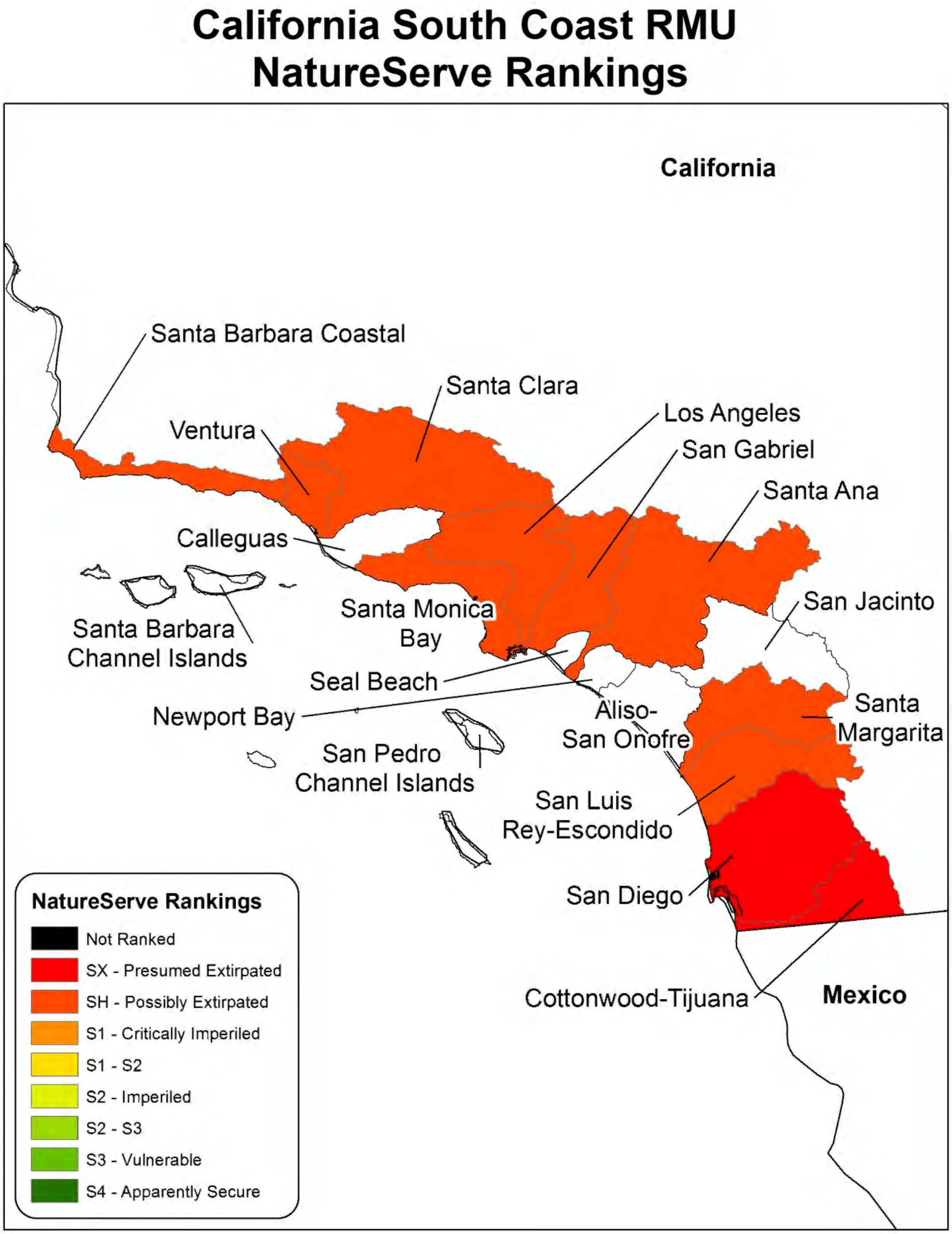

Figure 8-2. Final Conservation status ranks for the CA South Coast RMU 2017.

Threats and Limiting Factors to Pacific Lamprey in the CA South Coast RMU

Summary

Threats and limiting factors to Pacific Lamprey in the South Coast RMU are provided in Table 8-2, also discussed below. Passage remains the principal distributional constraint on lamprey populations in the South Central Coast RMU. An additional threat associated with passage is desiccation and dry reaches in the lower reaches of coastal rivers that can block adults migrating in from the ocean, as well as stranding outmigrating juveniles, which use flow events as cues to start downstream. The primary threats in the South Central Coast RMU are associated with desiccation of the lower reaches by diversions and groundwater withdrawals, as well as channel degradation and water quality in highly urbanized reaches.

Passage.— Passage is a substantial threat in larger drainages in the South Coast RMU, whereas in smaller drainages passage is generally represented by minor obstructions such as culverts, road crossings and channelized reaches. Notable exceptions were the Santa Margarita and San Luis Rey rivers, and many of the larger rivers had lower reaches that might still provide some suitable habitat. Passage in the Santa Clara River is impeded by a diversion dam (Freeman Diversion; United Water Conservation District) 10 miles from the estuary with substantial passage (upstream and downstream) issues that are currently under review and mitigation as part of a habitat conservation plan (United Water Conservation District; Reid 2017a). However, some lampreys have historically passed the diversion dam so it does not represent a complete barrier. Two principal tributaries, Santa Paula and Piru creeks, have dams; however, neither has historical records of lamprey, and the Santa Paula does not contain substantial upstream habitat (Reid 2015). Piru Creek has not been assessed for potential habitat suitability upstream of the dam. Sespe Creek, the principal Santa Clara tributary with historical lamprey occupancy, is unimpeded. In the Ventura Basin, Matilija Dam blocks substantial potential habitat that was apparently occupied historically. Removal of the dam is under consideration by local stakeholders. The two southernmost HUCs (San Diego and Cottonwood-Tijuana) have large impassable mainstem dams that block any suitable habitat were lampreys to attempt to recolonize.

An additional threat associated with passage is desiccation and dry reaches in the lower reaches of coastal rivers. These dewatered reaches limit access by adults to upstream spawning habitat and periodically cause mass mortalities of emigrating juveniles when flows, even during periodic storm events, do not reach the sea.

Changes in Scope and Severity from 2012-2017 reflect improved distributional information, the shift from area-based to linear calculations and increased awareness of adverse effects due to desiccation in the lower reaches and limited access to to/from the ocean. Severity was also increased to reflect impassability of dams.

Dewatering and Flow Management.— Southern California is naturally arid and the extensive use of water for agricultural and urban purposes further exacerbates the adverse conditions in local streams. Low flows in lower reaches except during periodic storm events limit access to migrating adults and can prevent emigrating juveniles from reaching the sea. At times, flows are insufficient to open sand bars at the mouths of some rivers, completely blocking passage. Alternatively, some systems have benefited from streamflow management, such as water imports, creating artificially perennial conditions and opportunities for conservation (e.g. Santa Margarita).

Changes in Scope and Severity scores from 2012-2017 reflected recognition that the Scope of impact in the Santa Clara should be increased due to a principal diversion's (Freeman) location in the coastal plain impacting all upstream habitat. Santa Ana ranks were also adjusted to better reflect habitat distribution in the drainage.

Stream & floodplain degradation.— Stream and floodplain degradation was generally ranked as a moderate to low threat. Many Southern California streams are highly modified and often denuded or channelized in urban areas. Nevertheless, there remains considerable habitat in most HUCs that would be relatively suitable for lampreys. Ranks for three highly modified drainages (Los Angeles, San Gabriel and Santa Ana) were decreased in Scope and increased in Severity to reflect habitat distribution.

Ranks for three highly modified drainages (Los Angeles, San Gabriel and Santa Ana) were decreased in Scope and increased in Severity to reflect habitat distribution.

Water quality.— Southern California's extensive agricultural and urban areas have contributed to water quality issues caused by point and non-point source pollutants. The effect of contaminants on the area's historical lamprey populations has not been evaluated. However, higher water temperatures, low flow conditions, eutrophication, high algal density and associated dissolved oxygen problems, especially in sediments occupied by ammocoetes, were ranked as threats to potential habitat for lampreys and resulted in high threat ranks in the Los Angeles Basin and moderate for the other HUCs.

Reduction in Scope and Severity scores from 2012-2017 in some HUCs (4 to3) reflects site visits and reassessment of local conditions.

Harvest.— As in most of California, Harvest was not considered a major threat in the South Coast RMU (ranked Insignificant in both scope and severity). We are aware of no substantial historical tribal harvest in the RMU, and in 2010 CDFG established a non-tribal daily bag limit of five adult lamprey. It is unlikely this will change when lampreys recolonize the southern drainages.

There were no changes in Scope or Severity scores from 2012-2017.

Predation.— Non-native predatory fishes are present in most southern California HUCs. Nevertheless, while there is certainly predation on larval and juvenile lampreys by introduced centrarchids (bass and sunfish) and catfishes, they have generally occupied the system since the late 1800s and were not considered to be a major threat to lamprey populations. Pinniped populations are relatively low.

There were no changes in Scope or Severity scores from 2012-2017.

Lack of Awareness and Other Threats— Increased education, outreach, coordination and inclusion in conservation planning will be essential for long-term conservation of lampreys in California and is a major continuing component of the PLCI in California (see California Introductory Chapter). The remaining threat categories were not considered in the California assessment as a whole due to lack of information (see discussion under Goodman and Reid 2014, Chap. 4 - California Regional Summary: Disease, Small Population Size, Ocean Conditions, and Climate Change).

Table 8-2. Threats to Pacific Lamprey within the CA South Coast RMU, as identified and ranked at regional meetings, site visits and further assessment of conditions. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Santa Barbara	3	3	2	2	1	1	3	2	1	1	2	1
Ventura	3	4	3	3	3	2	3	2	1	1	2	1
Santa Clara	4	3	4	3	1	1	3	2	1	1	3	1
Calleguas	-	-	-	-	-	-	-	-	-	-	-	-
Santa Monica	3	4	2	2	1	1	4	4	1	1	3	1
Los Angeles	4	4	4	3	3	4	4	4	1	1	3	1
San Gabriel	3	4	4	3	3	4	3	3	1	1	3	1
Seal Beach	-	-	-	-	-	-	-	-	-	-	-	-
San Jacinto	-	-	-	-	-	-	-	-	-	-	-	-
Santa Ana	3	4	3	4	3	4	3	3	1	1	3	1
Newport Bay	-	-	-	-	-	-	-	-	-	-	-	-
Aliso-San	-	-	-	-	-	-	-	-	-	-	-	-
Santa	2	2	4	3	2	2	3	3	1	1	3	1
San Luis Rey-	2	2	4	3	2	2	3	3	1	1	3	1
San Diego	4	4										
Cottonwood-	4	4	4	4								

Table 8-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the South Coast RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
Santa Barbara Coastal	Small Population	Assess possible causes of apparent historical absence in Jalama, Gaviota, Arroyo Hondo and Atascadero creeks.	Assessment	Completed
Ventura	Passage	Remove the Matilija Dam or provide passage over it.	Instream	Proposed
Santa Clara	Small Population	Survey for lampreys in the principal tributaries of the Santa Clara drainage, assess potential habitat and identify monitoring locations.	Survey/ monitor	Completed
Santa Clara	Small Population	Develop a monitoring program to monitor ammocoete presence in the Santa Clara drainage.	Survey/ monitor	Ongoing
Santa Clara	Small Population	Develop a reintroduction plan for the Santa Clara drainage.	Coord.	Ongoing
Santa Clara	Passage	Provide suitable upstream passage for adult lampreys at Freeman Diversion.	Coord./ Instream	Underway
Santa Clara	Dewatering/ Flow	Develop a management plan for Freeman Diversion for lampreys.	Coord./ Instream	Underway
Santa Clara	Passage	Provide suitable screening to prevent entrainment of macrophthalia at the Freeman Diversion and incorporate lampreys in diversion management.	Coord./ Instream	Underway
Santa Clara	Small Population	Develop a monitoring plan and provide suitable monitoring facilities at the Freeman Diversion to detect the presence of lampreys in the drainage and count adults.	Coord./ Instream	Underway
Santa Monica Bay	Passage	Remove the Ringe Dam or provide passage around it.	Instream	Proposed

San Gabriel	Passage	Provide outreach, training and local education to stakeholders, resource managers and community members.	Coord.	Ongoing
Santa Ana	Passage	Provide outreach, training and local education to stakeholders, resource managers and community members.	Coord.	Ongoing

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Pala Band of Mission Indians	Kurt Broz
	Shasta Gaughen
	Heidy Brow
San Diego Trout	Allen Greenwood
San Diego State Ecological Reserve	Pablo J. Bryant
Santa Barbara Land Conservancy	John Warner
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9. CA SOUTH CENTRAL COAST REGION

Summary

The CA South Central Coast RMU (Figure 9-1) includes all coastal drainages from the Golden Gate Bridge to Point Conception, including the coastal portion of the San Francisco Bay and most of the Central California Coastal USGS accounting units. It includes 12 anadromous watersheds (4th field HUCS), ranging from 574 - 8,519 km^2 (Table 9-1). The RMU occupies the Coast Range and Southern and Central Californian Chaparral / Oak Woodlands ecoregions. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012-2017 and improved in two HUCs (SF Coastal South and Central Coastal) due to improved distribution information and an expansion southward along the central coast. HUCs from the Central Coast north were categorized as S1 to S3. The southernmost HUCs apparently remain unoccupied (ranked SH) as of 2017 (Table 9-1).
- Our understanding of distribution was substantially improved through assessment of historical and current range state-wide and continued surveys, including long-term monitoring of southern coastal populations.
- In 2017, Pacific Lamprey re-extended their range 160 km to the south in the Central Coastal HUC and spawned in San Luis Obispo Creek in 2017. The southern limit of coastal populations had contracted as far north as Big Sur by 2011. Otherwise, Pacific Lamprey distribution remained essentially the same.
- Population abundance of Pacific Lamprey in the CA South Central Coast RMU is thought to be largely unchanged since the 2012 Assessment.
- No long-term count of Pacific Lamprey exists in CA South Central Coast RMU. Unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends and anecdotal reports from local residents.
- Both passage and channel desiccation remain principal distributional constraints on lamprey populations. However, a major dam has been removed on the Carmel River (San Clemente Dam, RKM 30) opening 10 km of additional habitat, and a lamprey passage modification on San Luis Obispo Creek in 2013 (Marre Weir) has allowed Pacific Lamprey to recolonize this drainage, extending the southern distribution by 160 km along the coast.
- The primary threats in the South Central Coast RMU are associated with desiccation of lower reaches by diversions and groundwater withdrawals. Dry reaches block adults migrating in from the ocean, as well as creating a sink for outmigrating juveniles. The periodic inability of freshet flows used by outmigrating juveniles to reach the ocean in both the Salinas and Carmel rivers periodically causes mass emigration mortalities and is now recognized as a substantial threat, both for success of local populations and as a drain on the regional metapopulation.

Threat rankings are shown in Table 9-2. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 9-3. A summary of completed and ongoing conservation measures, critical uncertainties, and high

priority project proposals to address key threats to Pacific Lamprey in the CA South Central Coast Region can be found in the Regional Implementation Plan for the South Central Coast RMU (Goodman and Reid 2015c, PLCI South Central Coast Implementation Plan).

Table 9-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the CA South Central Coast Region. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the CA South Central Coast Region. SH = Possibly Extirpated. S1 = Critically Imperiled. S2 = Imperiled. S3: Vulnerable. Note that historical and current occupancies are linear stream distances (4th order and above), reflecting improved distribution data since the 2012 Assessment (Goodman and Reid 2012, Reid and Goodman 2017). Conservation Status Rank highlighted in yellow indicate a decline (↓) or improvement(↑) in status in 2017 from 2011. The Estrella, a very sandy stream, is believed to have been seasonally dry and is not considered to be historical habitat for Pacific Lamprey.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km)	Current Occupancy (km)	Ratio Current/ Historical	Population Size (adults)	Short-Term Trend (% Decline)
San Francisco Coastal South	18050006	S3↑	80	80	1.00	Unknown	50 - 70%
San Lorenzo-Soquel	18060001	S1	46	46	1.00	Unknown	50 - 70%
Pajaro	18060002	S2	340	323	0.95	Unknown	50 - 70%
Salinas	18060005	S2	625	483	0.77	Unknown	50 - 70%
Alisal-Elkhorn Sloughs	18060011	S1	1	1	1.00	Unknown	50 - 70%
Carmel	18060012	S1	71	69	0.97	Unknown	50 - 70%
Central Coastal	18060006	S2↑	161	79	0.49	Unknown	50 - 70%
Cuyama (trib. Santa Maria)	18060007	SH	210		0.00	Extinct	-
Santa Maria	18060008	SH	155		0.00	Extinct	-
San Antonio	18060009	SH	25		0.00	Extinct	-
Santa Ynez	18060010	SH	222		0.00	Extinct	-
Estrella (trib. Salinas)	18060004	-	0	-	0.00	-	-

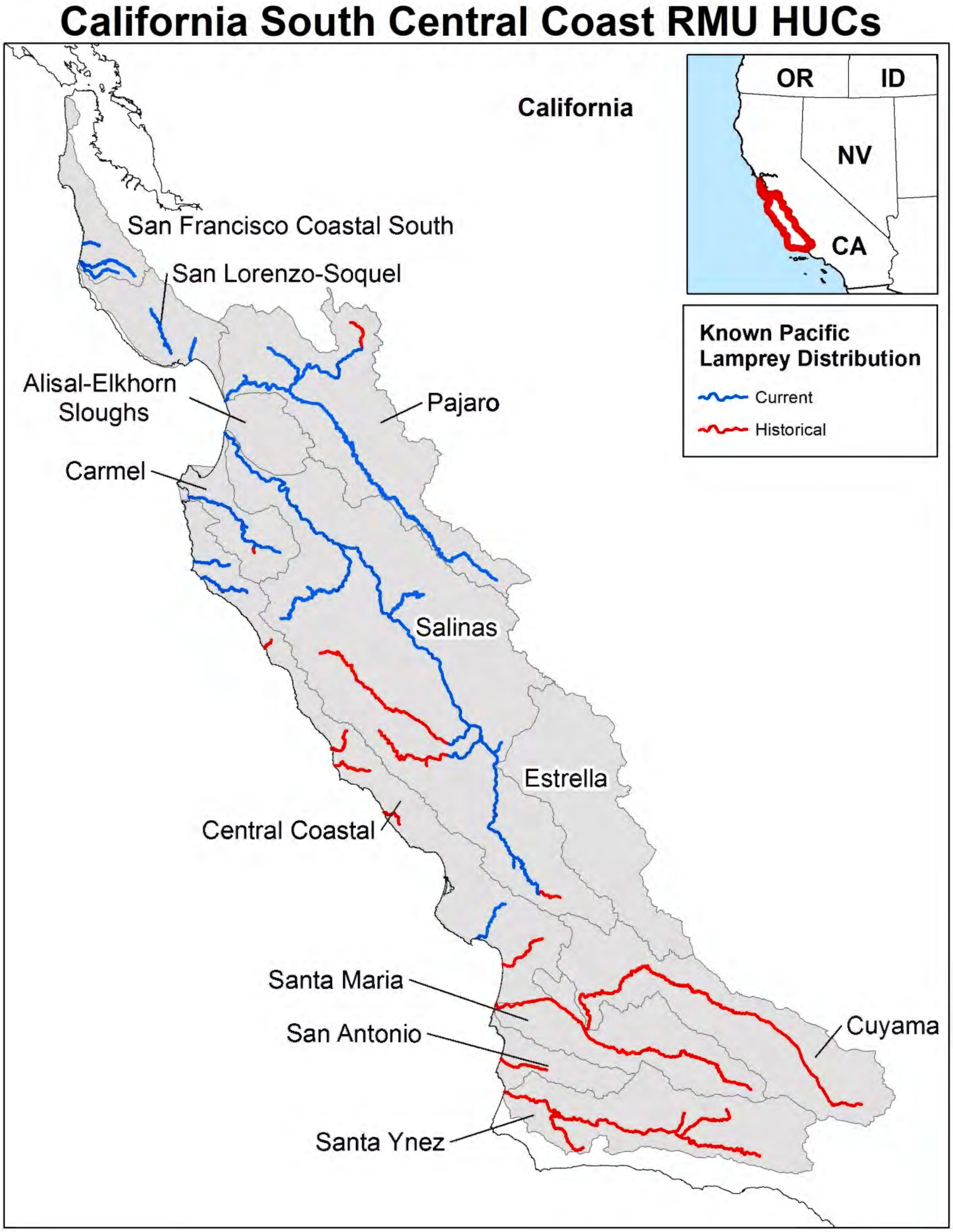

Figure 9-1. Current Pacific Lamprey distribution and location of 12 anadromous 4th Field HUCs in CA South Central Coast RMU (Reid and Goodman 2017). Carrizo Plain is endorheic.

Ranked Population Status of Pacific Lamprey in the CA South Central Coast RMU

NatureServe conservation status ranks improved in two HUCs (SF Coastal South and Central Coastal) when analyzed with similar methods between 2012 and 2017 and remained stable in the others. The shift was due to improved distribution information and an expansion southward along the central coast. HUCs from the Central Coast north were categorized as S1 to S3. The southernmost HUCs (ranked SH) apparently remain unoccupied as of 2017 (Reid and Goodman 2016, unpubl. data; Table 9-1).

Pacific Lamprey are assumed to have been widely distributed and abundant historically in the South Central Coast RMU, based on current distribution, available habitat and lack of natural barriers. However, historically they probably did not occupy most smaller coastal drainages less than 50 km^2 (Reid and Goodman 2016a).

Currently in the South Central Coast RMU, Pacific Lamprey occupy most historical anadromous habitat downstream of impassable dams from San Luis Obispo northwards, except in higher gradient reaches and in smaller coastal drainages (Reid, Goodman and Klochak 2012; Reid and Goodman 2016a, 2017a, unpubl. data). By 2011, the southern limit of coastal populations had contracted as far north as Big Sur (Reid and Goodman 2016). However, in 2017, following passage modification on a barrier near the mouth of San Luis Obispo Creek, Pacific Lamprey re-extended their range 160 km to the south in the Central Coastal HUC and spawned in San Luis Obispo Creek (Reid and Goodman unpubl. data).

Generally, the South Central Coast RMU has seen relatively little loss of historical distribution (4th order streams) caused by obstruction of passage, except in the Salinas Drainage, which has lost almost 25% (Figure 9-1). Changes in distributions between the 2012 and 2017 assessments reflect improved estimation of distributions (Reid and Goodman 2017a) and shift from drainage area based estimation to the current linear analysis reflecting actual stream channel length (4th order and higher).

Population abundance of Pacific Lamprey in the CA South Central Coast RMU is unknown, but thought to be largely unchanged since the 2012 Assessment, with the exception of the expansion southward to San Luis Obispo (Table 9-1). There are currently no monitoring stations for adult lamprey in the RMU. Although no long-term count of Pacific Lamprey exists for the CA South Central Coast RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends (Goodman and Reid 2012).

A long-term annual monitoring program of southern drainages and distribution limits was established under the PLCI in 2011 and continues (Reid and Goodman 2016a). Surveys focus on ammocoetes using standardized methodology to document presence and spawning success (Reid and Goodman 2015). Members of the Central California Lamprey Working Group, CDFW and the City of San Luis Obispo also maintain passage at San Luis Obispo Creek and monitor spawning activity in the drainage.

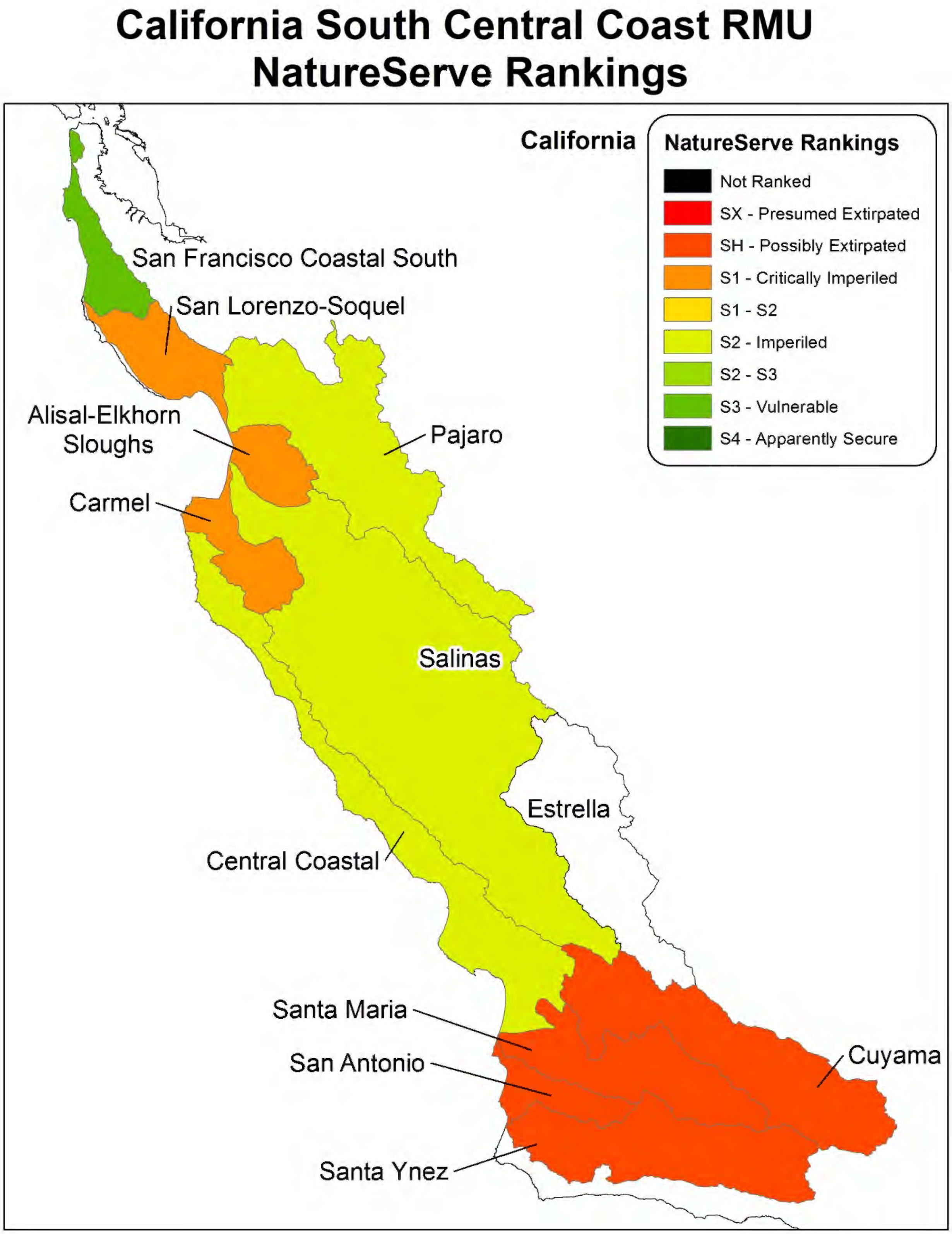

Figure 9-2. Final Conservation status ranks for the CA South Central Coast RMU 2017.

Threats and Limiting Factors to Pacific Lamprey in the CA South Central Coast RMU

Summary

Threats and limiting factors to Pacific Lamprey in the South Central Coast RMU are provided in Table 9-2, also discussed below. Passage remains the principal distributional constraint on lamprey populations in the South Central Coast RMU. An additional threat associated with passage is desiccation and dry reaches in the lower reaches of coastal rivers that can block adults migrating in from the ocean, as well as stranding outmigrating juveniles, which use flow events as cues to start downstream. The primary threats in the South Central Coast RMU are associated with desiccation of the lower reaches by diversions and groundwater withdrawals.

Passage.— Impassable dams remain a principal distributional constraint on lamprey populations on the central coast. Nevertheless, progress has been made. In 2015, San Clemente Dam was removed on the Carmel River (RKM 30), opening up an additional 20 km of potential lamprey habitat and a lamprey passage modification on lower San Luis Obispo Creek in 2013 (Marre Weir) has allowed Pacific Lamprey to recolonize this entire southern drainage. Upstream passage was ranked as high in Scope and Severity in three HUCs containing major dams that block nearly all suitable habitat in the drainages (ranked 4-4), all are currently south of the southern distributional limit in San Luis Obispo. The Pajaro and Salinas HUCs contain major dams that block a substantial portion of suitable habitat higher in in their drainages (ranked 3-4). The San Francisco Coastal South and San Lorenzo-Soquel HUCs, both just south of the Golden Gate had a number of smaller passage barriers (e.g., culverts and weirs) that restricted passage in a substantial portion of suitable habitat in the drainages (also ranked 3-3).

An additional threat associated with passage is desiccation and dry reaches in the lower reaches of coastal rivers that can block adults migrating in from the ocean, as well as creating a sink for outmigrating juveniles, which use flow events as cues to start downstream. Juveniles become stranded as flows end short of the ocean and sink into the sandy riverbeds. In the Salinas Drainage, the fourth largest in California, and Carmel River's high permeability of the sandy lower reaches combined with heavy agricultural groundwater pumping results in periods where the river channel has long dry reaches. These dewatered reaches limit access by adults to upstream spawning habitat and periodically cause mass mortalities of emigrating juveniles when flows, even during periodic storm events, do not reach the sea.

Changes in Scope scores from 2012-2017 reflect improved distributional information, the shift from area-based to linear calculations, and the improved passage on the Carmel River and San Luis Obispo Creek (Central Coastal HUC). Increased Scope for the Salinas, Carmel and Santa Maria rivers reflect increased awareness of adverse effects due to desiccation in the lower reaches and limited access to to/from the ocean. Severity was increased for the Pajaro based on impassable dams in the upper drainage and in the Santa Maria to reflect increased awareness of passage constraints due to desiccation in the lower reaches.

Dewatering and Flow Management.— The southern portion of the central coast, south of Santa Cruz is naturally arid and the extensive use of water for agricultural and urban purposes in most HUCs further exacerbates adverse conditions in local streams. In the Salinas and Carmel rivers, the former the fourth largest in California, high permeability of the sandy lower reaches combined with heavy agricultural groundwater pumping results in periods where the river channel has long dry reaches. These dewatered reaches limit access by adults to upstream spawning habitat and periodically cause mass mortalities of emigrating juveniles when flows, even during periodic storm events, do not reach the sea. In the Big Sur River, groundwater pumping in the lowest reach contributes to seasonal desiccation of the low gradient, rearing reach below Highway One. Reservoir management and agricultural use of water in the Pajaro, Salinas, Carmel, Cuyama (Santa Maria tributary), and Santa Ynez also severely reduce the available perennial upstream habitat for rearing ammocoetes.

Changes in Scope and Severity scores from 2012-2017 generally remained the same. Severity was increased (2 to 3) in the Pajaro to better reflect agricultural withdrawals.

Stream & floodplain degradation.— Many South Central Coast streams are highly impacted by agriculture and water management. Nevertheless, there remains considerable habitat in most HUCs that would be relatively suitable for lampreys, and stream habitat degradation was generally not considered a major threat in the RMU. The Alisal-Elkhorn Slough HUC is highly altered, but contained no historical 4th order habitat.

There were no changes in Scope or Severity scores from 2012-2017.

Water quality.— South Central Coast includes major agricultural and moderate to minor urban areas, and as such, has water quality issues with contaminants, although the effects on local lamprey populations has not been evaluated. However, higher water temperatures, low flow conditions, eutrophication, high algal density, and associated dissolved oxygen problems, especially in sediments occupied by ammocoetes, were ranked as a major threat in Alisal-Elkhorn Slough and as low to moderate threats elsewhere.

There were few changes in Scope or Severity scores from 2012-2017. Severity was increased in the Pajaro reflecting agricultural inputs and was reduced in the Santa Maria, which has a high percentage of relatively unaltered upstream habitat.

Harvest.— As in most of California, Harvest was not considered a major threat in the South Central Coast RMU (ranked Insignificant in both scope and severity). We are aware of no substantial tribal harvest in the RMU, and in 2010 CDFG established a non-tribal daily bag limit of five adult lamprey.

There were no changes in Scope or Severity scores from 2012-2017.

Predation.— Non-native predatory fishes are present in some South Central Coast HUCs, but were not considered a major threat to lamprey populations. Sacramento Pikeminnow *Ptychocheilus grandis* (native to the Pajaro and Salinas drainages) have become established in Chorro and Los Osos creeks, two principal tributaries to Morro Bay (Central Coast HUC). Large pikeminnow are piscivorous and are known to consume juvenile lampreys (Nakamoto and Harvey 2003). However, the impact of predation by pikeminnow on local lamprey populations is not known and may be ameliorated by downstream migration during periods of high flow and turbidity (Goodman et al. 2015). The two species are sympatric throughout much of the region, and the effect on Morro Bay populations is not known, particularly as neither creek is currently occupied by lampreys. Seals and sea lions are known to feed on migrating runs of adult lampreys near the mouths of rivers. However, the nature or severity of pinniped predation in southern streams has not been assessed. Predation threats were ranked low at this time.

There were no changes in Scope or Severity scores from 2012-2017.

Lack of Awareness and Other Threats.— Increased education, outreach, coordination and inclusion in conservation planning will be essential for long-term conservation of lampreys in California and is a major continuing component of the PLCI in California (see California Introductory Chapter). The remaining threat categories were not considered in the California assessment as a whole due to lack of information (see discussion under Goodman and Reid 2014, Chap. 4 - California Regional Summary: Disease, Small Population Size, Ocean Conditions, and Climate Change).

Table 9-2. Threats to Pacific Lamprey within the CA South Central Coast RMU as identified and ranked at regional meetings, site visits, and further assessment of conditions. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
San Francisco Coastal	2	2	2	2	2	2	2	2	1	1	2	1
San Lorenzo-Soquel	3	3	2	2	2	2	3	2	1	1	2	1
Pajaro	3	4	3	3	2	2	4	3	1	1	2	1
Salinas	4	3	3	3	2	2	4	2	1	1	2	1
Alisal-Elkhorn Sloughs	2	2	4	4	3	4	4	4	1	1	2	1
Carmel	4	3	3	3	2	2	4	2	1	1	2	1
Central Coastal	2	3	2	2	2	2	4	2	1	1	2	1
Cuyama (trib. Santa	4	4	4	4	2	2	4	2	1	1	2	1
Santa Maria	4	3	3	3	2	2	4	2	1	1	2	1
San Antonio	4	4	3	3	2	2	3	2	1	1	2	1
Santa Ynez	4	4	4	4	2	2	4	2	1	1	2	1
Estrella (trib. Salinas)	-	-	-	-	-	-	-	-	-	-	-	-

Table 9-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the South Central Coast RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
RMU	Other	Establish South Central Coast Lamprey Working Group.	Coordination	Ongoing
RMU	Population	Determine migration timing, spawning locations and timing in principal streams.	Research	Underway
SF Coastal South	Passage	Survey of barriers in Pilarcitos, Pescadero and Butano mainstems.	Assessment	Underway
SF Coastal South	Population	Distribution surveys to determine upstream extent in mainstems and principal tributaries.	Survey	Completed
San Lorenzo-Soquel	Passage	Survey of barriers in Soquel, Aptos and San Lorenzo mainstems.	Assessment	Underway
San Lorenzo-Soquel	Population	Distribution surveys to determine upstream extent in mainstems and principal tributaries.	Survey	Ongoing
Pajaro	Passage	Survey barriers in Pajaro, Uvas, Llagas and Corallitos mainstems.	Assessment	Underway
Pajaro	Population	Distribution surveys to determine upstream extent in mainstems.	Survey	Underway
Salinas	Dewatering/ Flow	Model potential mainstem stranding scenarios using flow events.	Assessment	Underway
Salinas	Population	Assess rotary screw trap programs to determine feasibility of collecting better lamprey data (e.g. sampling season, quantification, flow levels sampled)	Survey/monitoring /coordination	Ongoing
Salinas	Population	Monitoring program for ammocoete distribution and extent of permanent water in the Arroyo Seco.	Survey/monitor	Ongoing
Estrella (trib. Salinas)	Small Population	Assess possible causes of current and probable historical absence in Estrella River.	Assessment	Completed
Carmel	Dewatering/ Flow	Reduce ground and surface water consumption in the Carmel.	Instream	Underway
Carmel	Dewatering/ Flow	Determine probable outmigration timing based on flow events.	Assessment	Underway

HUC	Threat	Action Description	Type	Status
Carmel	Dewatering/ Flow	Establish procedure to document character, area, mortality of stranding events and explore mitigation measures.	Assessment	Underway
Carmel	Passage	Remove the Old Carmel Dam or provide passage around it.	Instream	Completed
Carmel	Passage	Remove the San Clemente Dam or provide passage around it.	Instream	Completed
Carmel	Passage	Monitor recolonization of reaches above San Clemente after removal.	Survey/monitor	Ongoing
Central Coastal	Passage	Provide lamprey passage over the Marre weir.	Instream	Completed
Central Coastal	Small Population	Assess possible causes of current and possible historical absence in small coastal streams.	Assessment	Completed
Central Coastal	Small Population	Develop a reintroduction plan for the San Luis Obispo drainage.	Coordination	Completed
Central Coastal	Small Population	Reintroduce lampreys to the San Luis Obispo drainage.	Coordination/ instream	Completed
Central Coastal	Small Population	Develop a monitoring program in the San Luis Obispo drainage.	Survey/monitor	Ongoing
Central Coastal	Small Population	Develop a monitoring program to monitor ammocoete presence along coast south of Point Lobos.	Survey/monitor	Ongoing
Central Coastal	Stream Degradation	Develop a study program to assess the effects of ammocoetes on coliform bacteria concentrations in the San Luis Obispo drainage.	Survey/monitor	Underway

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Monterey County	Nicholas Becker
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10. CA NORTH CENTRAL COAST REGION

Summary

The CA North Central Coast RMU (Figure 10-1) includes all coastal drainages from Punta Gorda (Mattole River) in the north to the Golden Gate in the south, including the southern half of the Northern California Coast (01) and the outer coast portion of the San Francisco Bay USGS accounting units. It includes five watersheds (4th field HUCS), ranging from 402 - 3,849 km^2 (Table 10-1). The RMU occupies the Coast Range and Southern and Central Californian Chaparral/Oak Woodlands ecoregions. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012-2017 and improved in one HUC (Gualala-Salmon) due to restoration efforts and improved information on potential threats. Four HUCs were categorized as S2 - Imperiled and one (Tomales Bay) was left at S1 due to impassable dams and limited distribution (Table 10-1).
- Our understanding of distribution was substantially improved through assessment of historical and current range state-wide and continued surveys.
- Current Pacific Lamprey distribution remained the same in all HUCs.
- Population abundance of Pacific Lamprey in the CA North Central Coast RMU is thought to be largely unchanged since the 2012 Assessment.
- No long-term count of Pacific Lamprey exists in CA North Central Coast RMU. However monitoring is now occurring on the Russian River. Unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends and anecdotal reports from local residents.
- Passage remains the principal distributional constraint on lamprey populations in the North Central Coast RMU. However, considerable effort has gone into better understanding passage needs of lamprey. The impact of seasonal dams is under review on the Russian River.
- The primary threats in the North Central Coast RMU were dewatering and the impacts of seasonal dams (passage and water quality) on the mainstem Russian River. Most threats were ranked as low in Severity, with no severe threats in any HUCs.
- No new threats were recognized.

Threat rankings are shown in Table 10-2. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 10-3. A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the CA North Central Coast Region can be found in the Regional Implementation Plan for the North Central Coast RMU (Goodman and Reid 2015b, PLCI North Central Coast Implementation Plan).

Table 10-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the CA North Central Coast Region. S1 = Critically Imperiled. S2 = Imperiled. Note that historical and current occupancies are linear stream distances (4th order and above), reflecting improved distribution data since the 2012 Assessment (Goodman and Reid 2012, Reid and Goodman 2017). Conservation Status Rank highlighted in yellow indicate a decline (↓) or improvement (↑) in status in 2017 from 2011.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km)	Current Occupancy (km)	Ratio Current/ Historical	Population Size (adults)	Short-Term Trend (% Decline)
Big-Navarro-Garcia	18010108	S2	375	375	1.00	Unknown	50 - 70%
Gualala-Salmon	18010109	S1↓	70	70	1.00	Unknown	50 - 70%
Russian	18010110	S2	348	312	0.90	250-1000	50 - 70%
Bodega Bay	18010111	S2	36	36	1.00	Unknown	50 - 70%
Tomales-Drake Bays	18050005	S1	37	37	1.00	Unknown	50 - 70%

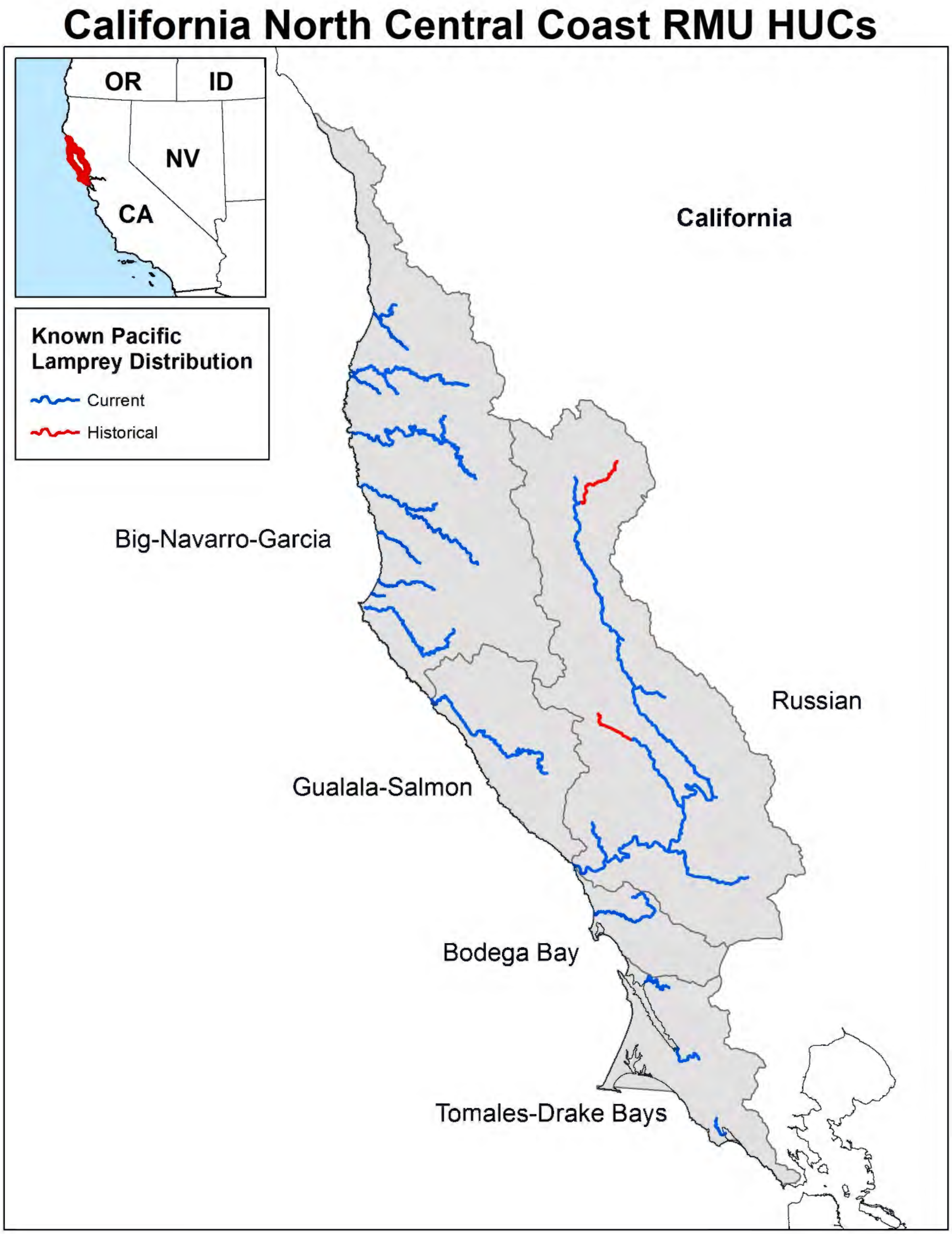

Figure 10-1. Current Pacific Lamprey distribution and location of 19 4th Field HUCs in CA North Central Coast RMU (Reid and Goodman 2017).

Ranked Population Status of Pacific Lamprey in the CA North Central Coast RMU

NatureServe conservation status ranks changed (improved) in one of 5 HUCs from 2012-2017 (Gualala-Salmon). This was due to improved information, which reduced the threat level for dewatering and instream gravel mining in the Gualala River (Table 10-1). Four HUCs were categorized as S2 - Imperiled and one (Tomales Bay) remained at S1 due to impassable dams and limited distribution.

Pacific Lamprey are assumed to have been widely distributed and abundant historically in the North Central Coast RMU, based on current distribution, available habitat and lack of natural barriers. However, they probably did not occupy most smaller coastal drainages less than 50 km^2 (Reid and Goodman 2016a).

Currently, Pacific Lamprey occupy most historical anadromous habitat in the North Central Coast RMU downstream of impassable dams, except perhaps in higher gradient reaches or smaller tributaries (Goodman and Reid 2017). The North Central Coast RMU has seen relatively little loss of historical distribution (4th order streams) caused by obstruction of passage, except in the Russian River, which has lost about 10% (Figure 10-1).

Population abundance estimates of Pacific Lamprey in the CA North Central Coast RMU are largely unchanged since the 2012 Assessment, with estimates ranging from Unknown to 1,000 fish (Table 10-1). This is primarily due to the lack of accurate monitoring and high apparent variability in adult run sizes. The only monitoring station in the RMU is at the Wohler Weir on the Russian River (RKM 37). The site is not optimized for lamprey monitoring and both timing and methods have varied over time, but observations of lampreys have ranged from 2-584 over the period 2000-2017, with the highest count in 2007 and average counts near 100 (Shawn Chase, Sonoma County Water Agency, pers. com 2018). A new fishway was completed in 2017 with enhanced video monitoring capabilities. Although no long-term count of Pacific Lamprey exists in CA North Coast RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on range-wide trends and anecdotal reports from local residents (Goodman and Reid 2012).

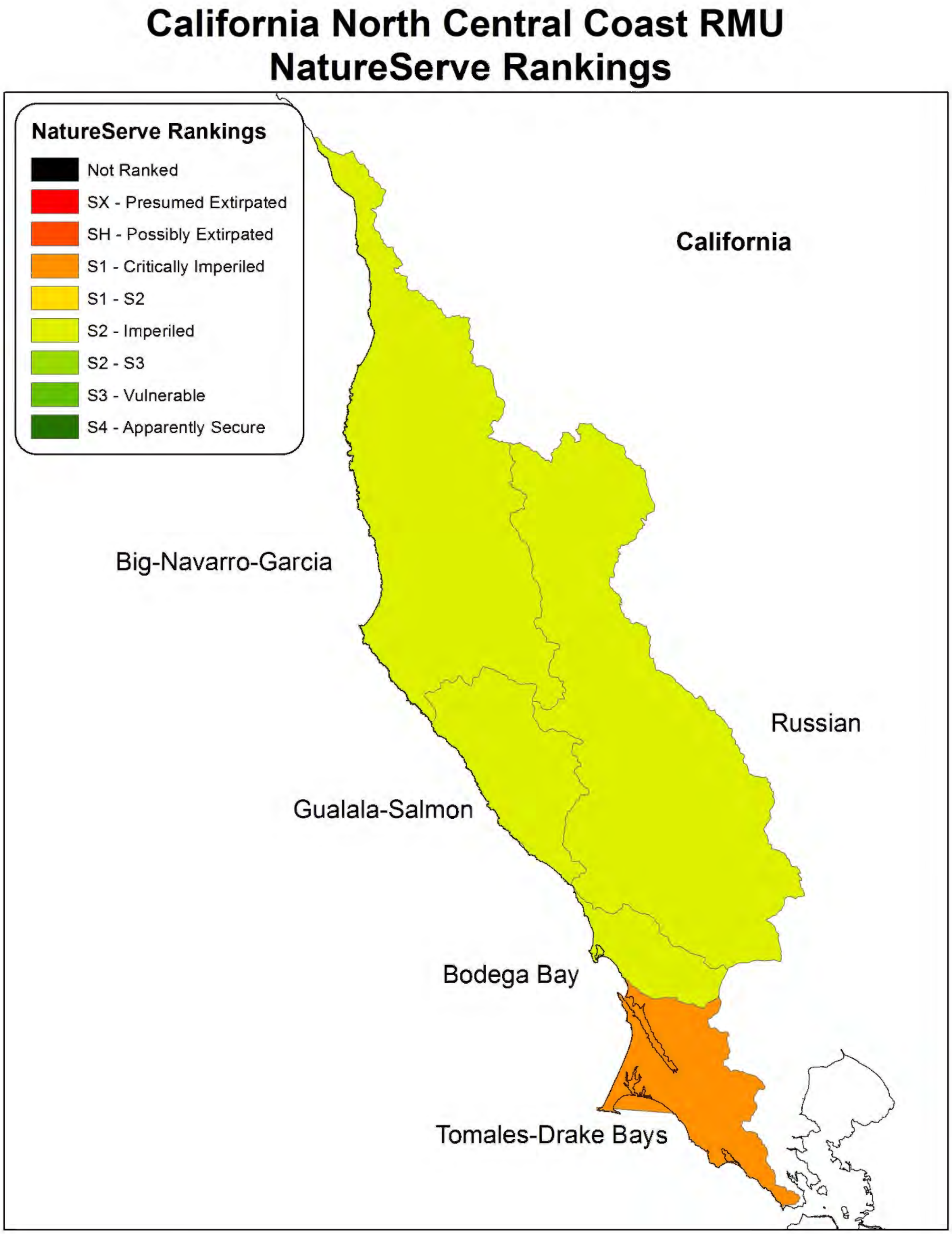

Figure 10-2. Final Conservation status ranks for the CA North Central Coast RMU 2017.

Threats and Limiting Factors to Pacific Lamprey in the CA North Central Coast RMU

Summary

Threats and limiting factors to Pacific Lamprey in the North Central Coast RMU are provided in Table 10-2, also discussed below. Passage remains a principal distributional constraint on lamprey populations, however impassable dams have reduced the distribution in 4th order and higher streams by less than 10 % in the North Central Coast RMU. The primary threats in the North Central Coast RMU were dewatering and the impacts of seasonal dams (passage and water quality) on the mainstem Russian River. Most threats were ranked as low in Severity, with no severe threats in any HUCs.

Passage.— Major impassable barriers to passage were found in only two HUCs (Russian and Tomales- Drake Bay) and did not affect large portions of suitable habitat in the watersheds, except for the relatively small Lagunitas drainage within the Tomales-Drake Bay HUC, although the dams do not block 4th order stream reaches. In the Russian River two large dams have blocked substantial reaches on the East Fork Russian River (Coyote Valley Dam, Lake Mendocino) and on Dry Creek (Warm Springs Dam, Sonoma Lake). However, in both cases upstream habitat may have been seasonally limited in the past due to dry late-summer conditions. The East Fork Russian River now receives continuous flow from the Potter Valley Diversion (Van Arsdale Dam on the Eel River). Releases from Sonoma Lake provide summer flow in the reaches of Dry Creek below the dam. A number of summer dams form additional barriers on the mainstem Russian River, likely blocking or impeding movement of adults from May through September. The impact of these seasonal dams is currently under investigation.

Changes in Scope and Severity scores from 2012-2017 in the Russian River reflect concerns over the impacts of seasonal dams, which are positioned relatively low in the drainage and impact upstream habitat. The increase in Severity for Tomales Bay (3 to 4) reflects the fully impassable barriers on the Lagunitas Drainage.

Dewatering and Flow Management.— Dewatering of streams (anthropogenic), resulting in reduced summer flows, was ranked as low in scope (often small-scale unregistered diversions) and severity in all but the Russian River, where the scope was broader due to more extensive agriculture (e.g. viticulture) and groundwater pumping has become more common. In the Russian River alone there are over 150 surface diversions and pumps (Passage Assessment Database, CalFish.org, 2014). With the exception of the Russian River, surface diversions and small pumps were cited to occur primarily in smaller streams, where they exacerbate naturally arid summer conditions.

Changes in Scope and Severity scores from 2012-2017 in the Big-Navarro-Garcia and Gualala-Salmon HUCs (3 to 2) reflect channel restoration efforts and reassessment of direct impacts to Pacific Lamprey.

Stream & floodplain degradation.— Stream degradation was generally ranked as low, including in the Gualala-Salmon HUC, where instream gravel mining has impacted the mainstem rivers. Numerous restoration projects have been completed or are planned for the RMU to address the effects of historical logging practices. The primary concern is that they incorporate the needs of lampreys, in particular with regard to habitat diversity and development of suitable depositional habitat for rearing ammocoetes.

Changes in Scope and Severity scores from 2012-2017 in the Gualala-Salmon HUC (3 to 2) reflect channel restoration efforts and reassessment of direct impacts to Pacific Lamprey.

Water quality.— Water quality issues were generally ranked as widespread, but low in severity throughout the RMU. The principal concern is in the Russian River, where low flows, high nutrient levels and warm temperatures have resulted in algal blooms, including toxic microcystin algae. Low flows, isolated pools and desiccation in the mainstem Gualala are also producing high water temperatures and low oxygen levels in summer refuge pools used by both adult lampreys and ammocoetes.

There were no changes in Scope or Severity scores from 2012-2017.

Harvest.— As in most of California, Harvest was not considered a major threat in the North Central Coast RMU (ranked Insignificant in both scope and severity). Although historically Pacific Lamprey were harvested in the RMU, we are aware of no substantial ongoing tribal harvest in the RMU, and in 2010 CDFG established a non-tribal daily bag limit of five adult lamprey.

There were no changes in Scope or Severity scores from 2012-2017.

Predation.— Predation was not considered a threat in most coastal streams. In the Russian River non-native predatory fishes are common in the mainstem and reservoirs (incl. basses, sunfishes, Striped Bass and various catfishes). The impact on local populations is not known, but was not generally considered a major threat to lamprey populations and may be ameliorated by the generally nocturnal activity patterns of lampreys and downstream migration during periods of high flow and turbidity. Sacramento Pikeminnow *Ptychocheilus grandis* are only present in the Russian River, where they are native. Seals and sea lions, as well as many predatory birds (e.g. eagles, ospreys, cormorants,herons), feed on migrating runs of adult lampreys near the mouths of rivers, as do eagles and ospreys. However, the nature or severity of pinniped predation in central coastal streams has not been assessed. A principal area of pinniped and bird predation appears to be the mouth of the Russian River. Another potential predator are sturgeon, given lamprey are a popular bait item used by local fisherman. Predation threats were ranked as Unknown, although they are proposed for assessment.

There were no changes in Scope or Severity scores from 2012-2017.

Lack of Awareness and Other Threats.—Increased education, outreach, coordination and inclusion in conservation planning will be essential for long-term conservation of lampreys in California and is a major continuing component of the PLCI in California (see California Introductory Chapter). The remaining threat categories were not considered in the California assessment as a whole due to lack of information (see discussion under Goodman and Reid 2012, Chap. 4 - California Regional Summary: Disease, Small Population Size, Ocean Conditions, and Climate Change).

Table 10-2. Threats to Pacific Lamprey within the CA North Central Coast RMU, as identified and ranked at regional meetings, site visits and further assessment of conditions. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Big-Navarro-	2	2	2	2	1	1	4	2	1	1	2	1
Gualala-Salmon	2	2	2	2	2	2	4	2	1	1	2	1
Russian	4	2	3	3	2	2	4	2	1	1	3	2
Bodega Bay	2	2	2	3	2	2	4	2	1	1	2	1
Tomales-Drake	3	4	2	3	1	1	4	2	1	1	2	1

Table 10-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the North Central Coast RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
RMU	Dewatering /Flow/WQ	Increase awareness of adverse impacts caused by marijuana cultivation.	Coordination	Ongoing
RMU	Dewatering /Flow/WQ	Legalization and increased regulation of marijuana cultivation in 2017.	Coordination	Ongoing
RMU	Population	Determine migration timing, spawning locations and timing in principal streams.	Research	Underway
Gualala-Salmon	Population	Distribution surveys of upstream extent in coastal streams within the HUC4 to assess upper limits of anadromy for lamprey.	Survey	Completed
Russian	Passage	Modify Healdsburg Veterans Park fishway to improve lamprey passage as necessary.	Instream	Underway
Big-Navarro-Garcia	Passage	Assess and retrofit the Noyo Egg Collection Facility for lamprey passage.	Instream	Underway
Russian	Passage	Assess entrainment at Potter Valley diversion.	Assessment	Underway
Russian	Passage	Assess passage constraints for lampreys at summer dams in the mainstem Russian River and develop adaptive improvements.	Assessment	Underway
Russian	Passage	Assess passage constraints at the Healdsburg Veterans Park fishway and develop improvements.	Assessment	Underway
Russian	Passage	Assess passage constraints for lampreys in the new Wohler fish ladder design and develop adaptive improvements, if necessary.	Assessment	Underway
Russian	Passage	Assess passage constraints for lampreys on Santa Rosa and Matanza creeks and develop adaptive improvements, if necessary.	Assessment	Underway
Russian	Population	Refine monitoring program for lampreys at the Wohler fishway.	Instream	Underway
Tomales-Drake Bays	Population	Incorporate Pacific Lamprey into local fish monitoring programs to determine frequency of use by Pacific Lamprey.	Instream	Ongoing

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11. CA NORTH COAST REGION

Summary

The CA North Coast RMU (Figure 11-1) 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 11-1). 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 following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks remained stable when analyzed with similar methods between 2012-2017 and changed in only one HUC (Smith River S3 to S2). The majority of currently occupied HUCs were categorized as S2 - Imperiled (Table 11-1).
- Our understanding of distribution was substantially improved through assessment of historical and current range state-wide and continued surveys.
- Current Pacific Lamprey distribution remained the same in all HUCs.
- Population abundance of Pacific Lamprey in the CA North Coast RMU is thought to be largely unchanged since the 2012 Assessment. However, in 2017 over 11,480 lampreys were documented passing through the new lamprey passage corridor on Van Arsdale Dam (Eel River) and tribal fishermen on the Klamath River reported relatively higher catches - this may have been an exceptional year.
- Although no long-term count of Pacific Lamprey exists in CA North Coast RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on anecdotal reports from local residents and the impressions of tribal fishermen. A monitoring station has been installed on the upper Eel River.
- Passage remains the principal distributional constraint on lamprey populations in the North Coast RMU. However, considerable effort has gone into better understanding passage needs of lamprey and experimental modification at Van Arsdale Dam (Eel River) has resulted in effective passage over the 19 m dam. There is also progress being made to reach agreement on removal of mainstem dams in the Klamath River. Relicensing discussions and assessment proposals have begun dams on the upper Eel.
- The only new threat recognized is dewatering and eutrophication due to small-scale unregulated agricultural uses which reduce flow, raise temperatures, add nutrients and promote algal blooms, particularly in the Eel, Mattole, and S.F. Trinity drainages. Recent legalization of Marijuana in California and improved regulation may influence this threat in the future.

Threat rankings are shown in Table 11-2. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 11-3. A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the CA North Coast

Region can be found in the Regional Implementation Plan for the North Coast RMU (Goodman and Reid 2015a, PLCI North Coast Implementation Plan).

Table 11-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the CA North Coast Region. SX = Presumed Extirpated. S1 = Critically Imperiled. S2 = Imperiled. Note that historical and current occupancies are linear stream distances (4th order and above), reflecting improved distribution data since the 2012 Assessment (Goodman and Reid 2012, Reid and Goodman 2017). Conservation Status Ranks highlighted in yellow indicate a decline (↓) or improvement (↑) in status in 2017 from 2011. The Butte HUC is endorheic (NA - not anadromous).

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km)	Current Occupancy (km)	Ratio Current/ Historical	Population Size (adults)	Short-Term Trend (% Decline)
Klamath Basin:							
Williamson	18010201	SX	136	0	0.00	Extinct	-
Sprague	18010202	SX	427	0	0.00	Extinct	-
Upper Klamath Lake	18010203	SX	92	0	0.00	Extinct	-
Lost	18010204	SX	48	0	0.00	Extinct	-
Butte	18010205	-	NA	-	-	-	-
Upper Klamath	18010206	S2	288	164	0.57	250-1000	50 - 70%
Shasta	18010207	S1	84	84	1.00	250-1000	50 - 70%
Scott	18010208	S2	139	139	1.00	250-1000	50 - 70%
Salmon	18010210	S2	161	161	1.00	1000-2500	50 - 70%
Trinity	18010211	S2	449	316	0.70	1000-2500	50 - 70%
South Fork Trinity	18010212	S2	249	249	1.00	1000-2500	50 - 70%
Lower Klamath	18010209	S2	373	373	1.00	1000-2500	50 - 70%
Eel Basin:							
Lower Eel	18010105	S2	517	517	1.00	1000-2500	50 - 70%
Middle Fork Eel	18010104	S2	220	220	1.00	1000-2500	50 - 70%
South Fork Eel	18010106	S2	225	225	1.00	1000-2500	50 - 70%
Upper Eel	18010103	S2	241	160	0.66	1000-2500	50 - 70%
Coastal:							
Smith	18010101	S2↓	227	227	1.00	Unknown	50 - 70%
Mad-Redwood	18010102	S2	401	362	0.90	Unknown	50 - 70%
Mattole	18010107	S2	154	154	1.00	Unknown	50 - 70%

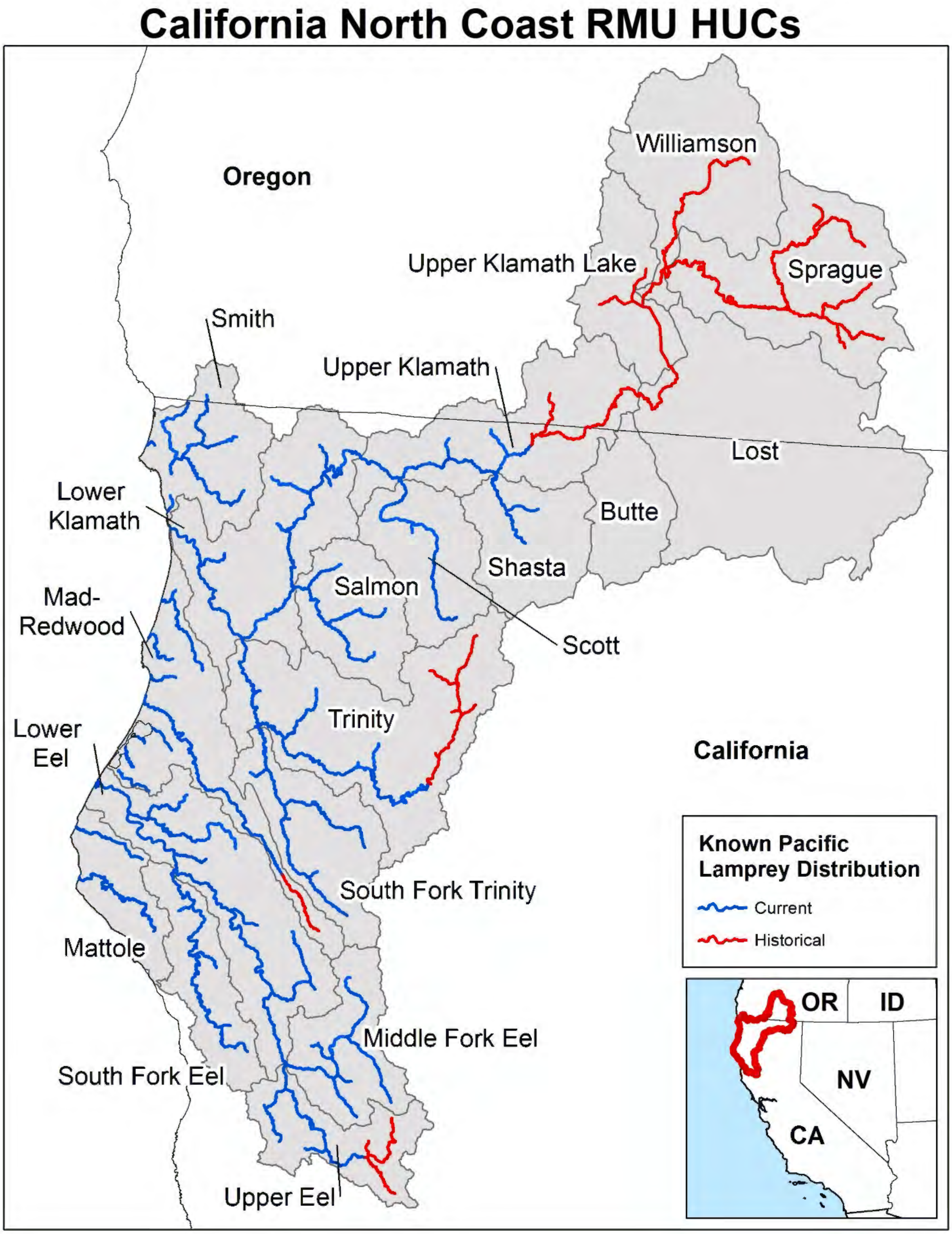

Figure 11-1. Current Pacific Lamprey distribution and location of 19 4th Field HUCs in CA North Coast RMU (Reid and Goodman 2017).

Ranked Population Status of Pacific Lamprey in the CA North Coast RMU

NatureServe conservation status ranks changed in only one of 19 HUCs from 2012-2017. This was in the Smith HUC (S3 to S2), where passage was assessed at the Rowdy Creek Hatchery and found to be constraining lampreys. Suitable lamprey modifications have been proposed and the fishway is in design phase for improvements.

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 follow Reid and Goodman (2017) and assume that they were able to utilize all suitable habitat with anadromous access. This is based on the widespread presence of resident populations of similar species of lamprey (*Entosphenus* spp.) throughout the upper Klamath Basin up to 1,800 m, the absence of natural barriers, historical records of Pacific Lamprey at elevations of up to 2,140 m in Idaho (Evermann and Meek 1898) and at least 1,490 m in California, as well as evidence for anadromous salmonids utilizing the upper basin in the past (Hamilton et al. 2005).

Currently, Pacific Lamprey occupy most historical anadromous habitat in the North Coast RMU downstream of impassable dams, except perhaps in higher gradient reaches or smaller tributaries (Goodman and Reid 2017a). The distribution has remained the same in most watersheds since the completion of the 2012 Assessment. The North Coast RMU has seen relatively little loss of historical distribution caused by obstruction of passage, generally < 10%, with the exception of the entire upper Klamath Basin above Iron Gate Dam (826 km of potential anadromous habitat), which was blocked in 1917 by the construction of Copco #1 Dam and later Iron Gate Dam (Hamilton et al. 2005). On the Trinity River, the Lewiston/Trinity dams block about 133 km of the upper Trinity River (ca. 30% of the HUC). On the Eel River, Scott Dam blocks about 82 km of the Upper Eel HUC (ca. 33%), and Van Arsdale Dam, with a difficult fish ladder constructed in 1922, restricts access to another 20 km. Dwinnell Dam on the Shasta River (constructed 1926) and Matthews Dam on the Mad River (constructed 1962) block relatively little suitable 4th order habitat. Only Van Arsdale Dam has facilities for fish passage, and its fish ladder is not optimized for lamprey passage. However, a recent modification has provided high passage success and much shorter transit times over Van Arsdale (Goodman and Reid 2017d; Reid and Goodman in prep.). Obstruction of smaller tributaries by culverts has been assessed in the Eel and Trinity drainages and found to limit access to relatively little suitable habitat (Stillwater Sciences 2014, Reid 2017b,c).

The ratio of current to historical distribution was estimated to be generally similar in the majority of HUCs, ranging from 0.90 to 1.00 in areas with current Pacific Lamprey occupancy. Drainages with substantial declines have been affected by large impassable dams (upper Klamath, Trinity and Eel rivers; see above). Changes in distributions between the 2012 and 2017 assessments reflect improved estimation of distributions (Reid and Goodman 2017) and shift from drainage area based estimation to the current linear analysis reflecting actual stream channel length (4th order and higher). We are aware of no short-term changes in actual distribution since the 2012 Assessment. Improvements in lamprey passage at Van Arsdale Dam on the upper Eel have resulted in improved access past the dam to about 20km of suitable spawning and rearing habitat.

Population abundance estimates of Pacific Lamprey in the CA North Coast RMU are largely unchanged since the 2012 Assessment with estimates ranging from zero to over 10,000 fish (Table 11-1). This is primarily due to the lack of accurate monitoring and high apparent variability in adult run sizes. The only monitoring station in the RMU was recently installed at Van Arsdale Dam in 2017 and has not yet developed a long-term record. However, in 2017 over 11,480 lampreys were documented passing through the new lamprey passage corridor - this may have been an exceptional year (Goodman, Reid and CDFW unpubl. data). Van Arsdale is relatively high in the Eel drainage (160 mi from the mouth), and there are a number of large tributaries downstream. Although no long term count of Pacific Lamprey exists in CA North Coast RMU, unobstructed populations are believed to have declined considerably since the 1970's and by 50-70% since 1990, based on anecdotal reports from local residents and the impressions of tribal fishermen (Goodman and Reid 2012).

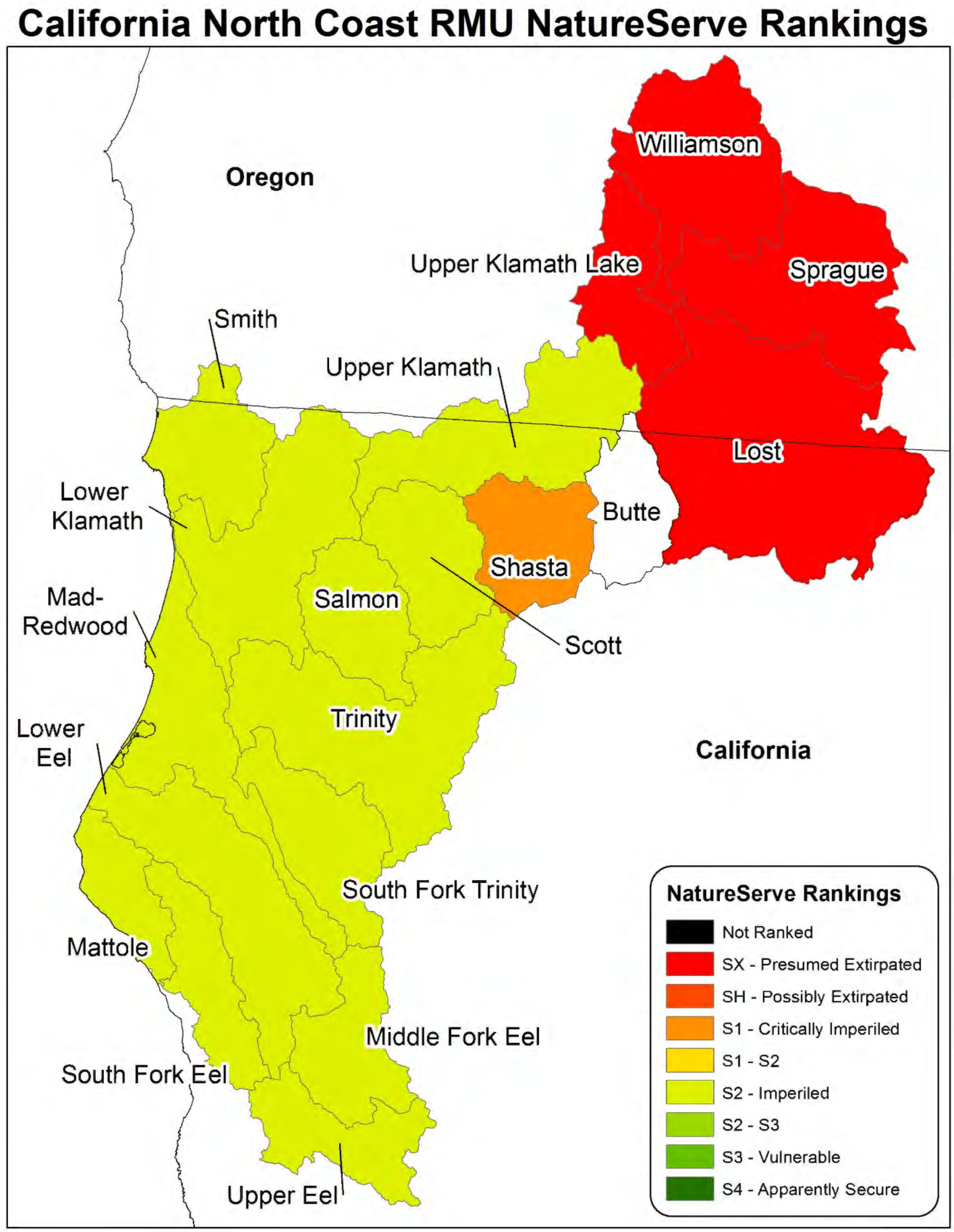

Figure 11-2. Final Conservation status ranks for the CA North Coast RMU 2017. The Butte HUC is endorheic without anadromous access.

Threats and Limiting Factors to Pacific Lamprey in the CA North Coast RMU

Summary

Threats and limiting factors to Pacific Lamprey in the North Coast RMU are provided in Table 11-2, also discussed below. Passage remains the principal distributional constraint on lamprey populations in the North Coast RMU. 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, flow management and associated water quality issues. 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, flow management and the legacy effects of streambed alteration. In the Eel River watersheds 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 a diversion 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. The North Coast RMU is the only California RMU where any substantial harvest occurs, however it is a subsistence fishery and considered a low threat.

Passage.— 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 restricted upstream passage by lampreys, although passage has now been resolved. Otherwise, passage concerns in the remaining watersheds are generally limited to culverts and smaller diversions on tributaries (≤ 3rd order) and were generally ranked low in scope. There is considerable effort and progress being made to reach agreement on removal of mainstem dams in the Klamath River. Relicensing discussions and assessment proposals have begun (2017) for Scott and Van Arsdale dams on the upper Eel.

Changes in Scope scores from 2012-2017 reflect improved distributional information, the shift from area-based to linear calculations, and the improved passage at Van Arsdale Dam (Upper Eel). Changes in Severity scores primarily reflect a changed ranking interpretation, increasing Severity to 4 at impassable dams, while adjusting Scope to reflect limited linear loss of habitat (e.g. Dwinnell Dam in the upper Shasta Drainage and a dam on Cahto Creek in the upper South Fork Eel). The severity ranking of Passage in the Smith River was increased due to assessment of the fishway at the Rowdy Creek Hatchery, which provides limited lamprey passage. Suitable lamprey modifications have been proposed and the fishway is in design phase for improvements.

Dewatering and Flow Management.— 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 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 Van Arsdale Dam. However, dewatering and eutrophication due to small-scale unregulated 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 (Bauer et al. 2015). However, this threat is dynamic given the recent legalization of marijuana cultivation in California (2017) and possible changes in the character of cultivation due to economic changes as well as increased regulation.

Changes in Scope and Severity scores from 2012-2017 in the South Fork Trinity and Eel River HUCS reflect recognition of the impacts of extensive water withdrawal by small-scale unregulated agricultural operations in these drainages.

Stream & floodplain degradation.— Stream and floodplain degradation was generally ranked as a 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, all resulting in reduced rearing fines in many reaches. 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.

Changes in Scope and Severity scores from 2012-2017 in the Trinity HUC reflects channel restoration efforts and reassessment of direct impacts to Pacific Lamprey.

Water quality.— 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. The impacts of water withdrawals, nutrients and contaminants resulting from unregulated agricultural uses in the region add additional threats to populations (Bauer et al. 2015). There is considerable effort and progress being made to reach agreement on removal of mainstem dams in the Klamath River. Relicensing discussions and assessment proposals have begun (2017) for Scott and Van Arsdale dams on the upper Eel.

Harvest.— Harvest was otherwise not considered a major threat in California (ranked Insignificant in both scope and severity). However, along the north coast there is some tribal harvest for local subsistence and ceremonial consumption, primarily in the Klamath and Eel drainages. There is no commercial fishery for lampreys in California, and commercially available bait lampreys (frozen) are imported from Alaska. Collection of Pacific Lampreys for bait (both adults and ammocoetes) probably still occurs at low levels, although we have not been able to assess this as it is illegal. A concerted daily effort to catch lampreys on the spawning grounds where they are especially vulnerable could have a substantial effect on a local population. In 2010 CDFG established a non-tribal daily bag limit of five lamprey.

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 naturally sympatric throughout the Sacramento, San Joaquin, Pajaro 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, Alvarez 2017). 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, as well as many predatory birds, 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 in the lower Klamath has not been assessed, and they were ranked as Low for the time being, although proposed for assessment.

Changes in Scope scores from 2012-2017 in the Eel River reflect recognition of the widespread distribution of introduced pikeminnow, extensive channel restoration efforts and reassessment of direct impacts to Pacific Lamprey. The shift from Severity of Unknown to 3 for Predation in the Trinity River reflects new information specific to Brown Trout predation on lampreys in the mainstem (Alvarez 2017).

Lack of Awareness and Other Threats.— This is a difficult threat to assess or quantify and was not ranked. Nevertheless, there is certainly a general lack of awareness of lampreys throughout the public, conservation and fisheries management communities in California. Many times people are unaware of the role of lampreys in the ecosystem or even their presence within a particular drainage, and in some cases there is a general antipathy towards lampreys. Lamprey needs are frequently not considered in habitat management plans, instream flow management, salmocentric stream restoration or fish passage projects. This can lead to direct adverse effects, especially in the seasonal dewatering of ammocoete habitat or design of fish passage structures that effectively exclude lampreys due to design features such as jumps or angular edges. Increased education, outreach, coordination and inclusion in conservation planning will be essential for long-term conservation of lampreys in California and is a major continuing component of the PLCI. Progress has been made.

The remaining threat categories were not considered in the California assessment as a whole due to lack of information (see discussion under Goodman and Reid 2014, Chap. 4 - California Regional Summary: Disease, Small Population Size, Ocean Conditions, and Climate Change).

Table 11-2. Threats to Pacific Lamprey within the CA North Coast RMU as identified and ranked at regional meetings, site visits, and further assessment of conditions. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Klamath Basin:												
Williamson	X	-	-	-	-	-	-	-	-	-	-	-
Sprague	X	-	-	-	-	-	-	-	-	-	-	-
Upper Klamath	X	-	-	-	-	-	-	-	-	-	-	-
Lost	X	-	-	-	-	-	-	-	-	-	-	-
Butte	NA	-	-	-	-	-	-	-	-	-	-	-
Upper Klamath	3	4	3	3	1	1	4	3	1	1	2	1
Shasta	1	4	3	2	1	1	3	3	1	1	1	1
Scott	2	2	3	3	3	3	3	3	1	1	2	1
Salmon	2	2	1	1	1	1	4	2	1	1	1	1
Trinity	2	4	3	2	2	2	4	2	1	1	3	3
South Fork Trinity	2	2	4	2	3	3	4	2	1	1	2	1
Lower Klamath	2	2	2	2	2	2	4	2	1	1	4	1
Eel Basin:												
Lower Eel	2	2	4	3	3	3	4	3	1	1	4	2
Middle Fork Eel	2	2	4	3	1	1	4	3	1	1	4	2
South Fork Eel	1	4	4	3	1	1	4	3	1	1	4	2
Upper Eel	2	4	4	3	1	1	4	3	1	1	4	2
Coastal:												
Smith	1	3	1	1	1	1	3	1	1	1	1	1
Mad-Redwood	2	2	2	2	1	1	4	2	1	1	2	1
Mattole	2	2	2	2	1	1	4	2	1	1	2	1

Table 11-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the North Coast RMU from 2012-2017.

Name	Threat	Action Description	Type	Status
RMU	Dewatering/ Flow	Increase awareness of adverse impacts caused by small-scale diversions and nutrient inflows.	Coord.	Ongoing
RMU	Population	Determine migration, spawning locations and timing.	Research	Underway
RMU	Population	Develop and implement a tribal harvest monitoring program.	Survey/ monitor	Proposed
RMU	Stream Degradation	Determine sediment habitat needs of ammocoetes	Research	Completed
RMU	Water Quality	Determine effects of low DO on ammocoetes in fine-grained habitats.	Research	Ongoing
Klamath Basin	Dewatering/ Flow/Passage	Incorporate lamprey needs into the Scott and Shasta Rivers Instream Flow Study Plans & Data Needs Assessment.	Coord. Assessment	Proposed
Klamath Basin	Population	Develop monitoring plan for outmigrating macropthalmia with screwtrap programs.	Survey/ monitor	Underway
Klamath Basin	Population	Telemetry to determine migration behavior and areas utilized by over-summering adults.	Research	Ongoing
Klamath Basin	Predation	Assess impact of Brown Trout on ammocoetes/macropthalmia.	Assessment	Completed
Klamath Basin	Water Quality	Assess impact of mercury on ammocoetes.	Assessment	Ongoing
Lower Klamath	Predation	Assess impact of pinnipeds on adult lamprey in river mouths	Assessment	Underway
Salmon	Passage	Improve Hotelling Creek road crossing	Instream	Underway
Salmon	Population	Distribution surveys of mainstems and principal tributaries.	Survey	Ongoing
Scott	Dewatering/ Flow	Assess groundwater extraction effects on surface stream flow and lamprey habitat/populations.	Assessment	Proposed
Scott	Passage	Assess Farmers Ditch Diversion screen and passage.	Assessment	Completed
Scott	Passage	Scotts Diversion (Young's Dam) passage assessment.	Assessment	Completed
Scott	Passage	Scotts Diversion (Young's Dam) passage improvement	Instream	Proposed
Scott	Population	Distribution surveys of mainstems and principal tributaries.	Survey	Ongoing
Shasta	Passage	Assess passage/entrainment issues at the Granada water diversion dam.	Assessment	Underway

Name	Threat	Action Description	Type	Status
Shasta	Passage	Resolve passage/entrainment issues at the Granada water diversion dam.	Instream	Underway
S.Fork Trinity	Passage	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assessment	Completed
S.Fork Trinity	Passage	Survey, assess and remediate low head dams in the Hayfork drainage.	Survey/ Assessment	Completed
S.Fork Trinity	Population	Distribution surveys of mainstems and principal tributaries.	Survey	Completed
Trinity	Dewatering/ Flow	Assess effects of artificial flow regulation on outmigrating lamprey in the mainstem Trinity River.	Assessment	Underway
Trinity	Dewatering/ Flow	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	Assess the passage potential and constraints of the Buckhorn Debris Dam's existing spillway ramp.	Assessment	Completed
Trinity	Passage	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assessment	Completed
Trinity	Population	Distribution surveys of mainstems and principal tributaries.	Survey	Completed
Trinity	Stream Degradation	Assess availability of fines in the mainstem Trinity below Lewiston Dam and the opportunities to modify gravel augmentation projects to include suitable particle size-ranges for ammocoete rearing.	Assessment	Proposed
Trinity	Stream Degradation	Evaluate sediment use by ammocoetes and sediment management strategies in the Hamilton Ponds.	Research	Completed
Upper Klamath	Passage	Assess and modify (if necessary) passage past Keno Dam fishway	Instream	Proposed
Upper Klamath	Passage	Remove mainstem Klamath River dams (Iron Gate, Copco 1, Copco 2, JCBoyle).	Instream	Proposed
Upper Klamath	Stream Degradation	Assess use and design features from Coho restoration for improvements for lamprey ammocoetes.	Assessment	Underway
Upper Klamath	Stream Degradation	Incorporate stream flow variation into hydrograph and management discussions.	Coord.	Completed
Upper Klamath	Stream Degradation	Work up Karuk/USFWS ammocoete habitat sampling.	Research	Underway

Name	Threat	Action Description	Type	Status
Eel Basin	Passage	Map and assess culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assessment	Completed
Eel Basin	Population	Distribution surveys of mainstems and principal tributaries.	Survey	Ongoing
South Fork Eel	Dewatering/ Flow	Assess flow management in upper Cahto Creek	Assessment	Completed
South Fork Eel	Dewatering/ Flow	Reduce diversion and impoundment of flow in upper Cahto Creek and restore permanent water to Cahto Creek.	Coord.	Underway
Upper Eel	Passage	Assess entrainment at Potter Valley diversion.	Assessment	Underway
Upper Eel	Passage	Assess passage (upstream and downtream) opportunities and habitat suitability at/above Scott Dam.	Assessment	Proposed
Upper Eel	Passage	Assess passage constraints for lampreys at the Van Arsdale fish ladder and develop improvements.	Assessment	Completed
Upper Eel	Passage	Modify Van Arsdale fish ladder to improve lamprey passage.	Instream	Completed
Upper Eel	Population	Develop a monitoring program and adapt facilities to census lampreys at the Van Arsdale fish ladder.	Instream	Completed
Mattole	Passage	Map, assess and prioritize culverts in principal tributaries and evaluate available lamprey habitat upstream.	Survey/ Assessment	Underway
Mattole	Population	Distribution surveys of mainstems and principal tributaries.	Survey	Underway
Smith	Passage	Assess the Rowdy Creek weir for lamprey passage and provide recommendations.	Assessment	Completed
Smith	Passage	Modify or retrofit the Rowdy Creek weir for lamprey passage.	Instream	Underway
Smith	Population	Distribution surveys of mainstem and principal tributaries.	Survey	Underway

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12. OREGON COAST REGION

Summary

The Oregon Coast Regional Management Unit is separated into two sub-regions equivalent to the USGS hydrologic unit accounting units 171002 (Northern Oregon Coastal) and 171003 (Southern Oregon Coastal). The North Oregon Coast Sub-Region includes all rivers that drain into the Pacific Ocean from the Columbia River Basin boundary in the north to the Umpqua River boundary in the south (Figure 12-1). It is comprised of seven 4th field HUCs ranging in size from 338 to 2,498 km^2. The South Oregon Coast Sub-Region includes all rivers that drain into the Pacific Ocean from the Umpqua River basin south to the Smith River boundary in California (Figure 12-1). It is comprised of twelve 4th field HUCs ranging in size from 1,216 to 4,662 km^2. NatureServe conservation status ranks changed in two of seven HUCs in the North Coast, and in six of 12 HUCs in the South Coast Sub-Region. All HUCs are currently ranked as Imperiled (S2) or Critically Imperiled (S1) across the RMU (Table 12-1; Table 12-2). Overall, understanding of Pacific Lamprey distribution and abundance has expanded in many coastal watersheds due to increased sampling effort (e.g., smolt trapping, redd surveys, occupancy sampling), and improved recognition of lamprey redds. Population demographic information was limited in the Rogue Basin, Illinois, Chetco and Siltcoos, though large lakes in the Siltcoos HUC make sampling for lamprey difficult. The following are key outcomes of the 2017 Assessment.

North Oregon Coast Sub-Region

- NatureServe conservation status ranks changed in two North Oregon Coast HUCs in 2017. Ranks fell from Imperiled (S2) to Critically Imperiled (S1) in the Siltcoos and rose from S1S2 to S2 in the Necanicum. Change in the Siltcoos is likely due to a decline in Current Occupancy, Ratio, and Population Size ranking values, while change in the Necanicum may be due to an increase in historical range extent and change of short-term trend to unknown.
- Assessment ranking of current distribution was reduced in all HUCs with the exception of the Necanicum. This decline is a result of more accurately calculating the numeric Area of Occupancy (versus using a visual estimate), rather than a decline in lamprey range.
- Population size rankings were reduced in all HUCs, with the exception of the Siuslaw which remained the same. This drop was due to better data quality (i.e., abundance estimates calculated from nest survey data), rather than a decline in lamprey abundance.
- Short-term population trend was ranked as unknown in most watersheds with available abundance information. There was consensus that lamprey populations have declined significantly from historical numbers about 50-60 years ago (Downey 1996), but there is insufficient data over the past 27 years to rank trend. Abundance indices have generally increased in the last 3 to 5 years, but without a long term data set it is unknown whether this apparent increase is simply an upswing in a larger cyclical trend.
- The highest priority threat to Pacific Lamprey in North Oregon Coast watersheds is stream and floodplain degradation followed by lack of awareness and water quality. Water quality and lack of awareness were new priority threats in 2017.

South Oregon Coast Sub-Region

- NatureServe conservation status ranks changed in six South Oregon Coast HUCs in 2017. Ranks fell from Vulnerable (S3) to Imperiled (S2) in the Chetco and from Imperiled (S2) to Critically Imperiled (S1) in the South Umpqua, Upper Rogue and Illinois. Status ranks rose from S1S2 to Imperiled (S2) in the North Umpqua and from Critically Imperiled (S1) to Imperiled (S2) in the Middle Rogue. Changes are generally the result of better data quality and enhanced understanding of lamprey population demographics.
- Assessment ranking of current distribution was reduced in all but three HUCs in the South Coast Sub-Region. This decline was a result of more accurately calculating the numeric Area of Occupancy (versus using a visual estimate), rather than a decline in lamprey range. Distribution information was limited in the Lower Rogue and Chetco HUCs.
- Population size rankings were increased in the North Umpqua and Applegate and reduced in the Umpqua, Coos, and Sixes. Adult abundance estimates provided by ODFW contributed to the changes in these areas. Abundance was ranked unknown in the Upper Rogue, Middle Rogue, Lower Rogue, Illinois, and Chetco HUCs.
- Short-term population trend was ranked as stable in most watersheds with available abundance information. Many watersheds have 3-8 years of high quality data, but information is inaccurate or undocumented before this time. Abundance indices have generally increased over the last several years, but it is unknown whether this apparent increase is simply an upswing in a larger cyclical trend.
- The highest priority threat to Pacific Lamprey in South Oregon Coast watersheds is lack of awareness followed by climate change, water quality, stream and floodplain degradation, and dewatering and flow management. Dewatering and flow management was a new priority threat in 2017.

A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the North Coast and South Coast Sub-Regions can be found in the Regional Implementation Plan for the Oregon Coast Regional Management Unit (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Table 12-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the North Oregon Coast Sub-Region. S1 = Critically Imperiled. S2 = Imperiled. Conservation Status Ranks highlighted in yellow indicate a decline (↓) or improvement (↑) in status in 2017 from 2011.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km^2)	Current Occupancy (km^2)	Population Size (adults)	Short-Term Trend (% decline)
Necanicum	17100201	S2↑	250-1000	20-100	250-1000	Unknown
Nehalem	17100202	S2	1000-5000	100-500	1000-2500	Unknown
Wilson-Trask-Nestucca	17100203	S2	1000-5000	100-500	1000-2500	Unknown
Siletz-Yaquina	17100204	S2	1000-5000	100-500	1000-2500	Unknown
Alsea	17100205	S2	1000-5000	100-500	1000-2500	Unknown
Siuslaw	17100206	S2	1000-5000	100-500	2500-10,000	Unknown
Siltcoos	17100207	S1↓	250-1000	20-100	50-250	Unknown

Table 12-2. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the South Oregon Coast Sub-Region.S1 = Critically Imperiled. S2 = Imperiled. Conservation Status Ranks highlighted in yellow indicate a decline (↓) or improvement (↑) in status in 2017 from 2011.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km^2)	Current Occupancy (km^2)	Population Size (adults)	Short-Term Trend (% decline)
North Umpqua	17100301	S2↑	1000-5000	100-500	1000-2500	Stable
South Umpqua	17100302	S1↓	1000-5000	100-500	250-2500	30-50%
Umpqua	17100303	S2	1000-5000	500-2000	250-1000	Stable
Coos	17100304	S2	1000-5000	100-500	1000-2500	Stable
Coquille	17100305	S2	1000-5000	500-2000	2500-10,000	Stable
Sixes	17100306	S2	1000-5000	100-500	250-1000	Stable
Upper Rogue	17100307	S1↓	1000-5000	100-500	Unknown	Unknown
Middle Rogue	17100308	S2↑	1000-5000	100-500	Unknown	Unknown
Applegate	17100309	S2	1000-5000	100-500	250-1000	Stable
Lower Rogue	17100310	S2	1000-5000	100-500	Unknown	Unknown
Illinois	17100311	S1↓	1000-5000	100-500	Unknown	Unknown
Chetco	17100312	S2↓	250-1000	100-500	Unknown	Unknown

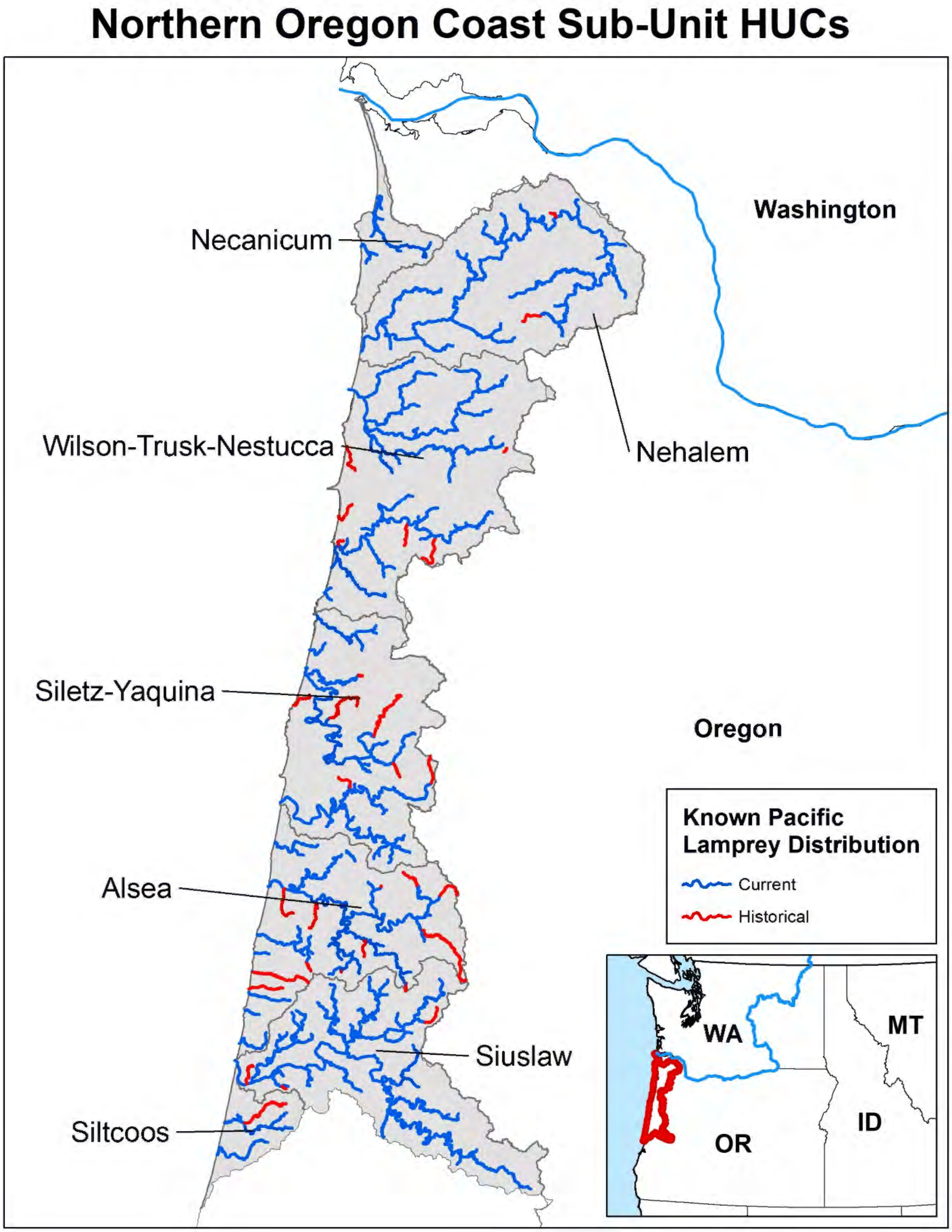

Figure 12-1. Current Pacific Lamprey distribution and location of seven 4th Field HUCs in the North Oregon Coast Sub-Region (USFWS Data Clearinghouse 2017).

Southern Oregon Coast Sub-Unit HUCs

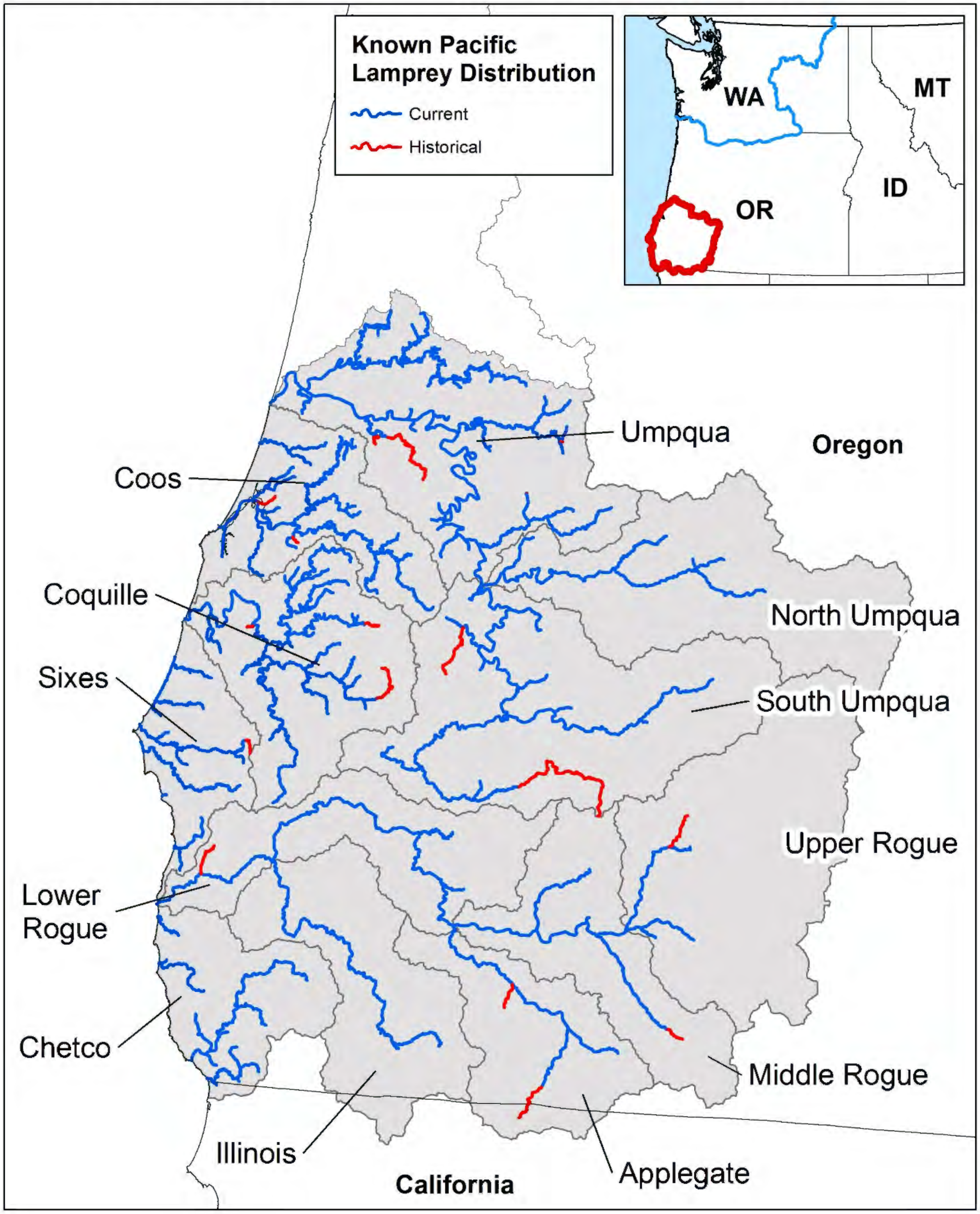

Figure 12-2. Current Pacific Lamprey distribution and location of twelve 4th Field HUCs in the South Oregon Coast Sub-Region (USFWS Data Clearinghouse 2017).

Ranked Population Status of Pacific Lamprey in the Oregon Coast Region

Understanding of Pacific Lamprey population factors has increased in many coastal watersheds. Monitoring efforts, in which lamprey are either the target species or information is collected during other species' monitoring, have expanded the amount of information available and the quality of this information in most watersheds. Overall, NatureServe conservation status ranks changed in eight of 19 HUCs across the Oregon Coast RMU. Status ranks fell from Imperiled (S2) to Critically Imperiled (S1) in the Siltcoos, South Umpqua, Upper Rogue and Illinois, and from Vulnerable (S3) to Imperiled (S2) in the Chetco. Status ranks rose from S1S2 to Imperiled (S2) in the Necanicum and North Umpqua, and from Critically Imperiled (S1) to Imperiled (S2) in the Middle Rogue. The decline in risk ranks was generally due to a lowering of ranking values in Current Occupancy, Population Size and/or Short-term trend categories. Values were lowered due to better data quality (i.e., calculating versus estimating area of occupancy) and increased information availability (i.e., ODFW abundance estimates), rather than a decline in Pacific Lamprey abundance or range. The improvement in status rank in the Necanicum was due to an increase in the Historical Occupancy ranking value and change in Short-term trend to unknown, while the improvement in the Middle Rogue was due to the reduction in threats scope and severity from high to moderate in the Stream and Floodplain category. Improvement in the North Umpqua was attributable to the increase in Pacific Lamprey population size and ranking of short-term trend as stable (see below).

Ranking of current Pacific Lamprey occupancy was reduced in all but three HUCs in the Oregon Coast RMU. As described previously, this reduction was a direct result of calculating the numeric area of occupancy (versus using a visual estimate), rather than a decline in lamprey range. The ratio of current to historical distribution was unchanged in most North Coast HUCs (0.25) with the exception of the Nehalem and Wilson-Trask-Nestucca which increased from 0.1 to 0.25 and the Siltcoos which was reduced from 0.75 to 0.25 (Table 12-3). Ratio was reduced in all but a single South Coast HUC (Middle Rogue), with lamprey currently occupying 25% or less of historical habitat (Table 12-3). The apparent decline in ratio was a result of re-calculating the area of occupancy, which reduced current occupancy ranks in nine South Coast HUCs.

Numeric estimates of population size were revised in the majority of coastal watersheds using new information from Oregon Department of Fish and Wildlife (ODFW) to estimate a range of Pacific Lamprey population abundance using available redd counts. As part of the monitoring for winter steelhead spawning populations, the Oregon Adult Salmonid Inventory and Sampling (OASIS) field crews record data on lamprey spawners and redds. These estimates are considered minimum population numbers, as the surveys are focused on steelhead, and end before the completion of Pacific Lamprey spawning (see Jacobsen et al. 2014; Jacobsen et al. 2015; Brown et al. 2017). Though Assessment ranking of lamprey population size was reduced in eleven total HUCs, the decline was attributable to better data quality (i.e., abundance estimates calculated from nest survey data) versus a decrease in lamprey abundance. Adult Pacific Lamprey abundance was increased in the North Umpqua and Applegate and ranked unknown in the Upper Rogue, Middle Rogue, Lower Rogue, Illinois, and Chetco Rivers.

Short-term population trend was ranked as stable or unknown in most watersheds with available abundance information. The South Umpqua was the only HUC to observe an improvement in population trend (from 50-70% to a 30-50% decline) in the last five years. The only ongoing long-term data set tracking lamprey numbers in the Oregon Coast is located on Winchester Dam on the North Umpqua. The population has been tracked since 1965 and has indicated a significant downward trend over time. For example, during 1965 – 1985, the average count of adult Pacific Lamprey at Winchester Dam was 12,343 fish (range: 877 – 46,785), compared with 1986 – 2012, when the average count was only 433 fish (range: 15 – 2,726). However the number of lamprey passing over Winchester Dam has recently shown a slight increase since the lamprey ramp was employed during 2013 – 2016, with an average of 964 lamprey (range: 758 – 1,278) counted passing. It is unclear if the increase in lamprey in recent years is due to the installation of the lamprey ramp and more efficient counting methods, actual increases in the number of adults migrating upstream past the dam, or both. Many watersheds in the Oregon Coast have 3-8 years of high quality data (~2009 – 2016), but information is inaccurate or undocumented before this time. Abundance indices have generally increased over the last several years, but without a long term data set it is unknown whether this apparent increase is simply an upswing in a larger cyclical trend.

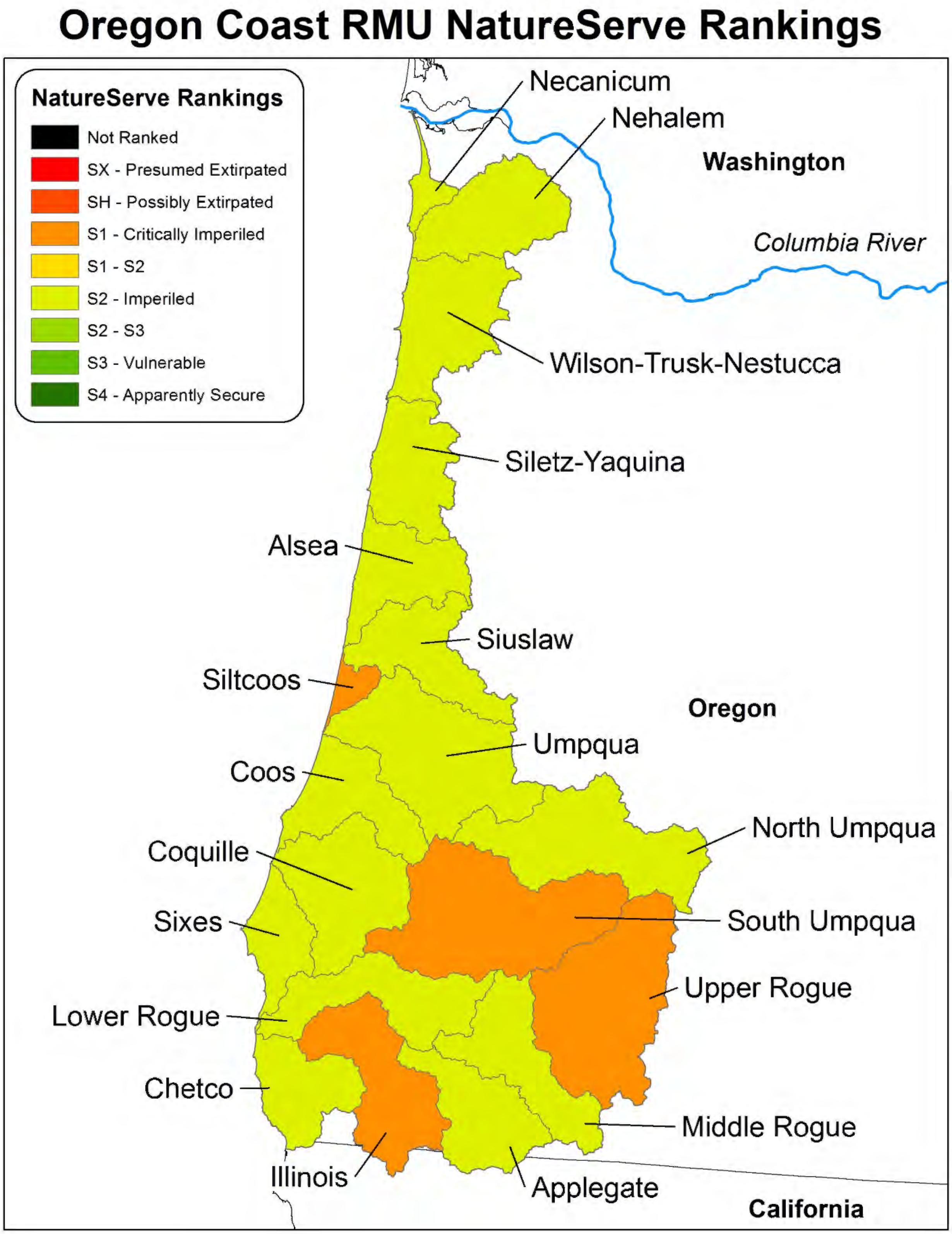

Figure 12-3. Final Conservation Status Ranks for the Oregon Coast RMU 2017.

Threats and Limiting Factors to Pacific Lamprey

North Coast Oregon

The highest priority threat to Pacific Lamprey in North Oregon Coast watersheds is stream and floodplain degradation followed by lack of awareness and water quality (Table 12-3). Water quality and lack of awareness ranked out as new priority threats in 2017. Although most threat categories were ranked as low or moderate risk in the sub-region, average scope and severity values were higher for the majority of categories in 2017. Categories for disease and small population size were ranked as unknown for both scope and severity in all HUCs due to insufficient information. The three highest ranked threats in the sub-region are discussed below. See Table 12-3 for threats ranked as low, insignificant or unknown in this sub-region.

Stream and Floodplain Degradation.—Stream and floodplain degradation was ranked moderate in scope and severity throughout all watersheds of the north Oregon Coast. Within lowlands, wetlands and side channels have been channelized, diked, diverted or drained to prevent flooding, create farmland or pastures, and provide land for commercial and residential development. In upland areas, historical and ongoing timber practices, agriculture, and urbanization have deforested or altered the function and diversity of riparian vegetation. Many watersheds in the RMU are lacking mature conifers that play a pivotal role in bank stability, water quality protection, thermal cover, and the provision of large woody debris.

Water Quality.—Threats due to water quality increased from an overall ranking of low in 2011 to a ranking of moderate in 2017. Elevated water temperature is the primary water quality concern in the North Coast sub-region. Excessive temperatures generally occur during summer months and may be attributed to increased air temperature, lack of riparian cover, or reduced instream flows associated with water withdrawals for irrigation, municipal or residential use. Other water quality concerns in tributaries include low dissolved oxygen and presence of bacteria (e.g., fecal coliform, e coli), that may be associated with elevated water temperatures and agricultural or urban runoff. Threats due to water quality generally ranked low in the Necanicum and Wilson-Trask-Nestucca HUCs, but were ranked as moderate for scope and/or severity in all other HUCs.

Lack of Awareness.—The threat associated with lack of awareness was elevated from low to high (in scope only) in all watersheds in the sub-region. Instream water work, whether for restoration activities or maintenance of diversions, can dewater areas or remove sediments in which juvenile lamprey are burrowed. Such actions without first salvaging lamprey may result in the death of hundreds of juveniles. Increasing public and agency awareness about the presence of juvenile lamprey in the sediments, adult lamprey spawning habitats and timing during inwater work, as well as the effect of water diversions, and education on actions to minimize these impacts, could greatly decrease localized mortality and injury to lamprey populations.

South Coast Oregon

The highest priority threat in the South Oregon Coast watersheds is lack of awareness followed by climate change, water quality, stream and floodplain degradation, and dewatering and flow management (Table 12-4). Dewatering and flow management was a new priority threat in 2017.

Average scope and severity values increased in a number of threat categories including: passage, dewatering and flow management, predation and climate change, though the overall threat was still ranked as low to moderate in these categories. Categories for disease and small population size were ranked as unknown for both scope and severity in all HUCs due to insufficient information. The five highest ranked threats in the sub-region are discussed below. See Table 12-4 for threats ranked as low, insignificant or unknown in this sub-region.

Lack of Awareness.—Scope and severity rankings for lack of awareness were unchanged from the 2011 Assessment, remaining high in scope and low in severity in all watersheds. Understanding of Pacific Lamprey life history characteristics, habitat needs, physiological limitations, and awareness in terms of Best Management Practices when conducting instream work has improved within conservation and fisheries management communities over the last 5-10 years. Nevertheless, there is still a large portion of the human population that is not aware of lamprey, its importance to freshwater ecosystems, and how to avoid impacts to them.

Climate Change.—The effects of climate change ranked as high or moderate for scope and/or severity in all HUCs except the Sixes, lower Rogue, and Chetco which ranked as low for both scope and severity. Some watersheds in the South Coast sub-region may be more resilient to impacts of climate change (Upper Rogue, Applegate, Sixes, North Umpqua), while others may be at greater risk from potential change (Illinois, Umpqua, South Umpqua) based upon the underlying geology, impoundments, and other factors. Climate models predict increasing water temperatures, which may restrict habitat availability. Increased high intensity storm events and more precipitation falling as rain at higher elevations could cause flooding, which may lead to erosion and scouring of lamprey habitat. Earlier melting of snow pack due to warmer ambient temperatures may alter flow regimes during periods of lamprey spawning.

Water Quality.—Current water quality conditions are impaired in many watersheds with the exception of the lower Rogue and Chetco HUCs, where the scope and severity of the threat was low to insignificant. Elevated water temperature associated with heavy water withdrawals and extensive floodplain degradation is the primary water quality concern in the sub-region. Chemical and herbicide inputs from agriculture and industrial forest practices were also noted as problematic, particularly in the Umpqua Basin.

Stream and Floodplain Degradation.—Stream and floodplain degradation ranked as moderate for scope and severity in all watersheds with the exception of the lower Rogue and Chetco which ranked as insignificant for scope and low for severity. Within lowlands, wetlands and side channels have been channelized, diked, diverted or drained to prevent flooding, create farmland or pastures, and provide land for commercial and residential development. In upland areas, historical and ongoing timber practices, agriculture, road construction, and urbanization have deforested or altered the function and diversity of riparian vegetation. Suction dredge mining is of particular concern in the South Umpqua, Umpqua, and Illinois River.

Dewatering and Flow Management.—Threats from dewatering and flow management increased from an overall ranking of low in 2011 to a ranking of moderate in 2017. Water withdrawals for irrigation, municipal, or residential purposes leave many watersheds in the South Coast sub-region dewatered or with inadequate flow during summer and fall months. Low flow conditions are most severe in the Illinois River, Umpqua and Rogue Basins. In recent years early cessation of rains, below average snow packs, and above average air temperature have further contributed to reduced stream flows in much of the region. The proliferation of marijuana farms and potential impacts from climate change may increase the frequency, duration and intensity of low flow conditions the future.

Table 12-3. Threats to Pacific Lamprey in the North Coast Sub-Region as ranked by participants at the regional meetings in 2017. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

North Coast 2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Necanicum	2	2	1	1	3	3	2	2	1	1	2	2
Nehalem	2.5	2	2	2	3	3	3	3	1	1	2	2
Wilson-Trask-Nestucca	3	2	2	2	3	3	2	2	1	1	2	2
Siletz-Yaquina	2	2	3	3	3	3	3	3	1	1	2	2
Alsea	2	2	3	3	3	3	3	2	1	1	2	2
Siuslaw	2	2	3	3	3	3	3	3	1	1	2	2
Siltcoos	3	2	3	3	4	3	3	2.5	1	1	3	U
Mean	2.36	2.00	2.43	2.43	3.14	3.00	2.71	2.50	1.00	1.00	2.14	2.00
Rank	L	L	L	L	M	M	M	M	I	I	L	L
Mean Scope & Severity	2.18		2.43		3.07		2.61		1.00		2.07	
Drainage Rank	L		L		M		M		I		L	

	Disease		Small Population Size		Lack of Awareness		Climate Change	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Necanicum	U	U	U	U	4	2	4	U
Nehalem	U	U	U	U	4	2	4	U
Wilson-Trask-Nestucca	U	U	U	U	4	2	4	U
Siletz-Yaquina	U	U	U	U	4	2	4	3
Alsea	U	U	U	U	4	2	4	U
Siuslaw	U	U	U	U	4	2	4	U
Siltcoos	U	U	U	U	4	2	4	U

Mean	4.00	2.00	4.00
Rank	H	L	H
Mean Scope & Severity	3.00		
Drainage Rank	M		

Table 12-4. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed by RMU partners in the North Coast Sub-Unit from 2012-2017.

HUC	Threat	Action Description	Type	Status
RMU	Stream Degradation	Implementation of instream and floodplain habitat restoration activities (e.g. large wood placement, side channel and floodplain reconnection, channel reconstruction, bank stabilization, etc.).	Instream	Ongoing
RMU	Population	Distribution surveys of mainstem and principal tributaries	Survey	Ongoing
RMU	Lack of Awareness	Consideration of lamprey when planning and implementing instream habitat restoration work	Coordination	Ongoing
RMU	Passage	Map, assess and prioritize passage barriers in tributaries and evaluate available lamprey habitat upstream	Assessment	Proposed
RMU	Population	Conduct spawning ground surveys in mainstem and principal tributaries to monitor Pacific Lamprey distribution, timing, and number of redds to develop relative abundance indexes.	Survey	Ongoing
Necanicum	Passage	South Fork Necanicum diversion dam removed and intake screens updated/improved.	Instream	Complete
Necanicum	Stream Degradation	Culvert removal or replacement projects to restore access to spawning and rearing habitat.	Instream	Ongoing
Nehalem & Siuslaw	Stream Degradation	Coho Strategic Action Plan – identifies high priority conservation areas for restoration and monitoring. Will likely benefit other native aquatic species.	Instream	Underway
Nehalem	Passage	Several tide gate replacement projects on lower North Fork	Instream	Ongoing
Wilson – Trask – Nestucca	Stream Degradation	Numerous culvert removal or replacement projects as part of Salmon SuperHwy Project.	Instream	Ongoing
Wilson – Trask – Nestucca	Passage	Removal of the East Fork South Fork Trask River Hatchery Dam.	Instream	Complete
Wilson – Trask – Nestucca	Passage	Skookum Reservoir Dam removal, Tillamook River Drainage	Instream	Underway
Siletz	Passage	Evaluation of passage constraints for lamprey at Siletz Gorge Falls fish	Instream	Proposed

		ladder/trap		
Alsea	Passage	Installation of Lamprey Passage Ramp at water diversion structure upstream from Alsea River Hatchery on North Fork Alsea River.	Instream	Underway
Alsea	Passage	Monitoring relative abundance of larval Pacific Lamprey upstream of water diversion structure pre and post lamprey ramp installation	Assessment	Underway
Siltcoos	Passage	Evaluation of passage constraints for lamprey at Siltcoos and Tahkenitch Dam fish ladders.	Assessment	Proposed
Siltcoos	Stream Degradation	Implementation of instream and floodplain habitat restoration activities (Fivemile-Bell, Grant Cr., Fiddle Cr.)	Instream	Ongoing

Table 12-5. Threats to Pacific Lamprey in the South Coast Sub-Region as ranked by participants at the regional meetings in 2017.

South Coast 2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
North Umpqua	4	3	4	3	2	3	3	2.5	1	1	2	
South Umpqua	3	3	3	4	4	3	4	3	1	1	3	3.5
Umpqua	2	2	3	3	3	3	3	3	1	1	4	4
Coos	2	2	2	2	3	3	3	3	1	1	3	2
Coquille	2	2	2.5	2	3	3	3.5	3	1	1	4	3
Sixes	1	1	1	2	3	3	3	3	1	1	1	1
Upper Rogue	3.5	2.5	3	3	3	2.5	3	3	1	1	1	1
Middle Rogue	3	2.5	3	3	3	3	3	3	1	1	2	2
Applegate	3	3	3	3	3	2.5	3	3	1	1	2.5	2
Lower Rogue	1	1	1	1	1	1.5	1	1	1	1	4	2
Illinois	2	2	4	4	3	3	4	4	1	1	3	3
Chetco	1	1	1	2	1	2	1	2	1	1	1	1
Mean	2.29	2.08	2.54	2.67	2.67	2.7	2.88	2.79	1.00	1.00	2.54	2.23
Rank	L	L	M	M	M	M	M	M	I	I	M	L
Mean Scope & Severity	2.19		2.60		2.69		2.83		1.00		2.38	
Drainage Rank	L		M		M		M		I		L	

South Coast 2017	Disease		Small Population Size		Lack of Awareness		Climate Change	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
North Umpqua	U	U	U	U	4	2	4	3
South Umpqua	U	U	U	U	4	2	4	4
Umpqua	U	U	U	U	4	2	4	4
Coos	U	U	U	U	4	2	3	3
Coquille	U	U	U	U	4	2	3	3
Sixes	U	U	U	U	4	2	2	2
Upper Rogue	U	U	U	U	4	2	2.5	2.5
Middle Rogue	U	U	U	U	4	2	3	2.5
Applegate	U	U	U	U	4	2	3	2.5
Lower Rogue	U	U	U	U	4	2	2	2

Illinois	U	U	U	U	4	2	4	3.5
Chetco	U	U	U	U	4	2	2	2
Mean					4.00	2.00	3.04	2.83
Rank					H	L	M	M
Mean Scope & Severity					3.00		2.94	
Drainage Rank					M		M	

Table 12-6. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed by RMU partners in the South Coast Sub-Unit from 2012-2017.

HUC	Threat	Action Description	Type	Status
RMU	Stream Degradation	Implementation of instream and floodplain habitat restoration activities (e.g. large wood placement, side channel and floodplain reconnection, channel reconstruction, bank stabilization, gravel recruitment, etc.).	Instream	Ongoing
RMU	Population	Conduct spawning ground surveys in mainstem and principal tributaries to monitor Pacific Lamprey distribution, timing, and number of redds to develop relative abundance indexes.	Survey	Ongoing
RMU	Stream Degradation	Senate Bill 838 imposed 5-year moratorium of suction dredge mining on all Oregon streams with designated Essential Salmon Habitat (ESH). Also restrictions on specific USFS and BLM waterways (e.g. Rogue, Illinois)	Instream	Underway
RMU	Population	Environmental DNA sampling to fill distribution gaps on Rogue River Siskiyou National Forest Land.	Survey	Underway
North Umpqua	Passage	Passage improvement at Soda Springs Dam.	Instream	Complete
North Umpqua	Passage	Pacific Lamprey spawning and rearing habitat suitability above Soda Springs Dam	Survey/ Assessment	Complete
North Umpqua	Passage	Passage improvement at Rock Creek Hatchery diversion dam fish ladder.	Instream	Complete
North Umpqua	Passage	Installation of Lamprey Passage Structure at Winchester Dam.	Instream	Complete
North Umpqua	Population	Conduct native fish inventory to establish baseline lamprey distribution dataset	Survey	Proposed
Umpqua	Predation	Smallmouth bass predation evaluation in lower Elk Creek and Umpqua R.	Assessment	Complete
Umpqua	Other	Formation of Umpqua River Basin Lamprey Working Group.	Coordination	Ongoing
Umpqua & Rogue Basins	Population	Lamprey distribution mapping and occupancy sampling.	Survey	Ongoing
Umpqua & Rogue Basins	Lack of Awareness	Provide education and outreach to stakeholders, resource managers and community members	Coordination	Ongoing
Rogue Basin	Passage	Rogue Basinwide Priority Barrier Removal Analysis - project characterized and prioritized 38 passage barriers in basin.	Assessment	Complete
Rogue Basin	Passage	Low cost passage retrofits at irrigation	Assessment/	Proposed

		diversion dams.	Instream	
Upper & Middle Rogue	Population	Distribution surveys in principal tributaries.	Survey	Underway
Middle Rogue	Passage	Removal of Fielder and Wimer dams on Evans Creek	Instream	Complete
Lower Rogue	Stream Degradation	Rogue River Estuary Strategic Plan and Lower Rogue Watershed Action Plan - to identify and prioritize conservation and restoration actions in lower Rogue and tributaries.	Assessment	Complete
Applegate & Illinois	Population	Distribution surveys in principal tributaries	Survey	Underway
Applegate & Illinois	Predation	Umpqua pikeminnow predation evaluation	Assessment	Proposed
Coos	Passage & Population	Evaluation of passage constraints and baseline presence/absence of lamprey within the Eel Lake basin	Assessment	Underway/ Complete
Coos	Passage	Installation of lamprey passage ramp/trap at Eel Creek Dam.	Instream	Underway
Coos	Population	Telemetry to monitor movement and distribution of Pacific Lamprey through Eel Lake Basin.	Assessment	Underway
Coos	Stream Degradation	Implementation of instream and floodplain habitat restoration activities (e.g. East Fork Millicoma Oxbow project, Ross Slough Project)	Instream	Complete
Coos/ Coquille	Passage	Multiple culvert replacement or removal projects where lamprey salvage efforts occurred.	Instream	Ongoing
Coquille	Population	Expansion of lamprey spawning ground surveys in South Fork Coquille River.	Survey	Proposed
Coquille	Climate Change	Water quality monitoring in lower Coquille River to identify cold water refuge.	Survey/ Assessment	Underway

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Rich Grost	Pacific Power
Keith Hatch	Bureau of Indian Affairs
Evan Leonetti	ODFW (Roseburg)
Helena Linnell	Coquille Indian Tribe
Travis Mackie	Cow Creek Band of Umpqua Tribe
Stephanie Messerle	BLM
Sam Moyers	ODFW (Roseburg)

Chris Reidy	NRCS
John Schaefer	Confederated Tribes of Coos, Lower Umpqua, and Siuslaw
Jakob Shockey	Applegate Partnership & Watershed Council
Cory Sipher	BLM (Roseburg)
Kelly Timchak	Lower Rogue Watershed Council/Curry Watersheds Partnership
Matt Weeber	ODFW (Corvallis)
Chuck Wheeler	NMFS
Lance Wyss	The Freshwater Trust

13. WILLAMETTE SUB-UNIT

Summary

The Willamette Sub-Unit of the Lower Columbia River/Willamette Regional Management Unit includes all watersheds within the Willamette Basin and the Willamette River mainstem. The Willamette Basin is influenced heavily influenced by human development (agricultural, industrial and urban), and contains multiple large dams for flood control and hydropower generation. The Willamette River drains into the Columbia River mainstem at Rkm 160 (Figure 13-1), and is comprised of twelve 4th field HUCs ranging in size from 1,668−4,850 km^2.

There were several changes to Willamette Sub-Unit NatureServe risk rankings in the 2017 Assessment. The following are key outcomes of the 2017 Assessment:

- Changes in the NatureServe conservation status ranks likely occur from one or both of the following:
  - Population estimates of 1) adult Pacific Lamprey at Willamette Falls and 2) numbers of adult Lamprey passing Willamette Falls; the available information increased population abundance in each HUC, and when entered into NatureServe, would contribute to improving conservation status rank.
  - Improved approach to refine and more accurately calculate historical range extent; this information, although more accurate, resulted in calculated decreases in distribution, and would contribute to a decline in conservation status rank. However, this refinement does not reflect an actual reduction in distribution.
- NatureServe conservation status ranks remained the same in six HUCs: four are ranked Imperiled (S2; Upper Willamette, McKenzie, South Santiam, Middle Willamette); two Critically Imperiled (S1; Middle Fork Willamette and Coast Fork Willamette).
- NatureServe conservation status ranks fell from Imperiled (S2) to Critically Imperiled (S1) in four HUCs: North Santiam, Yamhill, Molalla-Pudding, and Tualatin HUCs. Changes in these areas are likely the result of using an improved approach to more accurately calculate historical range extent, as stated above.
- NatureServe conservation status ranks improved in the Lower Willamette HUC, moving from Critically Imperiled (S1) to Imperiled (S2). These changes may be attributable to improved population estimates, and increased monitoring at Willamette Falls (e.g. Baker and McVay 2017). Also, there are no manmade barriers between Willamette Falls and the ocean.
- NatureServe conservation status rank improved in the Clackamas HUC, moving from Imperiled (S2) to Vulnerable (S3). These changes are attributable to increased monitoring and improved fish passage and collection facilities at PGE's Clackamas Hydroelectric project, a result of multiple recent restoration projects in the lower river, and or improved population estimates in the Lower Willamette. Additionally, the Clackamas River confluence is below and in close proximity to Willamette Falls.
- Population abundance of Pacific Lamprey was unknown when the 2011 Assessment was completed. However, the Confederated Tribes of the Warm Springs have since completed annual population estimates of Pacific Lamprey adults at Willamette Falls, beginning in 2010. Based on their data from 2010-2016, the average number of adults

passing Willamette Falls is 60,689; and the average number below 112,029. This represents a significant improvement in available data, as well as increases population abundance relative to the 2011 Assessment.

- Stream and floodplain degradation was the top threat to Pacific Lamprey in the Willamette Basin, as ranked in 2017, followed closely by water quality. Both ranked as high in terms of scope and severity. Dewatering and flow management, and passage were considered the next greatest threats in 2017. These "top four" threats were similarly ranked in 2011. Water quality had the largest increase in its ranking from 2011 to 2017. Differences in the Threats ranking can be attributed to the increased participation from regional partners
- Lack of awareness and climate change, previously ranked as key threats in 2010, were not considered "key threats" in 2017. Climate change, which the group agreed was still very real, was considered as an "*Unknown*" threat to Pacific Lamprey for the Willamette RMU, primarily because flow releases from the flood storage dams have the potential to mitigate increasing water temperatures. The reduction in lack of awareness as a threat likely reflects increased monitoring, conservation recommendations, and public outreach efforts for this species from state and federal agencies, and Tribes.

A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the Willamette Sub-Unit Region can be found in the Regional Implementation Plan for the Lower Columbia River/Willamette Regional Management Unit (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Table 13-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the Willamette Sub-Unit Region. S1 = Critically Imperiled. S2 = Imperiled S3= Vulnerable. Conservation Status Ranks highlighted in yellow indicate a decline (↓) or improvement (↑) in status from 2011 assessment.

Watershed	HUC Number	Risk Rank	Current Occupancy (km^2)	Historical Occupancy (km^2)	% Occupied	Current Population Size	Short-Term Trend (% decline)
Middle Fork	17090001	S1	20-100	1,000-5,000	2	1,000-2,500	50-70%*
Coast Fork Willamette	17090002	S1	20-100	250-1,000	12	2,500-10,000	50-70%*
Upper Willamette	17090003	S2	100-500	1,000-5,000	14	2,500-10,000	50-70%*
McKenzie	17090004	S2	100-500	1,000-5,000	10	2,500-10,000	50-70%*
North Santiam	17090005	S1↓	20-100	250-1,000	9	10,000-100,000	50-70%*
South Santiam	17090006	S2	100-500	1,000-5,000	17	2,500-10,000	50-70%*
Middle Willamette	17090007	S2	100-500	1,000-5,000	12	10,000-100,000	50-70%*
Yamhill	17090008	S1↓	100-500	1,000-5,000	10	1,000-2,500	50-70%*
Molalla-Pudding	17090009	S1↓	100-500	1,000-5,000	10	1,000-2,500	50-70%*
Tualatin	17090010	S1↓	100-500	1,000-5,000	13	1,000-2,500	50-70%*
Clackamas	17090011	S3↑	100-500	1,000-5,000	12	10,000-100,000	< 10%
Lower Willamette	17090012	S2↑	100-500	250-1,000	16	10,000-100,000	50-70%*

* indicates that the group decided to maintain the rank from 2010, which seem to be based on limited information at Willamette Falls (comparing 1940s information to now) and Bonneville Dam (1960s information to now), but acknowledge that there is much lacking in terms of available information, accuracy and consistency on population estimates that prevent direct comparisons and determining trends over the last 30 years.

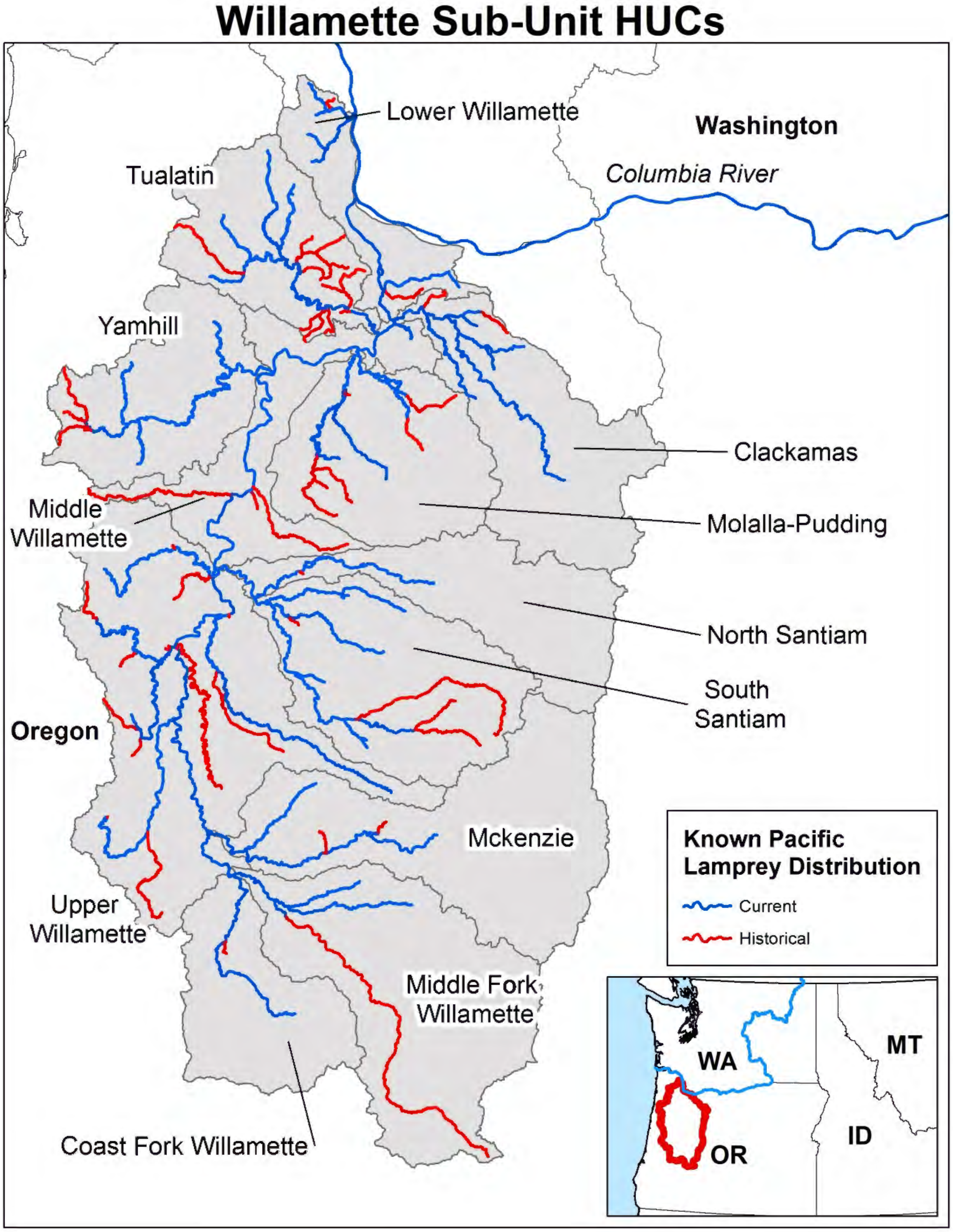

Figure 13-1. Distribution of Pacific Lamprey and location of 4th Field HUCs in Lower Columbia -Willamette RMU (USFWS Data Clearinghouse 2017).

Ranked Population Status of Pacific Lamprey in the Willamette Sub-Unit RMU

NatureServe conservation status ranks fell in four of 12 HUCs in 2017. Conservation status ranks fell from S2 (imperiled) to S1 (Critically Imperiled) in the North Santiam, Yamhill, Molalla-Pudding, and Tualatin HUCs. Changes in these areas are likely the result of using an improved approach to more accurately calculate historical range extent rather than an increase in Conservation risk, as described in chapter 3.

Current Pacific Lamprey distribution in the Willamette Sub-Unit RMU is still greatly reduced from historical range (figure 4-3). Current distribution of lamprey has largely remained the same in most watersheds since the completion of the 2011 Assessment with the exception of the Clackamas River Basin. New fish passage facilities and increased monitoring has improved our knowledge and increased the extent of distribution. However, the ratio of current to historical distribution is small in all of the HUCs.

Our knowledge of population abundance of Pacific Lamprey in the Willamette has improved due to studies conducted by the Confederated Tribes of Warm Springs Indian Reservation of Oregon at Willamette Falls (Table 13-2). Based on their data from 2010-2016, the average number of adults passing Willamette Falls is 60,689; and the average number below 112,029 (Total Abundance minus Number Passed; Baker and McVay 2017). Population estimates for tributaries to the Willamette are not available, but were estimated based on professional judgment of relative distribution and the average number of lamprey passing Willamette Falls (Table 13-3). Although no long-term count of Pacific Lamprey exists in the Willamette Basin, populations are generally believed to have declined by 50-70% over the past 50-60 years, based on limited harvest information at Willamette Falls (comparing 1940s information to now) and fishway counts at Bonneville Dam (1960s information to now).

Table 13-2, percent of total that were harvested, percent of total numbers that passed Willamette Falls (Baker and McVay 2017).

Year	Total Abundance At Willamette Falls	Percent Harvested	Numbers Passing Willamette Falls Fishways	Number Below Willamette Falls
2010	64,388	2.5%	27,043	37,345
2011	107,383	4.0%	46,819	60,564
2012	243,048	2.7%	111,559	131,489
2013	173,821	4.3%	49,365	124,456
2014	336,305	1.1%	125,778	210,527
2015	168,398	1.3%	32,112	136,286
2016	115,682	2.3%	32,148	83,534
Average	**172,718**	**2.6%**	**60,689**	**112,029**

Table 13-3. Proportion of adult lamprey, Population Estimate, and Corresponding Abundance Bin Range for input into the NatureServe Model. The portion was derived from the original bin selected at the 2017 RMU meeting and thus based on professional judgment. This proportion was then applied to the corresponding average number of adult lamprey from Table 13-2 to calculate a "Rough population estimate," which was then used to select the appropriate bin.

Watershed	Proportion (professional judgment)	Rough Population Estimate	Abundance- Bin Range for NatureServe Model Input
ABOVE FALLS			
Middle Fork	2.5%	1,517	1,000 -2,500
Coast Fork Willamette	10%	6,069	2,500-10,000
Upper Willamette	10%	6,069	2,500-10,000
McKenzie	10%	6,069	2,500-10,000
North Santiam	25%	15,172	10,000- 100,000
South Santiam	10%	6,069	2,500-10,000
Middle Willamette	25%	15,172	10,000- 100,000
Yamhill	2.5%	1,517	1,000 -2,500
Molalla-Pudding	2.5%	1,517	1,000 -2,500
Tualatin	2.5%	1,517	1,000 -2,500
BELOW FALLS			
Clackamas	50%	56,015	10,000- 100,000
Lower Willamette	50%	56,015	10,000- 100,000

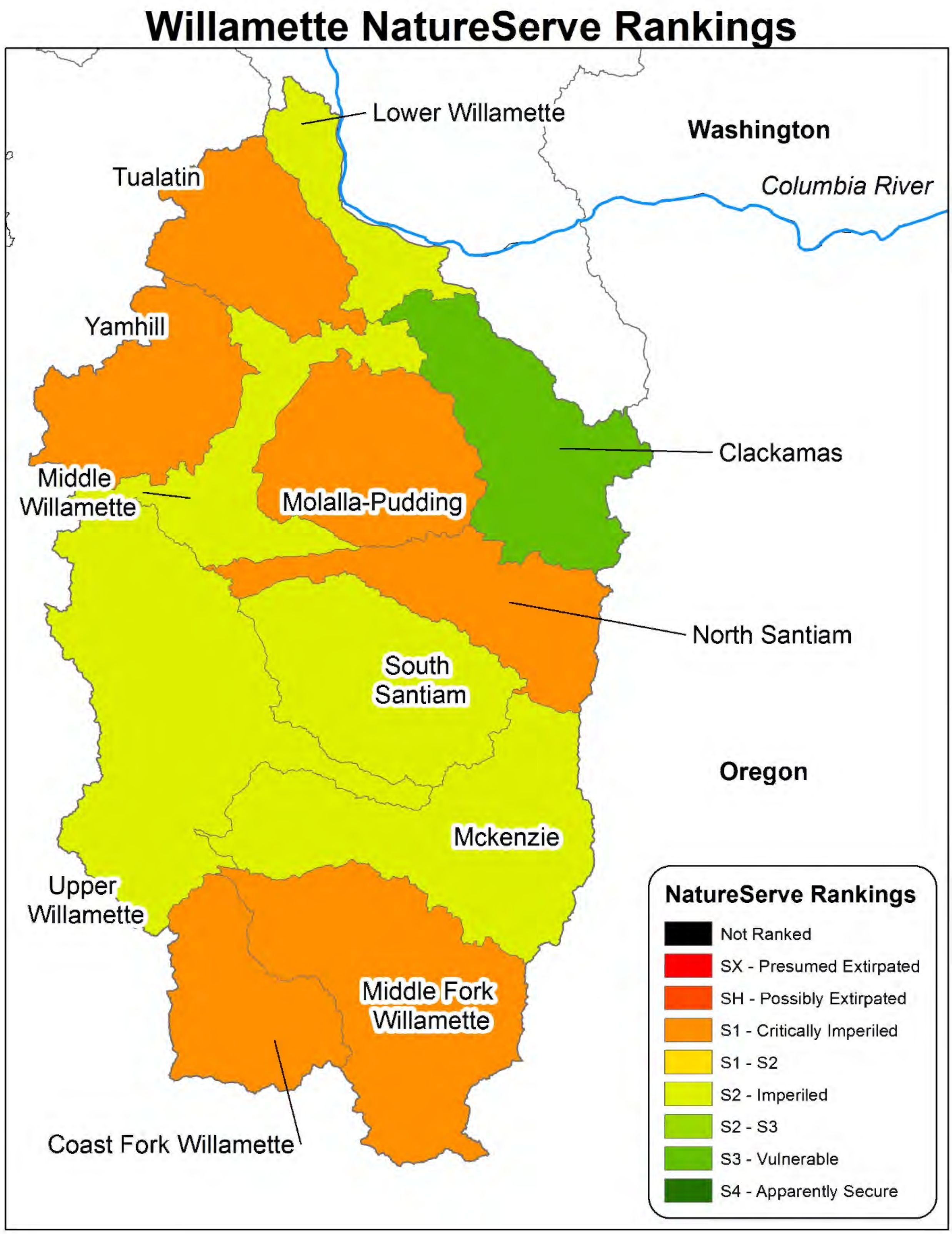

Figure 13-2. Final Conservation status ranks for Lower-Columbia/Willamette RMU 2017.

Threats and Limiting Factors to Pacific Lamprey in the Willamette Sub-Unit RMU

Summary

Stream and floodplain degradation and water quality were ranked as the greatest threat to Pacific Lamprey in the Willamette Sub-Unit, ranking high in both scope and severity, an increase from 2011 values. Dewatering and flow management, passage and predation remained moderate threats in 2017, though scope and severity values increased for all categories. Lack of awareness was downgraded from a moderate to a low threat within the Willamette Valley. Rankings for disease and small population size remained unknown due insufficient information. The category for climate change was also ranked as unknown, primarily because flow releases from the flood storage dams have the potential to mitigate increasing water temperatures. The rankings of each threat by HUC are presented in Table 13-4. The highest ranked threats in the RMU are discussed below.

Stream and Floodplain Degradation.—Stream and Floodplain Degradation remained the highest ranking threat in the Willamette Basin. Nearly 70 percent of Oregon's population resides in and around the Willamette Basin. Human settlement and development has greatly altered the physical habitat and hydrology of the Sub-Unit. In upland areas, where forestry is the predominant land use, many watersheds in the Willamette Sub-Unit are lacking mature conifers that play a pivotal role in bank stability, water quality protection, thermal cover, and the provision of large woody debris. In the valley, extensive agriculture and urban development have reduced the quality and complexity of aquatic and riparian habitats via many human activities (e.g. large flood control dams, reduced peak flows, dredging for navigation improvements, and wetland fill/draining). Simplification of the mainstem Willamette River (loss of side channels, braiding) and flow regulation have been hypothesized to cause decreased numbers of adult Pacific Lamprey harvested by Tribal members at Willamette Falls (Clemens et al. 2017b).

Water Quality.—Water quality ranked the second highest threat to Lamprey in the Willamette Sub-Unit. Elevated water temperature, low dissolved oxygen, bacteria, and toxic pollutants such as herbicides, pesticides, heavy metals and flame retardants, are some of the primary water quality concerns in the Willamette Sub-Unit, and largely attributable to human activities. Toxins may be particularly harmful to Pacific Lamprey because larvae burrow and feed in mud and fine substrates where toxins accumulate (Nilsen et al. 2015; Clemens et al. 2017b).

New information on temperature may have increased temperature concerns in the Willamette Valley. A combination of laboratory and field tests and field observations suggest that warm summertime temperatures (greater than or equal to 20ºC) during July-August can result in several biological end points that may prevent adult Pacific Lamprey from surviving, reproducing, or migrating far up into the Willamette Basin (Clemens et al. 2016).

In summary, this evidence suggests that warm summertime temperatures may thwart penetration into the upper basin with successful reproduction in a multiple ways.

Dewatering and Flow Management *(aka* Flow alterations in the 2017 Willamette RIP) was ranked as a Moderate key threat in 2017, as it was in 2011. Low flow conditions occur naturally in many watersheds of the Willamette Sub-Unit during summer months. These conditions may be aggravated by water withdrawals for municipal, industrial, commercial and agricultural use. In several tributaries, the large storage dams offset and augment seasonal low flows in much of the Willamette Basin, and some negatively impact natural temperature and flow regimes. Water releases from thermally stratified reservoirs generally result in cooler water temperatures downstream of the dam in summer and warmer water temperatures in fall and winter. Abnormal seasonal temperature fluctuations may impact the behavior, development, and fitness of adult and juvenile lamprey to an unknown extent. In 2005, the USACE completed a water temperature control tower at Cougar Dam on the South Fork McKenzie River, which has alleviated much of the dam-induced seasonal abnormalities in the McKenzie River. Such temperature control structures are still needed elsewhere in the Willamette Basin to return to more normative seasonal temperature regimes (e.g. North Santiam River, the Middle Fork Willamette).

Water diversions and impoundments alter the quantity and timing of flow events, which may impact adult and juvenile lamprey migration cues, decrease spawning habitat availability, prevent access to backwater or side channel habitats, create low water barriers, and contribute to mortality if incubating eggs or burrowing larvae are dewatered or exposed to a high temperature or low oxygen environment (Clemens et al. 2017b). Some improvements to flow regimes have occurred in the Willamette Basin. Since 2002, the USACE has largely operated their Willamette Valley Project dams according to minimum flows and ramping rates that were formalized under the Willamette Project Biological Opinion issued by the National Marine Fisheries Service (NMFS 2008) for the protection of anadromous salmonids. Further, through the Willamette Valley Sustainable River Project, The Nature Conservancy and the USACE and numerous other agencies and organizations are working to ensure that Willamette River flows are managed to benefit fish and wildlife habitats as well as local communities (https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/oregon/placesweprotect/wv-fact-sheet.pdf?redirect=https-301).

Passage. Passage was ranked as a Moderate key threat in 2017, as it was in 2011. The current distribution of Pacific Lamprey is largely determined by the many large dams throughout the Willamette Basin that do not provide passage (Clemens et al. 2012b; Schultz et al. 2014). The USACE Willamette Valley Project dams were built to reduce flood risks, but also generate electricity and provide water storage for irrigation, recreation and drinking water. Largely constructed in the early 1960s, thirteen federally owned dams block hundreds of miles of historical, anadromous spawning and rearing habitat and have adversely affected native fish populations in the basin.

Although most passage projects in the Willamette Sub-Unit are focused on improving conditions for ESA-threatened spring Chinook salmon and winter steelhead, a growing number of projects are providing passage for Pacific Lamprey. In conjunction with Federal Energy Regulatory Commission relicensing, Portland General Electric (PGE) has installed three lamprey passage structures at Willamette Falls Hydroelectric Project (Lower Willamette River), rebuilt the existing fish ladder at River Mill Dam (Clackamas River) and made modifications to the fishway that traverses both the Faraday and North Fork Dams (Clackamas River) to improve upstream passage of adult Pacific Lamprey. PGE is also monitoring the downstream migration of juvenile lamprey with two, new surface collectors at River Mill and North Fork Dams. These facilities are collecting and enumerating lamprey outmigrants. The collection efficiency of the downstream passage structures are unknown, but thousands of ammocoetes and macropthalmia have been collected each year since construction.

Predation. Predation was ranked as a Moderate key threat in 2017, as it was in 2011. Predation on lamprey likely occurs throughout the Willamette Basin: sea lion and white sturgeon activity is commonly seen immediately below Willamette Falls, and many warm-water predatory fish species are common throughout the basin in the large reservoirs and lower tributaries of the Willamette. These non-native fish are able to overwinter and survive in the basin largely because of large reservoirs or other modified habitats. At this time, there is very little direct study of predation in the Willamette Basin; thus, while there may be many potential predators of lamprey present, in many areas it is uncertain what the severity of such predation is to the lamprey population.

Harvest. Harvest was considered an insignificant threat to Lamprey in the Willamette Sub-Unit, just as it was in 2011. The only notable, known harvest of lamprey occurs at Willamette Falls by several Columbia Basin tribes. Baker and McVay (2017) estimated that harvested lamprey represent 1.1 to 4.3 percent of the lamprey at Willamette Falls from 2010-2016.

Translocation/Supplementation. In HUCs where translocation of adult lamprey was occurring or could occur, translocation was considered an insignificant threat to Lamprey in the Willamette Sub-Unit, just as it was in 2011. Translocation efforts are currently conducted in the Middle Fork Willamette at Fall Creek by the Confederated Tribes of the Grand Ronde, and in the Clackamas Basin at PGE's hydroelectric project. Both translocations are conducted to re-establish Pacific Lamprey into historical habitats considered restoration actions for evaluation.

Table 13-4. Threats to Pacific Lamprey within the Willamette Sub-basin RMU as identified and ranked at regional meetings. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value For several categories, the Willamette HUCs were ranked for "Dam" and "Non-Dam" in the Willamette Sub-Unit RIP; however, the values below represent the highest scope and severity for those categories designated with "^^". See the Willamette Sub-Unit RIP for further discussion on this issue.

2017	Passage^^		Dewatering and Flow Management^^		Stream and Floodplain Degradation^^		Water Quality^^		Harvest		Predation^^	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Middle Fork Willamette	4	4	4	4	4	4	4	4	1	1	3	3
Coast Fork Willamette	4	4	4	4	4	4	4	4	1	1	2.5	2.5
Upper Willamette	2.5	4	4	4	4	4	4	4	U	U	2	U
McKenzie	3	3	3	3	3	3	3	3	1	1	2	2
North Santiam	4	4	4	4	4	4	3	3	1	1	1.5	3
South Santiam	4	4	4	4	4	4	4	4	1	1	2	U
Middle Willamette	2	4	4	4	4	4	3.5	4	U	U	4	U
Yamhill	3	3	3	3	4	4	4	4	1	1	3	3
Molalla-Pudding	2.5	2.5	4	4	4	4	4	4	1	1	3	3
Tualatin	2.5	2.5	2.5	2.5	4	4	4	4	1	1	3	3
Clackamas	3	3	1	2	3	3	3	3	1	1	3	U
Lower Willamette	1	2	3	3	4	4	4	4	U	U	4	4
Mean	3.0	3.3	3.4	3.5	3.8	3.8	3.7	3.8	1.0	1.0	2.3	2.8
Rank	M	M	M	M	M	M	M	M	I	I	L	M
Mean Scope & Severity	3.1		3.4		3.8		3.7		1.0		2.8	
Drainage Rank	M		M		M		M		I		M	

2017 Watershed	Supplementation Scope	Supplementation Severity	Disease Scope	Disease Severity	Small Population Size Scope	Small Population Size Severity	Lack of Awareness Scope	Lack of Awareness Severity	Climate Change Scope	Climate Change Severity
Middle Fork Willamette	1	1	U	U	U	U	2	2	U	U
Coast Fork Willamette	NA	NA	U	U	U	U	2	2	U	U
Upper Willamette	NA	NA	U	U	U	U	2	2	U	U
McKenzie	1	1	U	U	U	U	2	2	U	U
North Santiam	1	1	U	U	U	U	2	2	U	U
South Santiam	1	1	U	U	U	U	2	2	U	U
Middle Willamette	NA	NA	U	U	U	U	2	2	U	U
Yamhill	NA	NA	U	U	U	U	2	2	U	U
Molalla-Pudding	NA	NA	U	U	U	U	2	2	U	U
Tualatin	NA	NA	U	U	U	U	2	2	U	U
Clackamas	1	1	U	U	U	U	2	2	U	U
Lower Willamette	1	1	2	U	U	U	2	2	U	U
Mean	1.0	1.0	2	U			2	2		
Rank	I	I	L	U	U	U	L	L	U	U
Mean Scope & Severity	1.00		2				2.00			
Drainage Rank	I		L		U		L		U	

Table 13-5. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed by RMU partners in the Willamette Sub-Unit of the Lower Columbia RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
RMU	Population	Distribution and occupancy sampling throughout Willamette Basin	Assessment	Ongoing
RMU	Population	Assessment of passage success and abundance of adult Pacific Lamprey at Willamette Falls	Assessment	Ongoing
Middle Fork Willamette	Population	Juvenile outmigrant trapping below Fall Creek Dam; some macropthalmia have been collected in 2018	Assessment	Ongoing
Middle Fork Willamette	Population	Telemetry to assess translocation and reintroduction of adult Pacific Lamprey above Fall Creek Dam.	Assessment	Ongoing
Middle Fork Willamette	Passage	Evaluating lamprey passage structures at Fall Creek Dam for potential trap and haul program	Instream	Ongoing
Middle Fork Willamette	Passage	Removal of Mill Pond at the Springfield Millrace improves lamprey access; additional habitat improvements to improve habitat diversity	Instream	Complete
Clackamas	Passage	Telemetry to assess lamprey passage success at North Fork fishway and identify problems to address.	Assessment	Ongoing
Clackamas	Passage	Telemetry to assess lamprey passage success at River Mill fishway has shown over 90% passage success.	Assessment	Complete
Clackamas	Passage/ Population	Trap and Haul efforts to transfer adult lamprey above North Fork Dam began 2017, and continuing through 2025.	Assessment	Ongoing
Clackamas	Passage	Two new surface collectors are installed for downstream fish passage at the River Mill and North Fork Dams; both are collecting juvenile lamprey outmigrants.	Instream	Ongoing
Clackamas	Stream Degradation	Multiple habitat restoration efforts have occurred in the Clackamas Basin (PGE, Metro and others)	Instream	Complete
Clackamas	Stream Degradation	“Shade Our Streams” efforts by the Clackamas River Basin Council and PGE to improve water quality and riparian habitats.	Instream	Ongoing

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Katherine Nordholm	ODFW
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Jarod Weybright	McKenzie Watershed Council:
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Jeff Ziller	ODFW

14. LOWER COLUMBIA RIVER SUB-UNIT

Summary

The Lower Columbia River Sub-Region within the Lower Columbia River/Willamette Regional Management Unit includes watersheds that drain into the Columbia River mainstem from Bonneville Dam at Rkm 235, west to confluence of the Columbia River with the Pacific Ocean (Figure 14-1). It is comprised of six 4th field HUCs ranging in size from 1,753−3,756 km^2. NatureServe conservation status ranks changed in two of six HUCs in 2017. Ranks varied from Imperiled to Critically Imperiled (S2-S1) in all HUCs with the exception of the Upper Cowlitz which retained a ranking of Presumed Extirpated (SH) (Table 14-1). Population demographic information was revised in most categories, including Population Size where ranks were changed from Unknown in the Sandy, Clatskanie, and Lower Columbia using new information provided by Oregon Department of Fish and Wildlife (ODFW). Overall, understanding of Pacific Lamprey distribution and abundance has expanded in Oregon State tributaries, though knowledge in many Washington State tributaries is still limited. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks changed in two Lower Columbia HUCs in 2017. Ranks fell from Imperiled (S2) to Critically Imperiled (S1) in the Lewis and from S1S2 to S1 in the Lower-Columbia Clatskanie. Change in the Lewis is likely the result of using an improved approach to more accurately calculate range extent and area of occupancy, while change in the Clatskanie may be due to an increase in threats severity from moderate to high.
- Assessment ranking of current distribution was reduced in all HUCs with the exception of the Upper Cowlitz. This decline is a result of more accurately calculating the numeric Area of Occupancy (versus using a visual estimate), rather than a decline in lamprey range.
- Pacific Lamprey abundance was revised from a ranking of unknown in the Sandy, Clatskanie, and Lower Columbia River HUCs. Population abundance is still unknown in the Lewis and Lower Cowlitz. Lamprey are believed to be extirpated from the Upper Cowlitz River.
- Ranking of short-term population trend was changed to unknown in all HUCs of the Lower Columbia Sub-Unit. No long term counts of Pacific Lamprey exist in tributary or mainstem areas of the Lower Columbia Sub-Unit. Populations are believed to be declined (from historical levels), but adequate information does not exist to estimate the magnitude of the decline over the last 27 years.
- The highest priority threat to Pacific Lamprey in the Lower Columbia River Sub-Unit is dewatering and flow management followed by passage, stream and floodplain degradation, and water quality. Water quality was the only new priority threat in 2017.

A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the Lower Columbia Sub-Unit can be found in the Regional Implementation Plan for the Lower Columbia/Willamette Regional Management Unit Lower Columbia Sub-Unit (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Table 14-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Code (HUC) watersheds located within the Lower Columbia Sub-Unit. S1 = Critically Imperiled. S2 = Imperiled. Conservation Status Ranks highlighted in yellow indicate a decline (↓) or improvement (↑) in status in 2017 from 2011.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km^2)	Current Occupancy (km^2)	Population Size (adults)	Short-Term Trend (% decline)
Lower Columbia-Sandy	17080001	S2	1000-5000	100-500	50-1000	Unknown
Lewis	17080002	S1↓	250-1000	100-500	Unknown	Unknown
Upper Cowlitz	17080004	SH	1000-5000	Zero	Zero	Unknown
Lower Cowlitz	17080005	S2	1000-5000	100-500	Unknown	Unknown
Lower Columbia-Clatskanie	17080003	S1S2↓	1000-5000	100-500	250-2500	Unknown
Lower Columbia	17080006	S2	1000-5000	100-500	250-2500	Unknown

Lower Columbia Sub-Unit HUCs

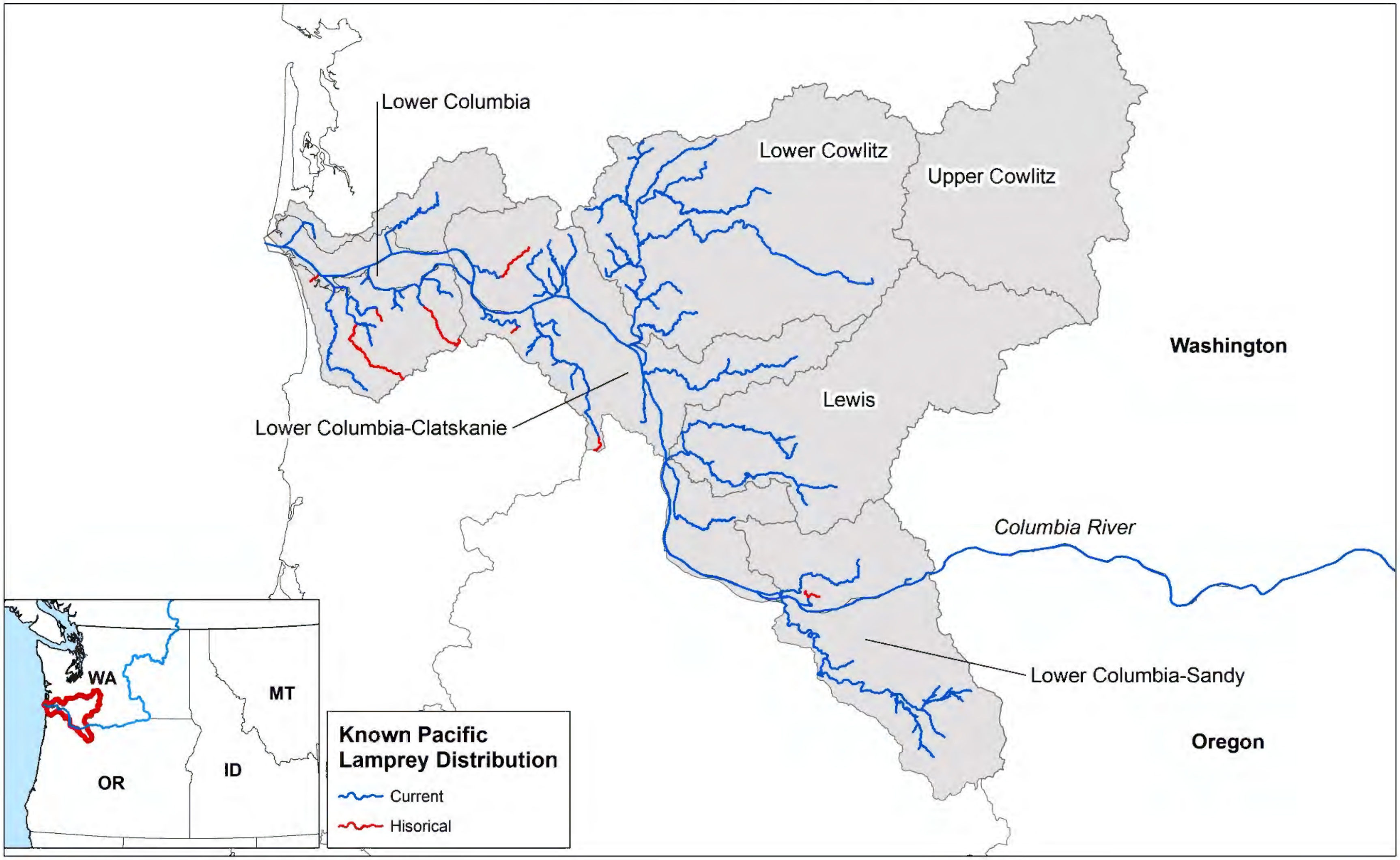

Figure 14-1. Current Pacific Lamprey distribution and location of six 4th Field HUCs in Lower Columbia Sub-Unit (USFWS Data Clearinghouse 2017).

Ranked Population Status of Pacific Lamprey in the Lower Columbia River Sub-Unit

NatureServe conservation status ranks changed in two of six HUCs in 2017. Ranks fell from S2 (imperiled) to S1 (Critically Imperiled) in the Lewis and from S1S2 to S1 in the Lower Columbia-Clatskanie. Change in the Lewis was likely influenced by using an improved approach to more accurately calculate range extent and area of occupancy, which reduced ranking values (see Methods). The ranking of population size and short-term trend as Unknown also may have contributed to the overall decline in risk rank. In the Clatskanie, the modest decline in risk rank from S2S1 to S1 was influenced by an increase in overall threats severity from moderate to high in Passage and Water Quality categories (Table 14-2).

Current Pacific Lamprey distribution in the Lower Columbia Sub-Unit is still greatly reduced from historical range (Table 14-1). Understanding of Pacific Lamprey distribution has expanded considerably in many Oregon State tributaries due to increased sampling effort (e.g., smolt trapping, redd surveys, occupancy sampling). However, less is known about lamprey distribution in Washington State tributaries. Existing information is largely based upon anecdotal observations, or has been collected incidentally while monitoring salmonid species. Assessment ranking of current distribution was reduced in all HUCs in the Sub-Unit with the exception of the Upper Cowlitz (Table 14-1). As previously mentioned, current Pacific Lamprey distribution was visually estimated from GIS derived occupancy maps in 2011. These estimates were refined in 2017 by overlaying GIS maps with a 1x1 km grid to calculate a numeric area of occupancy as described in Master et al. 2012. Grid calculated occupancy values tended to be more conservative than visual estimates which resulted in a lowering of ranking values. It is important to note that the reduction of ranking values in these areas is a direct result of re-calculating the numeric area of occupancy, rather than a decline in lamprey range. The ratio of current to historical distribution was estimated to be small in the majority of HUCs, ranging from 0.25 to 0.37 in areas with current Pacific Lamprey occupancy (Table 14-1). Ratio ranks were reduced in five HUCs due to the decrease in current distribution (see above).

Numeric estimates of population size were revised from a ranking of unknown in the Lower Columbia-Sandy, Lower Columbia-Clatskanie, and Lower Columbia River HUCs using new information provided by Oregon Department of Fish and Wildlife (ODFW). As part of the monitoring for winter steelhead spawning populations, Oregon Adult Salmonid Inventory and Sampling (OASIS) field crews record data on lamprey spawners and redds that are used to estimate a range of adult abundance (see Jacobsen et al. 2014; Jacobsen et al. 2015; Brown et al. 2017). These estimates are considered minimum population numbers as the surveys are focused on steelhead and end before the completion of Pacific Lamprey spawning. Population size estimates ranged from 50-1000 adults in the Sandy, and from 250-2500 adults in the Clatskanie and Lower Columbia. Adult Pacific Lamprey abundance is still unknown in the Lewis and Lower Cowlitz HUCs. Pacific Lamprey are believed to be extirpated from the Upper Cowlitz River (Table 14-1). Short-term population trend was changed to a ranking of unknown in all HUCs of the Lower Columbia Sub-Unit. No long term counts of Pacific Lamprey exist in tributary or mainstem areas of the Lower Columbia Sub-Unit. Populations are believed to be declined (from historical levels), but adequate information does not exist to estimate the magnitude of the decline. Oregon Department of Fish and Wildlife OASIS estimates provide 2-6 years of good abundance information in select lower Columbia tributaries (i.e., Sandy, Clatskanie, Youngs Bay and Big Creek), but this data set is not long enough to infer population trend.

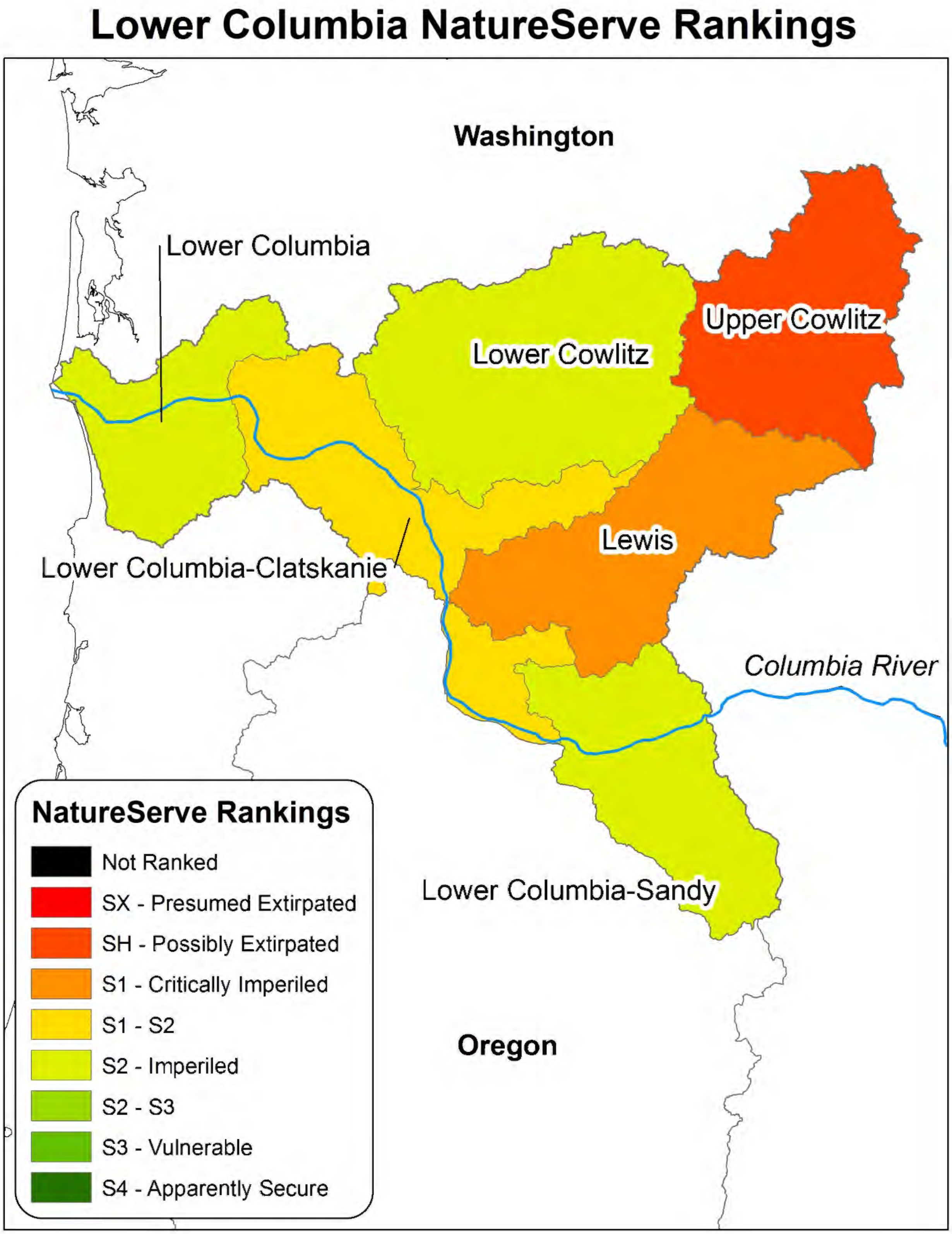

Figure 14-2. Final Conservation status ranks for Lower Columbia Sub-Unit 2017.

Threats and Limiting Factors to Pacific Lamprey in the Lower Columbia River Sub-Unit

Summary

The highest priority threat to Pacific Lamprey in the Lower Columbia River Sub-Unit is dewatering and flow management followed by passage, stream and floodplain degradation, and water quality (Table 14-3). Water quality was the only new priority threat in 2017, increasing from a low to moderate threat. Average scope and severity values for dewatering and flow management and stream and floodplain categories increased slightly from the 2011 Assessment, while scope and severity values fell slightly in the passage category. Scope and severity values for predation, small population size, lack of awareness, and climate change were largely unchanged from 2011, ranking high in scope and unknown in severity. Categories for disease and small population size were once again ranked as unknown for both scope and severity in all HUCs due to insufficient information. The highest ranked threats in the sub-unit are discussed below.

Dewatering and Flow Management.—Dewatering and flow management was ranked a moderate threat overall in the Lower Columbia River Sub-Unit. The scope and severity of this threat remained high in the Lewis, Upper Cowlitz, and Lower Cowlitz watersheds where instream flow is altered by large hydroelectric dams. In the remainder of HUCs, severity values remained the same or dropped in 2017, but scope was increased in all areas due to flow and backwater effects from Bonneville Dam. The Columbia River mainstem downstream from Bonneville Dam is highly susceptible to frequent fluctuations in discharge and water level resulting from the operation of Bonneville Dam for hydropower production and flood control. Flow regulation has significantly altered the natural flow patterns of the Columbia River (see Lower Columbia Fish Recovery Board 2010), which may influence migration timing or rates. Rapid water level fluctuations below Bonneville Dam (i.e., hydropeaking) can directly impact the quantity, accessibility and suitability of spawning and rearing habitat, especially in shallow water areas. Lamprey larvae are especially vulnerable to stranding as they rear in fine sediments along river margins and delta regions, but impacts related to hydropeaking below Bonneville Dam are unknown (Jolley et al. 2012; Mueller et al. 2015).

Passage.—Passage remained a moderate threat in the Sub-Unit, though the average scope and severity value of the threat decreased in 2017. Scope and severity values remained moderate or high in the Lewis and Cowlitz basins where a series of hydroelectric dams completely block upstream migration and access to important spawning and rearing habitat. Scope and severity values were generally unchanged in the rest of the region with the exception of the Lower Columbia-Sandy where scope and severity values were reduced from high to moderate, and the Lower Columbia where severity was reduced from high to moderate. Road crossing culverts, tide gates and small diversion dams/weirs are widespread throughout the watersheds of the Lower Columbia Sub-Region. Many structures occur low in watersheds (near tributary outlets), preventing access to miles of potential habitat.

Stream and Floodplain Degradation.—Stream and floodplain degradation was ranked moderate in scope and severity in all watersheds except the Lower Columbia-Clatskanie and Lower Columbia where scope values increased from moderate to high. Human settlement and land development have greatly altered the physical habitat of tributaries in the Sub-Unit. In upland areas, stream cleaning, forest fires (e.g., Yacolt Burn), and historical timber harvest practices have completely deforested or altered the diversity and age structure of riparian vegetation and trees. Within lowland areas, river channels have been straightened, diked and armored to protect property against flooding and erosion. Channel simplification and conversion of land for agriculture, grazing, and development (rural, urban, commercial, industrial) has reduced or eliminated a substantial amount of side channel and wetland habitat. The Columbia River mainstem below Bonneville Dam has been straightened and confined by major railroad and transportation corridors that run parallel to the river. Much of the shoreline is armored with riprap and connection to tributaries occurs through culverts and bridges. In the Lower Columbia River and estuary, dikes and levees have disconnected the mainstem from floodplain and estuary habitat (e.g., tidal swamp, marsh, wetlands), reducing the river to a single channel. Efforts to maintain the shipping channel (e.g., jetties, pile dikes) have altered flow patterns and increased sediment accumulation that requires periodic dredging to remove. The impacts of channel maintenance dredging on larval lamprey in the Lower Columbia River have not been thoroughly documented. Dredging may displace, injure or kill burrowing larvae, disturb or destroy potential rearing habitat, or re-suspend contaminated sediments into the river (Maitland et al. 2015; Clemens et al. 2017).

Water Quality.**—**Threats due to water quality increased from an overall ranking of low in 2011 to a ranking of moderate in 2017. Scope and severity values were unchanged in the Lower Columbia-Sandy, Lewis, and Cowlitz basins, however, rankings were increased from low and unknown to high for both scope and severity in the Lower Columbia-Clatskanie, and from low and unknown to moderate in scope and high in severity in the Lower Columbia. The higher threat ranking in these areas is primarily due to impaired water quality conditions in the Columbia River mainstem. Major water quality concerns in the Lower Columbia River mainstem include elevated water temperature, low dissolved oxygen, gas supersaturation, and biological and chemical contaminants. Average water temperature below Bonneville Dam often exceeds 19°C in late June to early September (Bragg and Johnston 2016). High water temperatures are likely a result of warmer ambient temperatures and cumulative effects of water withdrawal and land use activities in tributary and mainstem areas. Dissolved gas supersaturation resulting from spill from Bonneville Dam can exceed the EPA mandated limit of 110% saturation for several months during normal and low water years (Schneider and Barko 2006). These levels may extend throughout the entire lower Columbia River. The vulnerability of Pacific Lamprey to gas bubble disease or potential sensitivity at different life stages is unknown. Industrial discharge and surface water runoff from farms, roads and urban areas are the primary source of contaminants entering the Columbia River mainstem. Toxic contaminants such as DDE, PCBs, and heavy metals settle out and accumulate in fine sediments, reaching concentrations that may be harmful to aquatic and terrestrial organisms.

Table 14-2. Threats to Pacific Lamprey and their habitats within the Lower Columbia River Sub-Region, as identified and ranked by participants at regional meetings in 2017.High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Lower Columbia-Sandy	2.5	3	3.5	2	2.5	3	3	3	1	1	4	U
Lewis	3	3	4	4	3	3	3	3	1	1	3	U
Upper Cowlitz	4	4	4	4	3	3	1	1	1	1	U	U
Lower Cowlitz	3	3	3	4	3	3	1	2	1	1	4	U
Lower Columbia-Clatskanie	3.5	4	3	3	4	3	3.5	3.5	1	1	3.5	U
Lower Columbia	2	2.5	2.5	2	3.5	3	3	4	1	1	4	U
Mean	3.00	3.25	3.33	3.17	3.16	3.00	2.42	2.75	1.00	1.00	3.70	
Rank	M	H	M	M	M	M	L	M	I	I	H	
Mean Scope & Severity	3.13		3.25		3.08		2.59		1.00			
Drainage Rank	M		M		M		M		I			

	Disease		Small Population Size		Lack of Awareness		Climate Change	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Lower Columbia-Sandy	U	U	U	U	4	U	4	U
Lewis	U	U	U	U	4	U	4	U
Upper Cowlitz	U	U	4	U	4	U	4	U
Lower Cowlitz	U	U	U	U	4	U	4	U
Lower Columbia-Clatskanie	U	U	U	U	4	U	4	U
Lower Columbia	U	U	U	U	4	U	4	U
Mean			4.00		4.00		4.00	
Rank			H		H		H	
Mean Scope & Severity								
Drainage Rank								

Table 14-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed by RMU partners in the Lower Columbia Sub-Unit from 2012-2017.

HUC	Threat	Action Description	Type	Status
RMU	Population	Environmental DNA, spawning ground surveys, smolt trapping and occupancy sampling to better understand lamprey distribution.	Survey	Ongoing
RMU	Stream Degradation	Implementation of instream and floodplain habitat restoration activities.	Instream	Ongoing
RMU	Passage	Evaluation of adult Pacific Lamprey passage efficacy at fishways and barrier dams associated with salmon hatcheries.	Assessment	Underway
RMU	Population	Distribution surveys of mainstem and principal tributaries	Survey	Ongoing
RMU	Population	Use of eDNA to monitor effectiveness of large wood placement projects and recolonization of larval lamprey following restoration	Assessment	Proposed/ Underway
RMU	Lack of Awareness	Consideration of lamprey when planning and implementing instream habitat restoration work	Coordination	Ongoing
RMU	Passage	Map, assess and prioritize passage barriers in tributaries and evaluate available lamprey habitat upstream	Assessment	Proposed
Sandy	Stream Degradation	Sandy River floodplain reconnection, gravel augmentation in Bull Run River.	Instream	Complete
Sandy	Stream Degradation	Large wood augmentation, side channel reconnection in upper Sandy River.	Instream	Complete
Clatskanie	Population	Conduct adult spawning ground surveys to monitor Pacific Lamprey distribution, timing, and number of redds to develop relative abundance indexes.	Survey	Ongoing
Clatskanie	Population	Deep water sampling to document distribution and habitat use of larval lamprey in Columbia River mainstem.	Assessment	Complete
Clatskanie	Passage	Tide gate and culvert modification and removal projects to restore access to spawning and rearing habitat.	Instream	Ongoing
Lower Columbia	Passage	Evaluation of passage constraints for lamprey at Big Creek and North Fork Klaskanine Hatchery diversions	Instream	Proposed
Lower Columbia	Population	Conduct adult spawning ground surveys to monitor Pacific Lamprey distribution, timing, and number of redds to develop relative abundance indexes.	Survey	Ongoing

Lower Columbia	Passage	Tide gate and culvert modification and removal projects to restore access to spawning and rearing habitat.	Instream	Ongoing
Lower Columbia	Population	Investigation of salinity tolerance and larval lamprey occurrence in tidally influenced estuarine stream.	Assessment	Complete

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Steve Wise	Sandy River Basin WC

15. MID-COLUMBIA RIVER REGION

Summary

The Mid-Columbia River Regional Management Unit includes watersheds that drain into the Columbia River mainstem from the Walla Walla River at River Kilometer (Rkm) 507, west to Bonneville Dam at Rkm 235 (Figure 15-1). It is comprised of sixteen 4th field HUCs ranging in size from 1,793−8,158 km^2 (Table 15-1). Overall, there were relatively few changes to Mid-Columbia NatureServe risk rankings in the 2017 Assessment. Final Conservation Status Ranks changed in three HUCs and the majority of HUCs with Pacific Lamprey occupancy were categorized as Critically Imperiled (S1). Information availability and data quality were highest in the Walla Walla, Umatilla, Mid-Columbia Hood, Klickitat and Lower Deschutes RMUs. The status of Pacific Lamprey in Willow Creek is still unknown and Pacific Lamprey are still believed to be Possibly Extirpated (SH) or Presumed Extirpated (SX) in Walla Walla, Trout Creek, and all HUCs upstream from Pelton Dam in the Deschutes River basin (Table 15-1). The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks changed in three Mid-Columbia HUCs in 2017. Ranks fell from Imperiled (S2) to Critically Imperiled (S1) in the Umatilla and Mid-Columbia-Hood and from S1S2 to S1 in the Lower John Day. Changes in these areas are likely the result of using an improved approach to more accurately calculate historical range extent.
- Current Pacific Lamprey distribution remained the same in all HUCs, except the Umatilla and Mid-Columbia Hood which saw an increase in the extent of distribution. This increase may be attributable to successful adult translocation work in the Umatilla basin, passage improvements, or increased sampling effort.
- Population abundance of Pacific Lamprey in the Mid-Columbia RMU is largely unchanged since the 2011 Assessment. The Umatilla is the only watershed that has observed an increase in adult populations over the last 5-10 years.
- Although no long term count of Pacific Lamprey exists in Mid-Columbia tributaries, populations are believed to be declined by 10-70%. The Klickitat was the only subbasin to observe a further decline of Pacific Lamprey populations (from 10-30% to 50-70%) in the last five years.
- Columbia River mainstem passage and climate change continue to pose the greatest threat to Pacific Lamprey in the Mid-Columbia RMU. Small population size was the only new priority threat in 2017.

A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the Mid-Columbia Region can be found in the Regional Implementation Plan for the Mid-Columbia Regional Management Unit (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Table 15-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the Mid-Columbia Region. S1 = Critically Imperiled. SH = Possibly Extinct. Conservation Status Ranks highlighted in yellow indicate a decline (↓) or improvement (↑) in status in 2017 from 2011.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km^2)	Current Occupancy (km^2)	Population Size (adults)	Short-Term Trend (% decline)
Walla Walla	17060102	SX	1000-5000	Extinct	Zero to 1-50	>70%
Umatilla	17060103	S1↓	1000-5000	100-500	1000-2500	10-30%
Willow	17060104	SU	Not ranked	Not ranked	Not ranked	Not ranked
Mid-Columbia – Hood	17060105	S1↓	1000-5000	100-500	250-1000	Unknown
Klickitat	17060106	S1	1000-5000	20-100	50-250	50-70%
Upper John Day	17070201	S1	1000-5000	100-500	50-1000	50-70%
North Fork John Day	17070202	S1	1000-5000	100-500	50-1000	50-70%
Middle Fork John Day	17070203	S1	1000-5000	100-500	250-1000	50-70%
Lower John Day	17070204	S1↓	5000-20,000	100-500	50-1000	50-70%
Upper Deschutes	17070301	SX	1000-5000	Extinct	Extinct	Not ranked
Little Deschutes	17070302	SX	Not ranked	Extinct	Extinct	Not ranked
Beaver-South Fork	17070303	SX	1000-5000	Extinct	Extinct	Not ranked
Upper Crooked	17070304	SX	1000-5000	Extinct	Extinct	Not ranked
Lower Crooked	17070305	SX	1000-5000	Extinct	Extinct	Not ranked
Lower Deschutes	17070306	S1S2	1000-5000	100-500	2500-10,000	10-50%
Trout	17070307	SH	1000-5000	Zero	Zero	Unknown

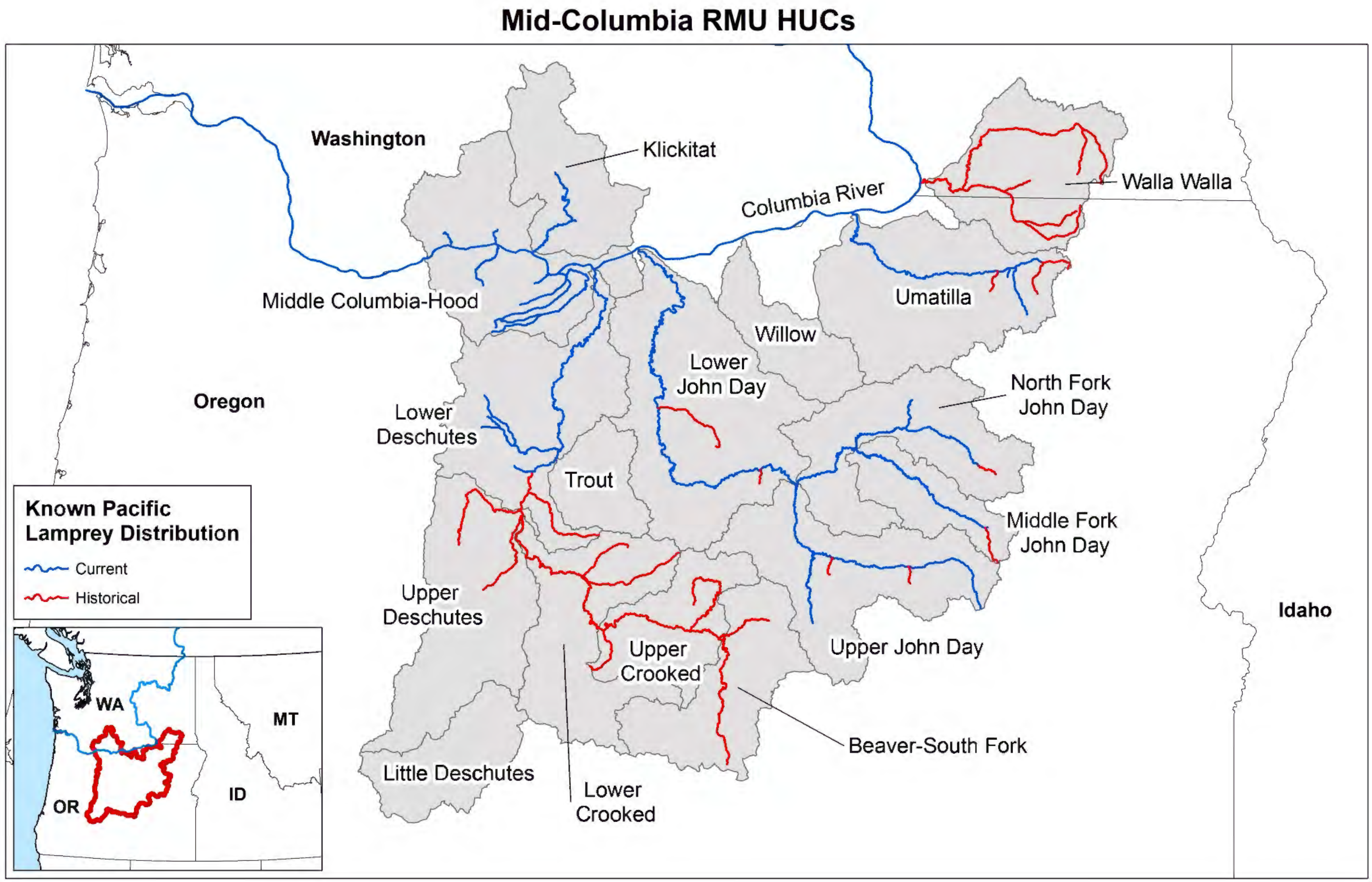

Figure 15-1. Current Pacific Lamprey distribution and location of 16 4th Field HUCs in Mid-Columbia RMU (USFWS Data Clearinghouse 2017).

Ranked Population Status of Pacific Lamprey in the Mid-Columbia RMU

NatureServe conservation status ranks changed in three of 16 HUCs in 2017. Status ranks fell from S2 (imperiled) to S1 (Critically Imperiled) in the Umatilla and Mid-Columbia Hood, and from S1S2 to S1 in the Lower John Day. Changes in these areas are likely the result of using an improved approach to more accurately calculate historical range extent rather than an increase in Conservation risk. During the 2011 Assessment, SIP was used as a surrogate for Pacific Lamprey range extent and NatureServe ranks were visually estimated from GIS derived SIP distribution maps. These estimates were refined in 2017 by overlaying the SIP GIS layer with a 1 km^2 grid to calculate a numeric area of historical range extent (see Chapter 3). Calculating rather than estimating historical range extent resulted in an expansion of NatureServe rankings in 13 Mid-Columbia River HUCs.

Current Pacific Lamprey distribution in the Mid-Columbia RMU is still greatly reduced from historical range. Distribution of lamprey has remained the same in most watersheds since the completion of the 2011 Assessment with the exception of the Umatilla and Mid-Columbia/Hood which saw an increase in the extent of distribution. This increase may be attributable to successful adult translocation work in the Umatilla basin, passage improvements, or increased sampling effort (e.g., smolt trapping, redd surveys, occupancy sampling). The ratio of current to historical distribution was estimated to be small in the majority of HUCs, ranging from .05 to .25 in areas with current Pacific Lamprey occupancy. Ratio ranks were reduced in seven HUCs likely due to the increase in historical range extent (see above) rather than a decline in lamprey range.

Population abundance of Pacific Lamprey in the Mid-Columbia RMU is largely unchanged since the 2011 Assessment, with estimates ranging from zero to over 10,000 fish (Table 15-1). The Umatilla is the only watershed that has seen an increase in adult populations over the last 5-10 years. The Confederated Tribes of the Umatilla Indian Reservation has an active Pacific Lamprey translocation program, ongoing for the last 20 years. This program has contributed to increases in rearing ammocoetes and number of returning adults (Jackson et al. 1997, Close et al. 2003, Howard et al. 2004). Although no long term count of Pacific Lamprey exists in Mid-Columbia tributaries, populations are believed to be declined by 10-70% (Table 15-1). The Klickitat was the only subbasin to observe a further decline of Pacific Lamprey populations (from 10-30% to 50-70%) in the last five years. Numbers of larval/juvenile lamprey captured in a rotary screw trap near Lyle Falls (Rkm 3.5) have declined from 2,000-4,000 fish annually (2003-2006), to around 50 fish annually (Ralph Lampman, Yakama Nation Fisheries (YNF), personal communication)

The status of Pacific Lamprey in Willow Creek is still unknown. Willow Creek dam (Rkm 84.3) provides no fish passage and targeted sampling has not occurred in the basin. Pacific Lamprey are still believed to be extirpated from the Walla Walla River. Although Western Brook Lamprey are present in the basin, Pacific Lamprey have not been observed during ongoing electrofishing, screw trap and spawning survey efforts. Pacific Lamprey are also believed to be extirpated in Trout Creek as well as the Deschutes River basin upstream from Pelton Dam.

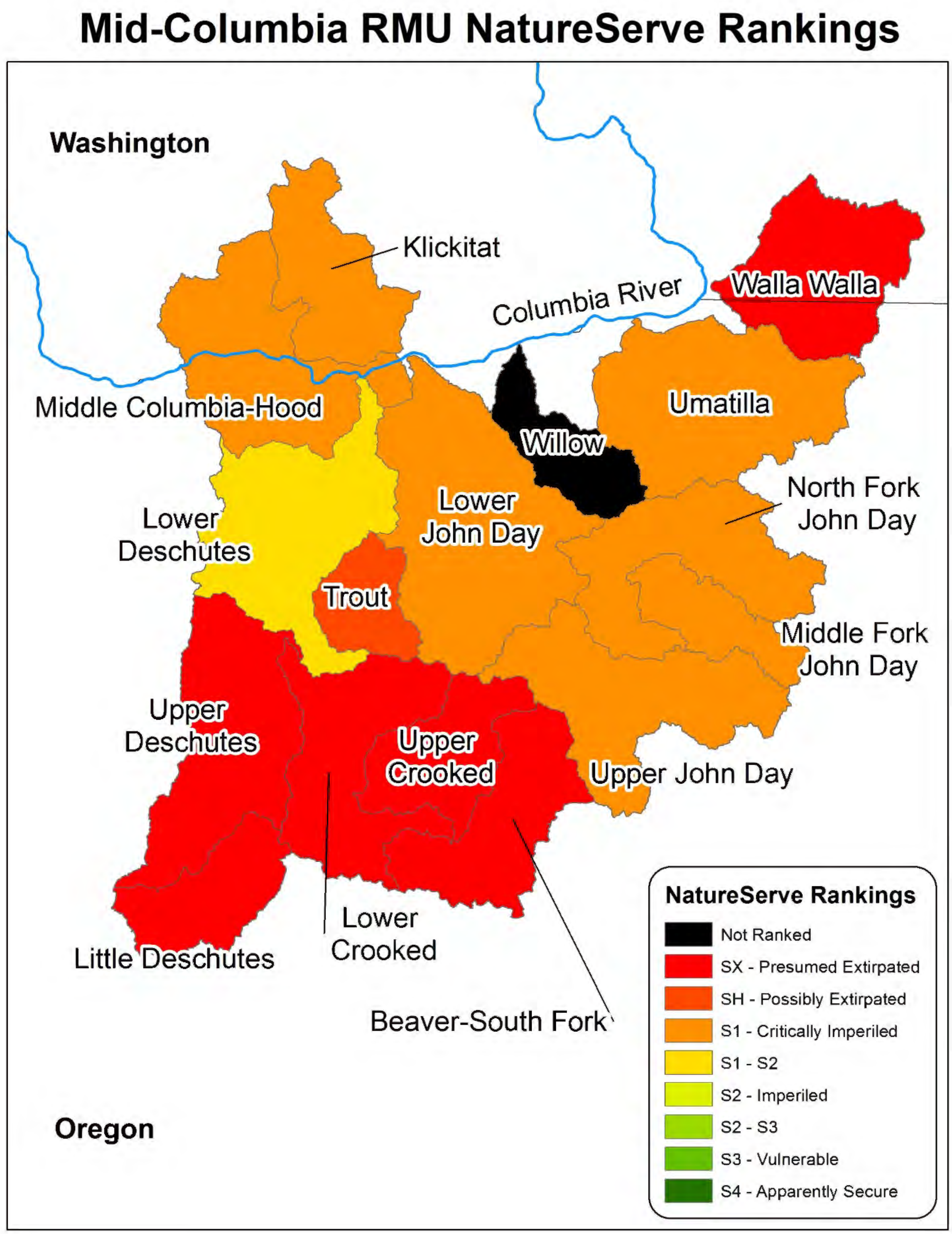

Figure 15-2. Final Conservation status ranks for Mid-Columbia RMU 2017.

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

Summary

Columbia River mainstem passage and climate change continue to pose the greatest threat to Pacific Lamprey in the Mid-Columbia RMU, ranking high in both scope and severity. Water quality, tributary passage, lack of awareness, stream and floodplain degradation, and dewatering and flow management remained moderate threats in 2017, though scope and severity values increased for all categories. Small population size was the only new priority threat in 2017, increasing from a low to moderate threat, and predation was downgraded from a low to insignificant threat. Rankings for the disease category remained unknown for both scope and severity due to insufficient information. The highest ranked threats in the RMU are discussed below.

Passage.**—**Columbia River mainstem passage was ranked a severe threat in the Mid-Columbia RMU. Upstream migration of adults and downstream movement of juveniles is impeded by four Federal Columbia River Power System dams (Bonneville, The Dalles, John Day, and McNary) (see Columbia River mainstem RIP or mainstem chapter for details). Passage in Mid-Columbia tributaries was ranked a moderate threat overall. Scope and severity values increased in many HUCs with the exception of the Mid-Columbia Hood which saw a reduction in scope/severity. Willow and tributaries and mainstem areas of the Upper Deschutes were revised to a ranking of high. Willow Creek Dam (Willow) and Pelton Round Butte Hydroelectric Project (Deschutes River) completely block lamprey passage and have likely led to the extirpation of lamprey in these areas. Passage was also revised to a ranking of high in the Walla Walla. Low head diversion dams for livestock and crop irrigation are numerous in the basin. Many diversions are unscreened or inadequately screened and may entrap or impinge migrating juveniles. Additionally, diversion dams may delay or inhibit the passage of adult lamprey that are unable to navigate past sharp edges (e.g. 90° angles), especially in areas of high velocity (e.g., dam crest; Pacific Lamprey Technical Workgroup 2017). Diversion dams are also an issue of concern in the Umatilla and John Day basins. Passage was increased from a ranking of insignificant to moderate in the Klickitat. A low head weir at Klickitat Hatchery currently impedes adult lamprey access to a substantial portion of suitable habitat in the subbasin. Passage was reduced to a low threat in the Mid-Columbia Hood. Although unscreened diversions remain an issue throughout the HUC, three large dams have been removed from the region since the completion of the 2011 Assessment (i.e., Powerdale Dam, Odell Dam, and Condit Dam), and recent monitoring indicates natural recolonization of Pacific Lamprey is beginning to occur above the former sites of Powerdale Dam on the Hood River and Condit Dam on the White Salmon River (Hess et al. 2015; Jolley et al. 2016).

Climate change.**—**Scope and severity rankings for climate change were unchanged from the 2011 Assessment, remaining high in all watersheds except the Klickitat which ranked as moderate for both scope and severity. Climate changes is expected to produce changes in ambient temperature, precipitation, and streamflow patterns. In a region heavily dominated by agricultural crop production, rising ambient temperatures will likely increase demand for water for irrigation that will in turn reduce streamflows and elevate water temperatures. Climate change is identified as a critical subject for the Mid-Columbia RMU, but the feasibility of making tangible changes will be challenging and require large scale institutional changes.

Water quality.—Water quality conditions are still impaired (ranked moderate or high) in most watersheds with the exception of the Lower Deschutes where scope and severity of the threat was low. Elevated water temperature is the primary water quality concern in the Mid-Columbia RMU. Increased temperatures may be associated with excessive solar radiation, removal of riparian vegetation, reduction of instream flow, and flood irrigation water returns. Other water quality concerns include low dissolved oxygen, pH extremes, sedimentation, and the presence of bacteria, heavy metals, and toxic pollutants (e.g., insecticides, PCBs). These issues are likely attributable to land use practices or other natural causes.

***Small Population Size.*—**Threats from small population size increased from an overall ranking of low in 2011 to a ranking of moderate in 2017. With the exception of the Lower John Day and Lower Deschutes, all HUCs ranked the threat of small population size as moderate or high due to the absence/extirpation of Pacific Lamprey (Walla Walla, Upper Deschutes, Little Deschutes, Beaver-South Fork, Upper Crooked, Lower Crooked) or extremely low abundance (Umatilla (pre-translocation), Hood, and Klickitat).

***Lack of Awareness.*—**Scope and severity rankings for lack of awareness increased to moderate or high in many HUCs with the exception of the Lower Deschutes which remained low in both scope and severity. General knowledge of Pacific Lamprey has improved considerably within conservation and fisheries management communities, however, many stream restoration and passage improvement projects are still funded and designed to benefit salmonids with little understanding of how these actions may impact lamprey. In addition, the general public is still relatively unfamiliar with lamprey, their ecological and cultural importance, and how to avoid impacts to them.

***Stream & floodplain degradation.*—**Stream and floodplain degradation was ranked moderate or high in scope and severity in all watersheds except the Klickitat which ranked as low. Aquatic habitat conditions within the Klickitat and Lower Deschutes HUCs are relatively intact with only moderate impacts to riparian vegetation. In the majority of the Mid-Columbia RMU however, land use activities and human settlement have greatly altered the physical habitat and hydrology of the region. In upland areas, historical and ongoing timber practices have completely deforested or altered the function and diversity of riparian vegetation. Within lowlands, efforts to prevent flooding and provide irrigation for crops and livestock have straightened and scoured streambeds, eliminated side channels and cut off floodplains. Cultivation, riparian clearing and conversion of land for transportation infrastructure, crops, pastures and residential development have filled and/or drained wetlands, increased soil erosion and sedimentation, and promoted the establishment and spread of invasive plant species.

Dewatering and Flow Management.—Dewatering of streams was ranked a moderate to high threat in all but the Klickitat and Lower Deschutes HUCs which ranked dewatering a low threat. Extensive water withdrawals for irrigation leave many watersheds in the Mid-Columbia RMU dewatered or with inadequate flow during summer and fall months. These conditions are most severe in the Walla Walla, Umatilla, and John Day basins where demand often exceeds available water supply. Streamflow is an important determinant of water quality and aquatic habitat conditions (Clemens et al. 2017). Reduced flows may increase water temperatures to critical levels, lower dissolved oxygen levels, reduce spawning and rearing habitat availability, prevent access to backwater or side channel habitats, and create low water barriers.

Table 15-2. Threats to Pacific Lamprey within the Mid-Columbia RMU as identified and ranked at regional meetings in 2017. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Walla Walla	4	4	4	4	4	4	3.5	3.5	1	1	U	U
Umatilla	4	3	3	3.5	4	4	3.5	3	1	1	2	2
Willow	4	4	4	4	4	4	3.5	3.5	1	1		
Mid. Columbia-Hood	2	2	3	4	3	3	3.5	3.5	U	U	1	1
Klickitat	3	3	2	2	2	2	4	3.5	1.5	1	2	2
Upper John Day	3.5	3.5	3.5	3.5	3.5	4	4	4	1	1	2	2
North Fork John Day	2	2	2.5	2.5	2.5	2.5	3	3	1	1	2	2.5
Mid. Fork John Day	2	2	2.5	2.5	3.5	3.5	3	3	1	1	1.5	1.5
Lower John Day	3	3	4	4	3.5	3.5	4	4	1.5	1.5	3	U
Upper Deschutes	4	4							1	1	1	1
Little Deschutes	4	4							1	1	1	1
Beaver-South Fork	4	4							1	1	1	1
Upper Crooked	4	4							1	1	1	1
Lower Crooked	4	4			3	3	3	3	1	1	1	1
Lower Deschutes	2	2.5	1.5	1.5	2.5	2.5	2	2	2.5	2.5	1	1
Trout					3	3						
Mean	3.30	3.27	3.00	3.15	3.21	3.25	3.36	3.27	1.18	1.14	1.50	1.42
Rank	M	M	M	M	M	M	M	M	I	I	L	I
Mean Scope & Severity	3.28		3.08		3.23		3.32		1.16		1.46	
Drainage Rank	M		M		M		M		I		I	

2017 Watershed	Disease Scope	Disease Severity	Small Population Size Scope	Small Population Size Severity	Lack of Awareness Scope	Lack of Awareness Severity	Climate Change Scope	Climate Change Severity	Mainstem Passage Scope	Mainstem Passage Severity
Walla Walla	U	U	4	4	3	3	3.5	3.5	4	4
Umatilla	U	U	3.5	3.5	3	3	3.5	3.5	4	4
Willow	U	U			4	4	4	4	4	4
Mid. Columbia-Hood	U	U	2.5	2.5	2.5	2.5	4	4	4	4
Klickitat	U	U	3.5	3.5	3.5	3	3	3	4	4
Upper John Day	U	U	3	3	3	3	3.5	3.5	4	4
North Fork John Day	U	U	3	3	3	3	3.5	3.5	4	4
Mid. Fork John Day	U	U	3	3	3	3	3.5	3.5	4	4
Lower John Day	U	U	2	2	3	3	3.5	3.5	4	4
Upper Deschutes			4	4	4	4			4	4
Little Deschutes			4	4	4	4			4	4
Beaver-South Fork			4	4	4	4			4	4
Upper Crooked			4	4	4	4			4	4
Lower Crooked			4	4	4	4			4	4
Lower Deschutes	U	U	2	2	2	2	3.5	3.5	4	4
Trout	U	U							4	4
Mean			3.32	3.32	3.33	3.30	3.55	3.55	4.00	4.00
Rank			M	M	M	M	H	H	H	H
Mean Scope & Severity			3.32		3.32		3.55		4.00	
Drainage Rank			M		M		H		H	

Table 15-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed by RMU partners in the Mid-Columbia RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
RMU	Population	Environmental DNA, spawning ground surveys, smolt trapping and occupancy sampling to better understand lamprey distribution.	Survey	Ongoing
RMU	Stream Degradation	Implementation of instream and floodplain habitat restoration activities.	Instream	Ongoing
RMU	Passage	Evaluation of juvenile entrainment mechanisms and preventative measures.	Assessment	Underway
RMU	Population	Development of protocols and techniques for artificial propagation and larval rearing of Pacific Lamprey	Research	Underway
RMU	Dewatering/ flow	Water savings through Columbia Basin Water Transactions Program	Instream	Ongoing
Umatilla	Population	Translocation/reintroduction of adult Pacific Lamprey.	Instream	Underway
Umatilla	Population	Monitoring larval density trends and adult passage success to spawning areas.	Instream	Underway
Umatilla	Passage	Installation of Lamprey Passage Systems to enhance passage for Pacific Lamprey at three water diversion dams.	Instream	Complete
Umatilla	Passage	Telemetry to assess use of Lamprey Passage Systems at diversion dams.	Assessment	Complete
Umatilla	Passage	Sampling of Bureau of Reclamation canals to estimate extent of juvenile entrainment into diversions.	Survey	Ongoing
Umatilla	Passage	Removal of Boyd, Dillon and Brownell diversion dams.	Instream	Complete/ Underway
Mid-Col. Hood	Passage	Monitoring natural recolonization above former site of Powerdale Dam on Hood River and Condit Dam on White Salmon River.	Survey	Ongoing
Mid-Col Hood	Population	Larval occupancy/density surveys in principal tributaries.	Survey	Ongoing
Klickitat	Population	Distribution surveys of mainstems and principal tributaries.	Survey	Ongoing
Klickitat	Passage	Installation of Lamprey Passage Structure at Lyle Falls fish ladder.	Instream	Complete
Klickitat	Passage	Passage improvement for adult Pacific Lamprey at Klickitat Hatchery weir	Instream	Proposed
John Day Basins	Stream Degradation	Large channel restoration project in core area for lamprey (Middle Fork John Day)	Instream	Underway

John Day Basins	Passage	Removal of over 100 push-up diversion dams	Instream	Ongoing
John Day Basins	Passage	Fish screening improvements	Instream	Ongoing
Lower Deschutes	Passage	Installation of LPS at Warm Springs National Fish Hatchery fishway	Instream	Complete

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16. UPPER-COLUMBIA RIVER REGION

RMU Description

The Upper Columbia River Regional Management Unit includes watersheds that drain into the Columbia River upstream of, and including, the Yakima River (Figure 16-1). For the 2017 Assessment, we considered twelve 4th field HUCs ranging in size from 1,735−11,318 km2 (Table 16-1). For the purposes of this discussion, the Lower Crab Creek and Upper Crab Creek HUCs were combined and are referred to as “Crab Creek”. Several smaller fish bearing-streams that are not part of larger watersheds (Foster Creek, Colockum and Lieutenant Murray Wildlife Area creeks) were also included as the “Smaller Tributaries” HUC. Three HUCs located upstream of Chief Joseph and Grand Coulee dams (Sanpoil, Kettle, and Colville) were excluded from this analysis due to the current lack of fish passage at these facilities.

Summary

Overall, there were relatively few changes to Upper Columbia NatureServe risk rankings in the 2017 Assessment. Final Conservation Status Ranks changed in five HUCs: two improved and three declined (Table 9-1). Pacific Lamprey are still believed to be either Critically Imperiled (S1) or Possibly Extinct (SH), in all Upper Columbia RMU HUCs (Table 9-1). Information availability and data quality were highest in the Lower Yakima, Upper Yakima, and Methow HUCs and lowest the Crab Creek, Chelan, Similkameen, and Smaller Tributary HUCs. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks changed in five Upper Columbia HUCs in 2017. Ranks fell from Critically Imperiled (S1) to Possibly Extinct (SH) in the Chelan, Okanogan, and Similkameen HUCs. Rankings rose from Possibly Extinct (SH) to Critically Imperiled (S1) in the Upper Yakima and Naches HUCs. Changes in these rankings largely resulted from real world declines in some systems, adult translocations in others, and implementation of an improved and more accurate approach to calculating historical and current range extent.
- Current Pacific Lamprey distribution shifted within the RMU. Notable distribution increases occurred in the Upper Yakima, Naches, Lower Yakima and parts of the Wenatchee HUCs. Notable decreases occurred in the Similkameen and Okanogan HUCs.
- Overall population abundance of Pacific Lamprey in the Upper Columbia RMU has increased slightly since the 2011 Assessment.
- Increased distribution and abundance rankings are both largely due to adult translocation to the Lower Yakima, Naches, Upper Yakima, Wenatchee and Methow watersheds. Since 2011, at least 3,537 translocated adult Pacific Lamprey have been released within the RMU.
- Decreased distribution and abundance rankings in the Okanogan and Similkameen HUCs are due to a functional loss of Pacific Lamprey in these systems. The last Pacific Lamprey (juveniles, n = 3) reported in the Okanogan were captured a rotary screw trap on April 23, 2010 (Colville Confederated Tribes, unpublished data).
- Conservation and translocation efforts in the Yakima, Wenatchee and Entiat rivers of the RMU have outpaced the Chelan, Methow and Okanogan rivers, where efforts have been more focused on data collection.

- Columbia River mainstem passage and climate change continue to pose the greatest threat to Pacific Lamprey in the Upper Columbia RMU. Predation was the only new priority threat in 2017.

Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 16-4. A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the Upper Columbia Region can be found in the Regional Implementation Plan for the Upper-Columbia Regional Management Unit (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Table 16-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the Upper-Columbia Region. S1 = Critically Imperiled. SH = Possibly Extinct. Conservation Status rankings highlighted in yellow indicate a decline (↓) or improvement (↑) in 2017 relative to the 2011 Assessment.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km^2)	Current Occupancy (km^2)	Population Size (adults)	Short-Term Trend (% decline)
Crab Creek	17020013, 17020015	SH	1000-5000	Zero	Zero	Unknown
Wenatchee	17020011	S1	1000-5000	20-100	250-1000	Stable
Entiat	17020010	S1	1000-5000	100-500	250-1000	Stable
Chelan	17020009	SH↓	Unknown	Zero	Zero	Unknown
Methow	17020008	S1	1000-5000	100-500	50-250	30-50%
Okanogan	17020006	SH↓	1000-5000	20-100	1-50	>70%
Similkameen	17020007	SH↓	<100	Zero	Zero	>70%
Upper Yakima	17030001	S1↑	1000-5000	20-100	1-50	Increasing (+ >10%)
Naches	17030002	S1↑	1000-5000	20-100	1-50	Stable
Lower Yakima	17030003	S1	1000-5000	100-500	250-1000	Increasing (+ >10%)
Smaller Tributaries	--	--	Unknown	Zero	Zero	Unknown

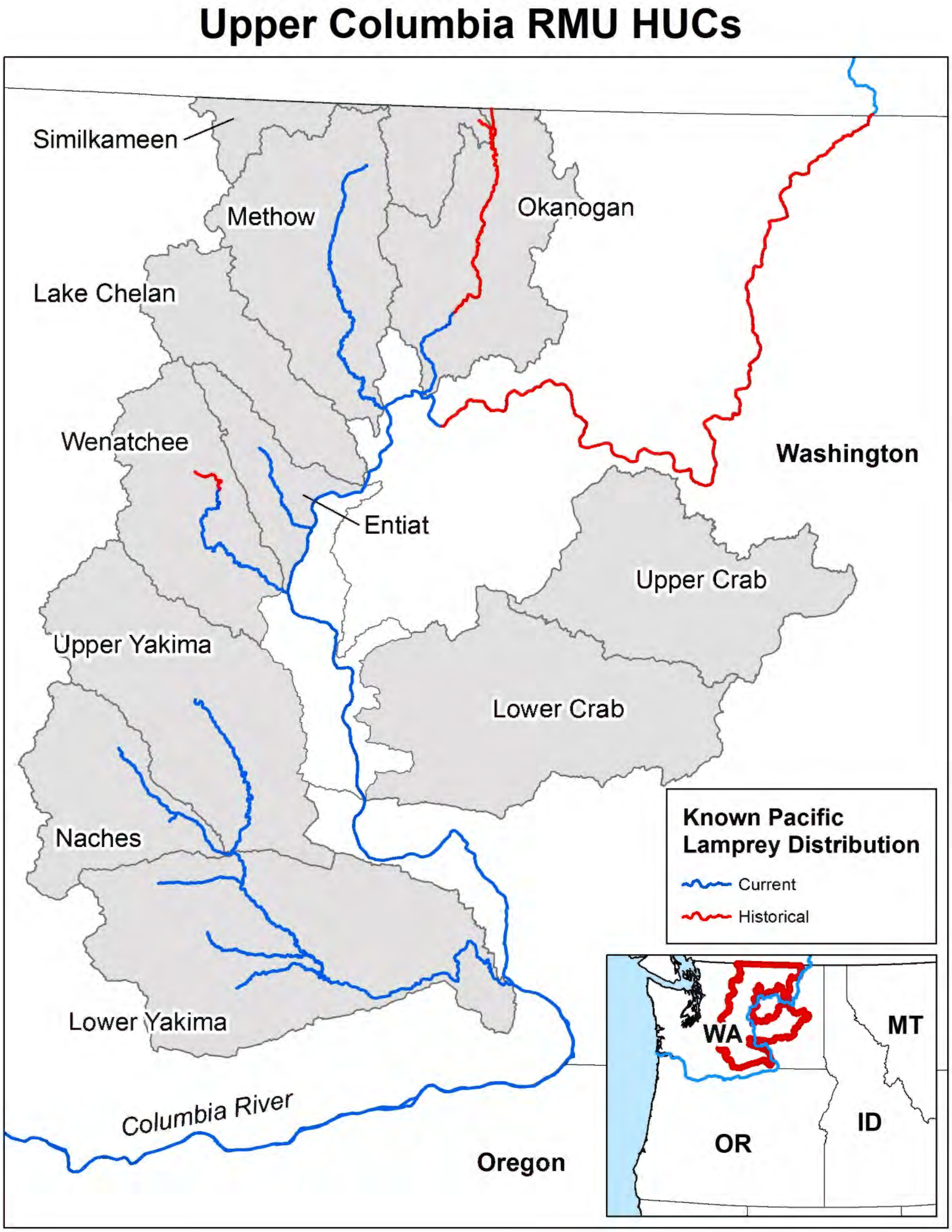

Figure 16-1. Current Pacific Lamprey distribution and location of 16 4th Field HUCs in the Upper Columbia RMU (USFWS Data Clearinghouse 2017).

Ranked Population Status of Pacific Lamprey in the Upper-Columbia RMU

NatureServe conservation status ranks changed in five of ten HUCs in 2017. Status ranks rose from SH (Possibly Extinct) to S1 (Critically Imperiled) in the Upper Yakima and Naches HUCs largely due to adult translocations. At the same time, status ranks fell from S1 (Critically Imperiled) to SH (Possibly Extinct) in the Okanogan, Similkameen and Chelan HUCs. These ranking changes were due, in part, to real-world declines, but were also affected by use of an improved approach to more accurately calculate historical range extent. During the 2011 Assessment, steelhead intrinsic potential (SIP) was used as a surrogate for Pacific Lamprey range extent and NatureServe ranks were visually estimated from GIS derived SIP distribution maps. These estimates were refined in 2017 by overlaying the SIP GIS layer with a 1 km^2 grid to calculate a numeric area of historical range extent (see Chapter 3). Calculating rather than estimating historic and current distribution resulted in decreased current distribution rankings in 5 Upper Columbia River HUCs.

The current Pacific Lamprey distribution in the Upper Columbia RMU is still greatly reduced from historic range, and lamprey distribution within the RMU has shifted since the 2011 Assessment. New survey information suggests that Pacific Lamprey are functionally extinct in several HUCs, whereas translocation efforts have returned lamprey to systems where they were previously extirpated. From 2011 – 2017, the USFWS conducted electrofishing surveys in multiple Upper Columbia tributaries (Wenatchee, Entiat, Mad, Methow, Okanogan, and Chelan rivers). These surveys, combined with screw trapping data from the Colville Confederated Tribes indicate Pacific Lamprey no longer inhabited the Okanogan and Similkameen rivers. Surveys were conducted in the Chelan River, however the historic presence is unknown. Meanwhile, Yakama Nation Fisheries (YNF) began an adult Pacific Lamprey translocation program in 2015 focused on bolstering numbers in lamprey-depleted rivers. To date, YNF has translocated adult Pacific Lamprey to five Upper Columbia RMU HUCs (Methow, Wenatchee, Upper Yakima, Naches, Lower Yakima) (Lampman 2017a, Lampman 2017b, Lampman 2017c). Distribution in the Wenatchee HUC also increased, following translocation releases located upstream of Tumwater Dam which was previously thought to be impassible to lampreys.

Of the ten HUCs ranked 2017, three saw increases in the ratio of current to historical area of distribution, and seven saw decreases (see range extent, current distribution, and ratio calculations in Table 16-1). However, these rankings don't perfectly reflect changes on the ground as the changes we also made to the 2017 occupancy calculation methodology discussed above. This new approach is both more accurate and more conservative, which is reflected in the reduced 2017 distribution rankings of several HUCs (Wenatchee, Entiat, Methow) relative to their 2011 scores.

Overall population abundance of Pacific Lamprey in the Upper-Columbia RMU has increased since the 2011 Assessment, with estimates ranging from zero to 1,000 fish (Table 16-1) per HUC. Lamprey abundance information was collected from screw traps (USFWS, CCT), spawning grounds surveys (USFWS), translocation data (YNF), juvenile electrofishing surveys (USFWS, YNFP), radio telemetry and PIT tag data (USFWS, YNFP, Chelan County PUD), and adult inter-dam conversion rates between Rock Reach, Rock Island, and Wells Dams (Fish Passage Center). No formal population analysis has been conducted for this RMU.

Population rankings increased in five of the Upper Columbia HUCs (Wenatchee, Entiat, Methow, Upper Yakima, and Lower Yakima), stayed constant in three HUCs (Crab Creek, Okanogan and Naches), and decreased in two HUCs (Chelan, and Similkameen). Increased population abundance in the Upper Columbia HUCs is largely due to YNF translocation programs which have both supplemented existing runs (Lower Yakima, Methow), and reintroduced lampreys to areas where they were previously extirpated (Upper Yakima, Wenatchee upstream of Tumwater Dam). Since in 2011, at least 3,537 translocated adult Pacific Lamprey have been released throughout the Upper Columbia RMU (Table 16-2). In 2016, YNF documented naturally reproduced ammocoetes in the Wenatchee River upstream of Tumwater Dam, and YNF work evaluating the reproductive success of translocated lamprey is ongoing. While improved population abundance rankings were widespread throughout the Upper Columbia RMU, the magnitude of these increases is modest. No Upper Columbia HUC is estimated to support more than 1,000 adult Pacific Lamprey. Population abundance in the Chelan and Similkameen HUCs was downgraded from U (Unknown) in the 2011 Assessment to Z (no individuals believe to be extant) in 2017 on the basis of additional surveys and the presence of passage barriers.

Table 16-2. Summary of adult Pacific Lamprey Translocations to HUCs within the Upper Columbia RMU.

Watershed	Translocation Years	YNF Translocated Adults	USFWS Translocated Adults	Translocation Totals
Wenatchee	2016 - 2017	519	0	519
Methow	2015 - 2017	419	0	419
Upper Yakima	2013 - 2015	419	45	45
Naches	2013 - 2014	0	44	44
Lower Yakima	2011 - 2017	1927	164	2091

Upper Columbia RMU Nature Serve Rankings

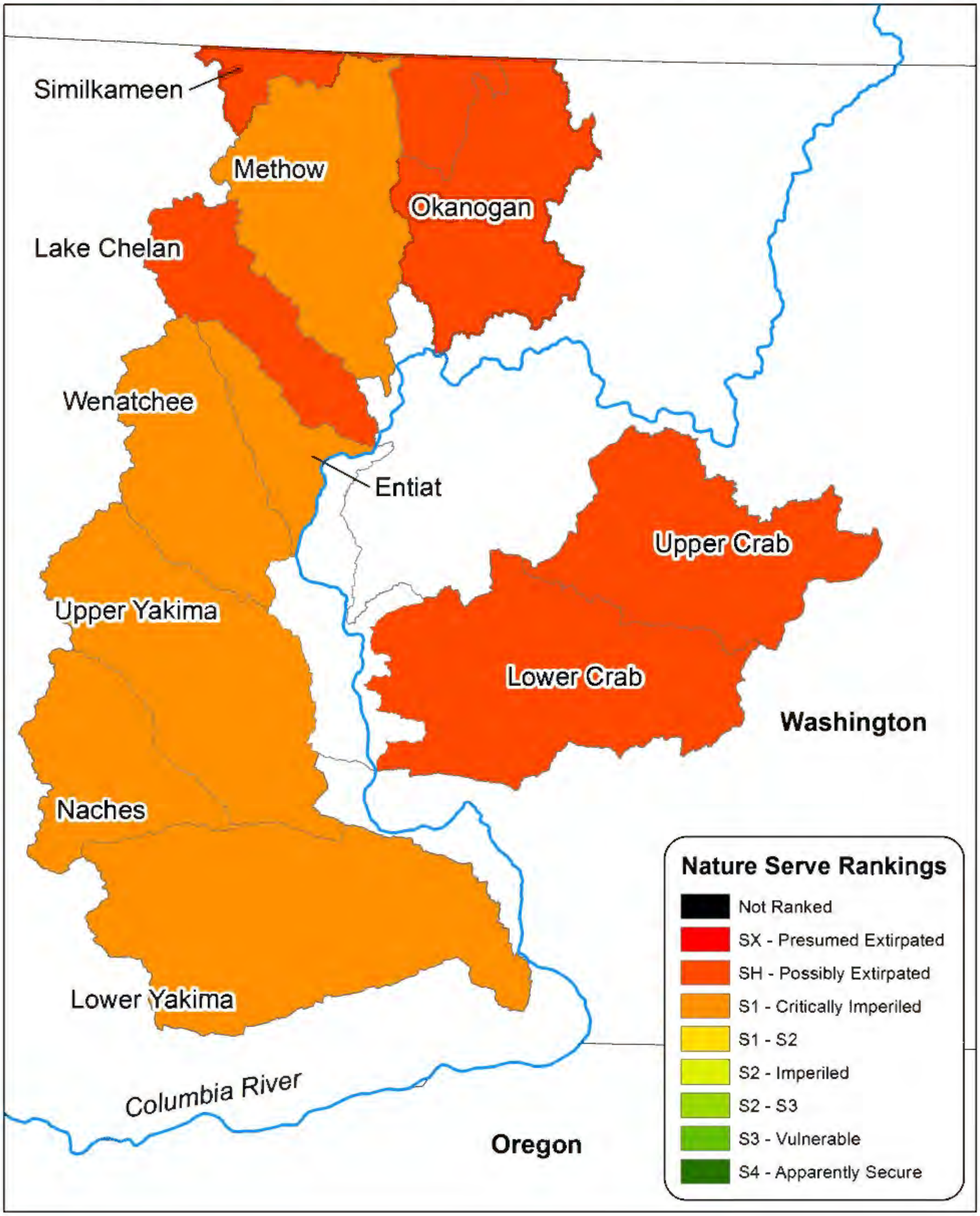

Figure 16-2. Final Conservation status ranks for the Upper-Columbia RMU.

Threats and Limiting Factors to Pacific Lamprey in the Upper-Columbia RMU

See Table 16-3 for threats ranked as low, insignificant or unknown in this RMU. The Okanogan and Similkameen HUCs were combined for the threats analysis, given the limited habitat currently accessible to Pacific Lamprey below Enloe Dam (rkm 14.6).

Summary

Columbia River mainstem passage and climate change continue to pose the greatest threats to Pacific Lamprey in the Upper Columbia RMU, ranking high in both scope and severity. The risk posed by small population size decreased as a result of translocations, dropping this threat from high to moderate. New information on predation increased the risk ranking for this threat from insignificant to moderate. The rankings for dewatering and flow management (moderate), tributary passage (low), water quality (low), and stream and floodplain degradation (low) remained unchanged in 2017, although there were minor increases in the scope and severity scores for the first three categories.

The category of translocation was changed to 'supplementation' in 2017 to include activities such as artificial propagation and translocation, and was ranked an insignificant threat across all HUCs with current lamprey occupancy. Rankings for the disease, harvest, and lack of awareness categories remained unranked for both scope and severity due to insufficient information. The highest ranked (priority) threats in the RMU are discussed below.

Passage.— Columbia River mainstem passage was ranked a severe threat in the Upper Columbia RMU. Upstream migration of adults, and downstream movement of juveniles is impeded by five Federal Columbia River Power System dams (Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells) and no fish passage exists at Chief Joseph and Grand Coulee dams (see Chapter 18 for details). Passage improvements at Chelan County PUD's Rocky Reach Dam have resulted in adult lamprey passage efficiencies exceeding 98% (Maenhout, 2017), while Grant County PUD's Wanapum and Priest Rapids have recorded adult lamprey passage at 87% and 84% respectively (Le et al. 2018). Adult passage at Douglas County PUD's Wells Dam was ranged from 67% to 51% (Robichaud and Kyger 2014); however only a total of 38 adult lamprey were recorded passing the dam for the period of January 1, 2012 to January 1, 2017 (Fish Passage Center 2018). In addition, lamprey passage and survival through reservoirs created by the mainstem Upper Columbia River dams remains poorly understood for all life stages. Passage in Upper Columbia tributaries was ranked a low threat overall, but varies between drainages. Adult passage problems in Yakima River drainages are more problematic in both scope and severity than in other Upper Columbia tributaries. This is due to the numerous agricultural diversion and reservoir storage dams throughout the Yakima sub-basin, including several dams with poor passage (Wanawish/Horn Rapids, Prosser, Roza), and those without fish passage structures (Tieton/Rimrock , Bumping, Keechelus, Kachess, and Cle Elum). Fewer dams in the Upper Columbia drainages result in reduced passage risk in this portion of the RMU, although several structures (Tumwater Dam in the Wenatchee, Enloe Dam on the Similkameen) substantially or completely impeded adult passage and warrant future evaluation. Larval and uvenile lamprey passage remains problematic throughout the Upper Columbia RMU. While most water diversions are screened to prevent entrainment of juvenile salmonids, these screen designs, materials, and mesh sizes are often inadequate to exclude larval and juvenile lampreys.

Climate change.— The overall scope and severity rankings for climate change were unchanged from the 2017 Assessment, remaining high for the Upper Columbia RMU. New information on Pacific Lamprey vulnerability to climate change (Schaller et al. 2017) was the basis of scope and severity rankings for the Methow (both moderate), Upper Yakima (both high) and Lower Yakima (both high). The climate change risk for five HUCs (Chelan, Entiat, Wenatchee, Crab Creek, and Smaller Tributaries) remains unranked due to a lack of information for these watersheds. Climate change is expected to produce changes in ambient temperature, precipitation, and streamflow patterns. In a region heavily dominated by agricultural crop production, rising ambient temperatures will likely increase demand for water for irrigation that will in turn reduce streamflow, elevate water temperatures, and increase larval/juvenile entrainment and dewatering mortality. Owing to its overarching effects on other threat categories, climate change is identified as a critical subject for the Upper-Columbia RMU. However, the feasibility of making tangible changes will be challenging and require large scale institutional changes.

Small Population Size.—The threat from small population size decreased from an overall ranking of high in 2011 to a ranking of moderate in 2017. This decrease was due to adult translocations into HUCs that were previously identified as being most at risk (Lower Yakima) along with HUCs that were not previously ranked (Wenatchee, Entiat, Methow).With the exception of the Entiat and, all HUCs ranked the threat of small population size as moderate or high due to low adult returns, limited larval/juvenile production, and extirpation of Pacific Lamprey above impassable barriers.

Dewatering and Flow Management.—Dewatering of streams was ranked a moderate to high threat in the Yakima drainage, and an insignificant to moderate the rest of the Upper Columbia drainage. Dewatering affects larval/juvenile lamprey directly through stranding mortality, and indirectly through changes in the flow regime and increased exposure to predators. Extensive water withdrawals for irrigation leave many watersheds in RMU dewatered or with minimal flows during summer and fall months. These conditions are most severe in the Yakima HUCs, where irrigation demands are the greatest demand may exceed available water supply. In addition, balancing seasonal water deliveries to the lower Yakima River from headwater reservoirs can result in rapidly fluctuating tributary water levels that leave larval/juvenile lamprey (and other aquatic organisms) stranded. End-of-season dewatering is likewise detrimental to larvae/juveniles that have been entrained in irrigation canals and water delivery systems. Drawdown salvage efforts at irrigation facilities on the Yakima and Wenatchee rivers return tens of thousands of immature lampreys to the river which represents only a small fraction of annual entrainment losses across the RMU.

Predation.—Predation risk was ranked as moderate in 2017, increased from insignificant in 2011. Predation risk was greatest in the three Yakima drainage HUCs and in the Okanogan River because these systems have altered hydrology that favors large populations of non-native piscivores. Predation work by YNF suggest that larval lamprey are susceptible to a wide variety of fish predators, including non-native (smallmouth bass Micropterus dolomieu, common carp Cyprinus carpio, yellow bullhead Ameiurus natalis) and native (white sturgeon Acipenser transmontanus, and sculpin Cottus ssp.) fishes. Several HUCs in the Upper Columbia drainage (Methow, Chelan, Entiat, Wenatchee, Smaller Tributaries, and Crab Creek) were unranked for predation risk because of a lack of information.

Table 16-3. Threats to Pacific Lamprey within the Upper Columbia RMU, as identified and ranked at regional meetings. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Upper Columbia Drainage												
Crab Creek	-	-	2	2	3	3	4	4	-	-	-	-
Smaller Tributaries	1	1	3	2	1	2	1	2	-	-	-	-
Wenatchee	3	3	3	2	3	3	2	2	-	-	-	-
Entiat	1	1	2	2	3	3	2	2	-	-	-	-
Chelan	-	-	-	-	1	1	1	1	-	-	-	-
Methow	1	1	2.5	1	3	3	1	1	-	-	-	-
Okanogan/Similkameen	1	1	3	3	3	3	3	3	-	-	2.5	3
Mean	1.40	1.40	2.58	2.00	2.43	2.57	2.00	2.14	-	-	2.50	3.00
Rank	I	I	M	L	L	M	L	L	-	-	M	M
Mean Scope and Severity	1.40		2.29		2.5		2.07		-		2.75	
Drainage Rank	I		L		M		L		-		M	
Yakima Drainage												
Upper Yakima	4	4	4	4	2	2	2	2	-	-	2	2
Naches	3	3	3	3	2	2	2	2	-	-	2	2
Lower Yakima	3	4	4	4	2	2	4	4	-	-	4	4
Mean	3.33	3.67	3.67	3.67	2.00	2.00	2.67	2.67	-	-	2.67	2.67
Rank	M	H	H	H	L	L	M	M	-	-	M	M
Mean Scope and	3.50		3.67		2.00		2.67		-		2.67	

Severity												
Drainage Rank	H		H		L		M		-		M	
Upper Columbia Region												
Overall	2.13	2.25	2.94	2.56	2.30	2.40	2.20	2.30	-	-	2.63	2.75
Mean Scope & Severity	2.19		2.75		2.35		2.25		-		2.69	
Drainage Rank	L		M		L		L		-		M	

Table 16-3 Continued.

2017	Supplementation		Disease		Small Population Size		Lack of Awareness		Climate Change		Mainstem Passage	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Upper Columbia Drainage												
Crab Creek	-	-	-	-	-	-	-	-	-	-	4	4
Smaller Tributaries	-	-	-	-	-	-	-	-	-	-	4	4
Wenatchee	1	1	-	-	3	3	-	-	-	-	4	4
Entiat	-	-	-	-	2	2	-	-	-	-	4	4
Chelan	-	-	-	-	-	-	-	-	-	-	4	4
Methow	1	1	-	-	3	4	-	-	3	3	4	4
Okanogan/Similkameen	1	1	-	-	4	4	-	-	4	4	4	4
Mean	1.00	1.00	-	-	3.00	3.25	-	-	3.50	3.50	4.00	4.00
Rank	I	I	-	-	M	M	-	-	H	H	H	H
Mean Scope and Severity	1.00		-		3.13		-		3.50	-	4.00	
Drainage Rank	I		-		M		-		H	-	H	
Yakima Drainage												
Upper Yakima	1	1	-	-	4	4	-	-	4	4	4	4
Naches	1	1	-	-	4	4	-	-	3	4	4	4
Lower Yakima	1	1	-	-	3	3	-	-	4	4	4	4
Mean	1.00	1.00	-	-	3.67	3.67	-	-	3.67	4.00	4.00	4.00
Rank	I	I	-	-	H	H	-	-	H	H	H	H
Mean Scope and Severity	1.00		-		3.67		-		3.83		4.00	
Drainage Rank	I		-		H		-		H		H	

Table 16-3 continued.

Upper Columbia Region														
Overall	1.00	1.00	-	-	3.29	3.43	-	-	3.50	3.80			4.00	4.00
Mean Scope & Severity	1.00		-		3.36		-		3.65		-		4.00	
Drainage Rank	I		-		M		-		H		-		H	

Table 16-4. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the Upper Columbia RMU from 2012-2017.

HUC	Threat	Action Description (Agency)	Type	Status
Okanogan	Population	Distribution surveys to evaluate larval lamprey presence in the main stem Okanogan River (USFWS)	Survey	Complete
Methow	Population	Distribution surveys to evaluate the upper extent of larval lamprey presence in the main stem Methow, Chewuch, and Twisp rivers (USFWS, YNFP, MSRF)	Survey	Ongoing
Chelan	Population	Distribution surveys to evaluate larval lamprey presence in the lower Chelan River (USFWS)	Survey	Complete
Entiat	Population	Distribution surveys to evaluate the upper extent of larval lamprey presence in the main stem Okanogan River and Mad River (USFWS)	Survey	Complete
Wenatchee	Population	Distribution surveys to evaluate larval lamprey presence in the main stem Wenatchee River and tributaries (Peshastin Creek, Icicle Creek)(USFWS, YNFP)	Survey	Ongoing
Smaller Tributaries	Population	Distribution surveys to evaluate larval lamprey presence in the Colockum Plateau Streams and Foster Creek (USFWS)	Survey	Complete
Lower Yakima	Population	Distribution surveys to evaluate larval lamprey presence in the main stem Yakima River and tributaries (YNFP)	Survey	Ongoing
Upper Yakima	Population	Distribution surveys to evaluate larval lamprey presence in the main stem Upper Yakima River and tributaries (Wenas Creek,	Survey	Ongoing

		Teanaway River) (YNFP)		
Naches	Population	Distribution surveys to evaluate larval lamprey presence in the main stem Naches River (YNFP)	Survey	Ongoing
Methow	Population	Translocate & release adult lamprey to bolster the existing run (YNFP)	Supplementation	Ongoing
Wenatchee	Population	Translocate & release adult lamprey to bolster the existing run (YNFP)	Supplementation	Ongoing
Lower Yakima	Population	Translocate & release adult lamprey to bolster the existing run (YNFP)	Supplementation	Ongoing
Upper Yakima	Population	Translocate & release adult lamprey to bolster the existing run (YNFP)	Supplementation	Ongoing
Naches	Population	Translocate & release adult lamprey to bolster the existing run (YNFP)	Supplementation	Ongoing
Lower Yakima	Passage	Radio Telemetry assessment of adult lamprey passage at Wanawish, Prosser, Sunnyside, and Wapato Dams (USFWS)	Assessment	Complete
Upper Yakima	Passage	Radio Telemetry assessment of adult lamprey passage Roza Dam (USFWS)	Assessment	Complete
Naches	Passage	Radio Telemetry assessment of adult lamprey passage Cowiche Dam (USFWS)	Assessment	Complete
Lower Yakima	Passage	Construction, operation, and evaluation of vertical wetted wall LPS units at Prosser Dam (USFWS, USBOR, YNFP)	Assessment	Ongoing
Lower Yakima	Passage	Coordinate funding and design of LPS passage structures at Sunnyside and Wapato dams (YNFP, NRCS)	Coordination	Underway
Wenatchee	Passage	Investigate passage constraints for lampreys	Assessment	Complete

		Tumwater Dam (CCPUD)		
Wenatchee	Dewatering/Flow Management	Monitoring and salvage juvenile lamprey entrained at the Dryden irrigation diversion (CCPUD, USFWS, YNFP, WDFW)	Instream	Ongoing
Lower Yakima	Dewatering/Flow Management	Monitor and salvage juvenile lamprey entrained multiple irrigation diversions/canals (YNFP)	Instream	Ongoing
Upper Yakima	Dewatering/Flow Management	Monitor and salvage juvenile lamprey entrained in the Taneum Diversion (YNFP)	Instream	Ongoing
Naches	Dewatering/Flow Management	Monitor and salvage juvenile lamprey entrained multiple irrigation diversions/canals (YNFP)	Instream	Ongoing
RMU	Lack of awareness	Conduct outreach and provide educational opportunities (USFWS, YNFP)	Education	Ongoing
Wenatchee	Lack of awareness	Conduct lamprey identification training (YNFP, USFWS)	Education	Complete
Lower Yakima	Predation	Lab study to investigate larval lamprey susceptibility to predators (YNFP)	Research	Complete

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17. SNAKE RIVER REGION

Summary

The Snake River Region includes the Snake River and all waters draining into it downstream of Hells Canyon Dam to its confluence with the Columbia River (Figure 17-1). There are three Regional Management Units (RMU): the Salmon, Clearwater and Lower Snake, comprised of 23 4th code HUCs that are still accessible to Pacific Lamprey (Table 17-1). Several historically occupied areas are not included in this assessment as they are now blocked by impassable dams. These include the Snake River from Hells Canyon Dam Complex upstream to Shoshone Falls and it's major tributaries (Gilbert and Evermann 1895), and the North Fork Clearwater, now blocked by Dworshak Dam. The Palouse River historically had Pacific Lamprey from the mouth upstream 9.7 km to Palouse Falls (P.Luke, Yakama Tribe, personal communication) but current status has not been reviewed.

There were few changes to the Snake River Region NatureServe risk rankings in the 2017 Assessment. The following are key outcomes of the 2017 Assessment.

- The Upper Grande Ronde, South Fork Salmon and the Wallowa changed from SH (Possibly Extirpated) to S1 (Critically Imperiled) due to supplementation efforts by the Nez Perce Tribe. Change in the Imnaha, Middle Salmon-Chamberlain, Middle Salmon-Panther and Lower Middle Fork Salmon from SH to S1 is the result of either inclusion of data left out of the 2011 assessment or increased occupancy sampling over the last 5 years. Pacific Lampreys have not been found in the Little Salmon in recent years, so the risk rank changed from S1 to SH.
- Aside from the HUCs listed above, Pacific Lamprey distribution and abundance have stayed the same since the 2011 Assessment. The decline in populations remains >70%.
- The combined impact of mainstem passage impediments on the Columbia and Snake rivers is the highest priority threat to the natural distribution, connectivity and effective population size of Pacific Lamprey in the Snake River Region. While individual HUC's and RMU's may be impacted by other threats, mainstem passage is the biggest threat across the region. The second highest threat is small population size, a result of Pacific Lamprey unable to reach the watersheds due to passage issues.
- Recognizing that mainstem passage is the highest priority threat affecting the number of adults returning to the Snake River Region, our ongoing and planned efforts are intended to increase our understanding of the distribution and health of populations across the region, translocate adults as an interim measure while passage is corrected, and to monitor supplementation activities.

Threat rankings are shown in Table 17-2. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed from 2012-2017 are shown in Table 17-3. A summary of completed and ongoing conservation measures, critical uncertainties, and high priority project proposals to address key threats to Pacific Lamprey in the Snake River Region can be found in the Regional Implementation Plan for the Snake River Region (https://www.fws.gov/pacificlamprey/PlansMainpage.cfm).

Table 17-1. Drainage Size and current NatureServe status of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the Snake River Region that are currently accessible to Pacific Lamprey. S1 = Critically Imperiled. SH = Possibly Extinct. Conservation Status rankings highlighted in yellow indicate a decline (↓) or improvement (↑) in 2017 relative to the 2011 Assessment.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km2)	Current Occupancy (km2)	Current Population Size (adults)	Short-term Trend (% decline)
Lower Clearwater	17060306	S1	1000-5000	100-500	1-50	>70%
Middle Fork Clearwater	17060304	S1	250-1000	20-100	1-50	>70%
South Fork Clearwater	17060305	S1	1000-5000	100-500	50-250	>70%
Lochsa	17060303	S1	1000-5000	20-100	1-50	>70%
Lower Selway	17060302	S1	1000-5000	20-100	1-50	>70%
Upper Selway	17060301	S1	1000-5000	20-100	1-50	>70%
Lower Salmon	17060209	S1	1000-5000	100-500	1-50	>70%
Little Salmon	17060210	SH↓	250-1000	4-20 Zero, believed extant	Zero, Extinct	>70%
South Fork Salmon	17060208	S1↑	1000-5000	20-100	50-250	>70%
Middle Salmon-Chamberlain	17060207	S1↑	1000-5000	100-500	1-50	>70%
Lower Middle Fork Salmon	17060206	S1↑	1000-5000	20-100	1-50	>70%
Upper Middle Fork Salmon	17060205	SH	1000-5000	4-20	1-50	>70%
Middle Salmon-Panther	17060203	S1↑	1000-5000	20-100	1-50	>70%
Lemhi	17060204	SH	250-1000	Zero, believed extant	Zero, Extinct	>70%
Pahsimeroi	17060202	SH	250-1000	Zero, believed extant	Zero, Extinct	>70%
Upper Salmon	17060201	SH	1000-5000	Zero, believed extant	Zero, Extinct	>70%
Lower Snake-Asotin	17060103	S1	1000-5000	100-500	50-250	>70%
Lower Grande Ronde	17060105	S1	1000-5000	100-500	1-50	>70%
Upper Grande Ronde	17060104	S1↑	1000-5000	100-500	1-50	>70%
Imnaha	17060102	S1↑	1000-5000	4-20	1-50	>70%
Wallowa	17060105	S1↑	1000-5000	4-20	1-50	>70%
Mainstem Snake R Hells	17060101	S1	1000-5000↑	100-500	1-50	>70%

Canyon						
Lower Snake-Tucannon	17060107	S1	1000-5000	100-500	1-50	>70%

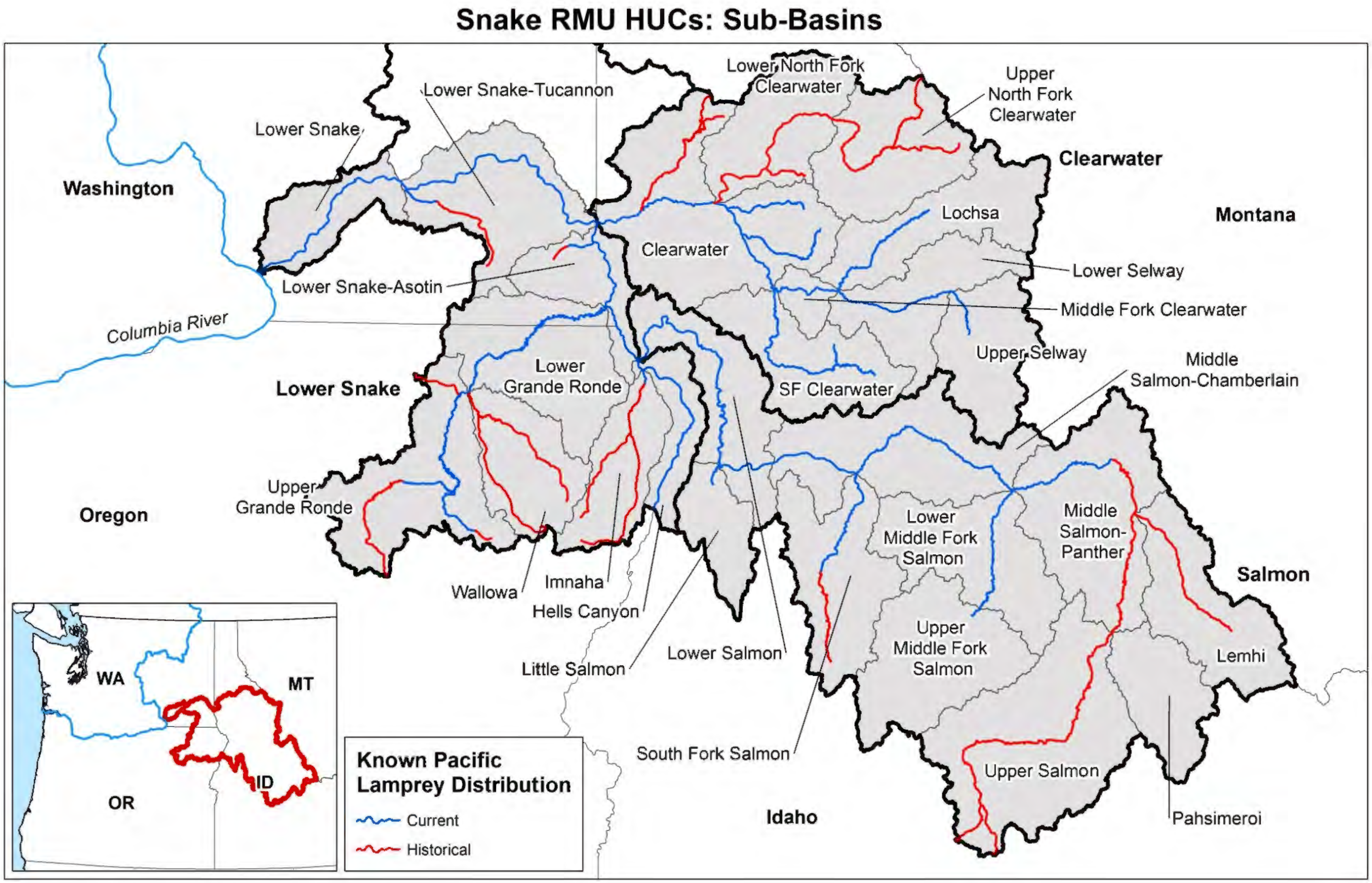

Figure 17-1. Current Pacific Lamprey distribution and location of 16 4th Field HUCs in the Snake River RMU USFWS Data Clearinghouse 2017).

Ranked Population Status of Pacific Lamprey in the Snake River Region

NatureServe conservation status ranks changed in 8 of 23 HUCs in 2017 (Table 17-1). Status ranks improved from SH (Possibly Extirpated) to S1 (Critically Imperiled) in the Upper Grande Ronde, South Fork Salmon and Wallowa as a result of supplementation efforts by the Nez Perce Tribe, and in the Imnaha, Middle Salmon-Chamberlain, Middle Salmon-Panther and Lower Middle Fork Salmon as a result of data collected since the last assessment which filled in knowledge gaps. Sampling in the Little Salmon since 2008 indicates that Pacific Lamprey are no longer in the watershed, so it's ranking fell to SH from S1.

In 2011, Steelhead Intrinsic Potential (SIP) was used as a surrogate for historical Pacific Lamprey range extent, and NatureServe ranks were visually estimated from GIS derived SIP distribution maps. In 2017, these estimates were refined by overlaying the SIP GIS layer with a 1 km2 grid to calculate a numeric area of historical range extent (see Chapter 3). This resulted in changes in Historical and Current Occupancy for several watersheds (Table 17-1). The calculated historical range increased in the Lower Clearwater, Little Salmon and the mainstem Snake River Hells Canyon, but shrank in the Lemhi, Pahsimeroi and Upper Salmon. Current calculated occupancy increased in the South Fork Clearwater, Lochsa, Upper and Lower Selway, Lower Salmon, South Fork Salmon, Middle Salmon-Chamberlain, Lower Snake-Asotin, Upper Grande Ronde, Imnaha, Wallowa, and Mainstem Snake Hells Canyon. Watersheds not ranked in 2011 (Lower Middle Fork Salmon, Upper Middle Fork Salmon, and Lower Snake-Tucannon) now have an occupancy rank.

The current distribution of Pacific Lamprey is severely reduced from the historical extent, with the ratios of current to historical distribution from 0.01 to 0.15 (Appendix X). Adult population abundance increased to 50-250 in the South Fork Clearwater, South Fork Salmon and Lower Snake-Asotin, the result of translocation efforts by the Nez Perce Tribe. In all other watersheds the adult abundance remained at 1-50. These values (Table 17-1) are estimates based on professional opinion, juvenile sampling and redd counts.

Clearwater Basin NatureServe Rankings

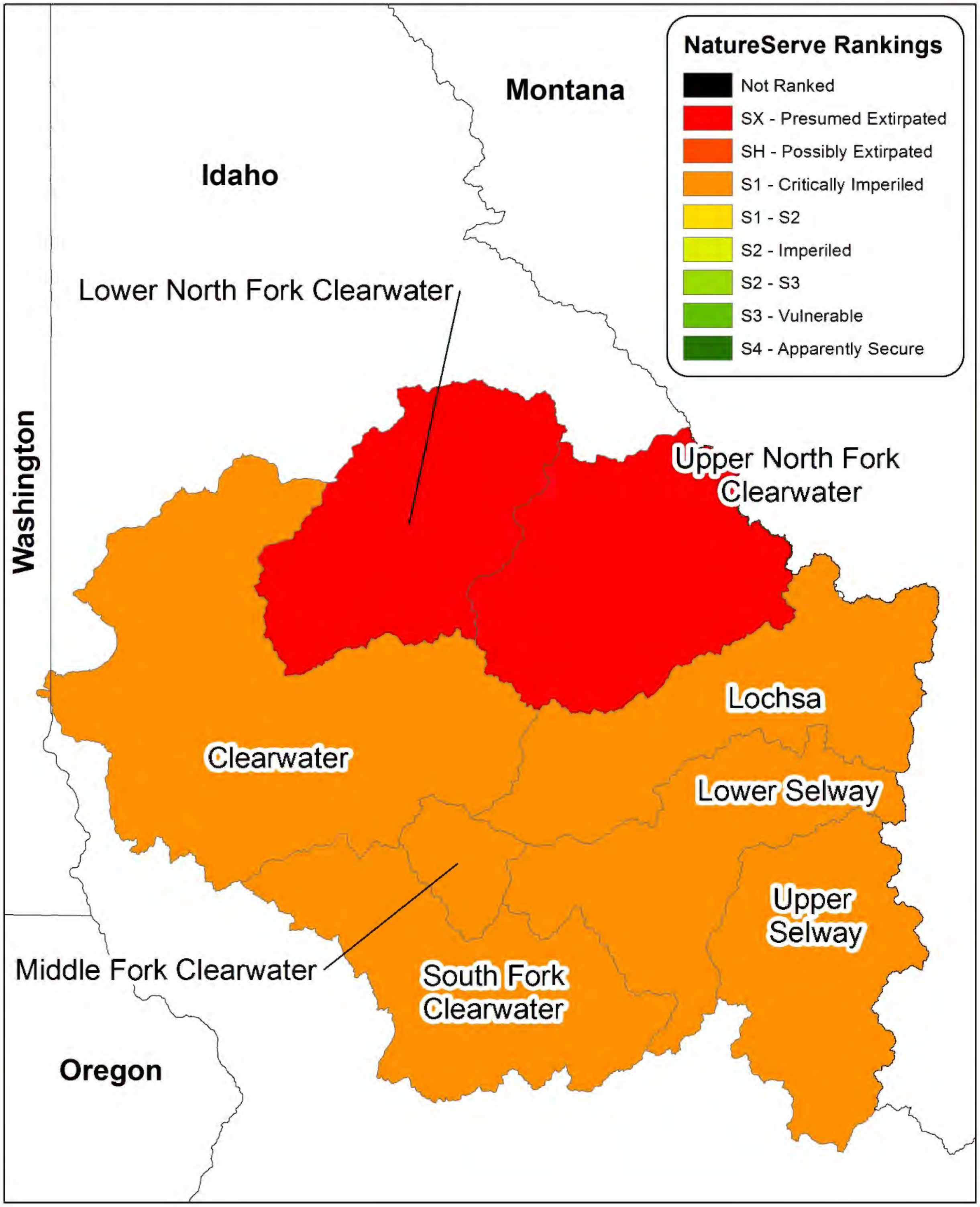

Figure 17-2. Final Conservation status ranks for the Clearwater Basin in the Snake River RMU 2017.

Salmon Basin NatureServe Rankings

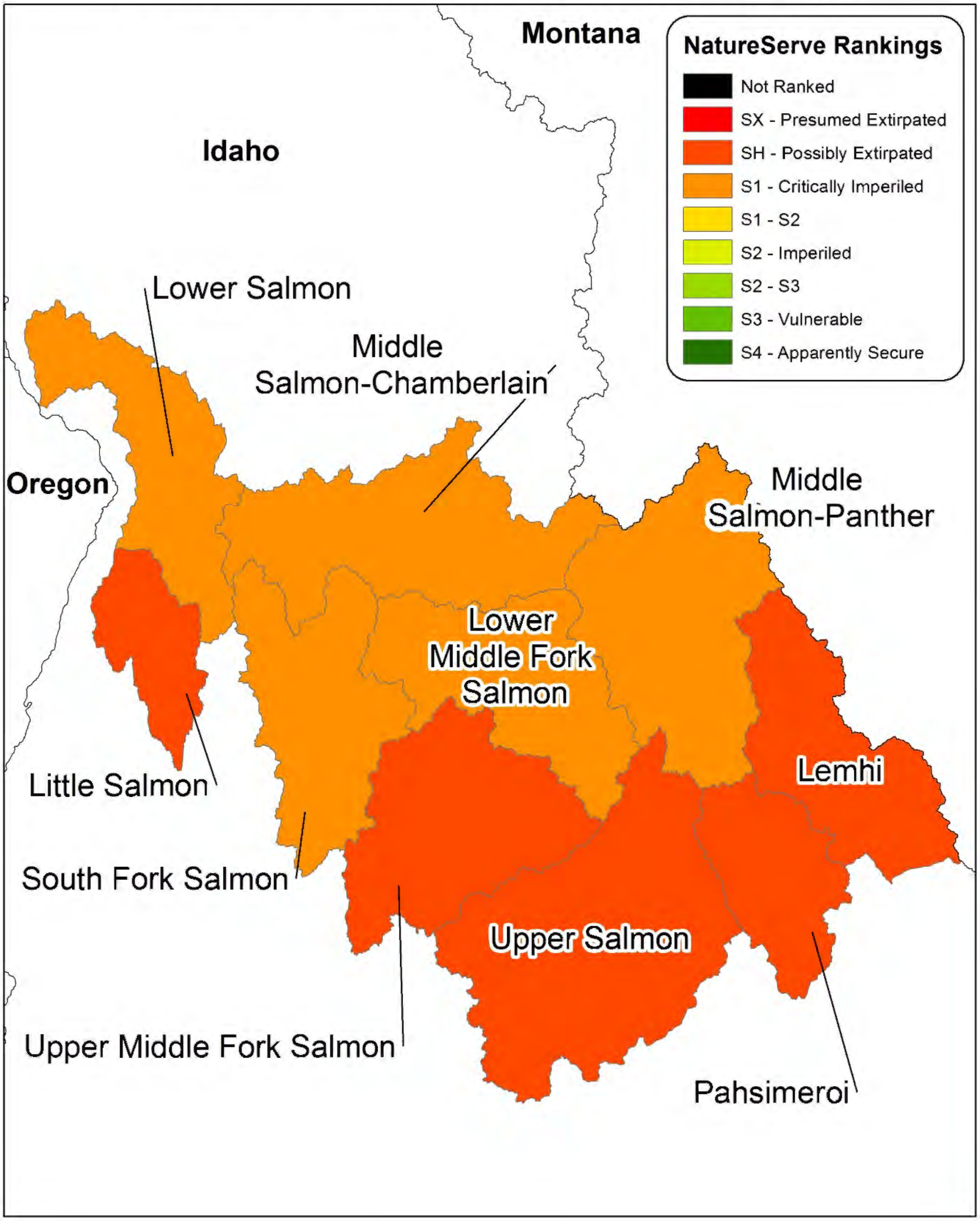

Figure 17-3. Final Conservation status ranks for the Salmon Basin in the Snake River RMU 2017.

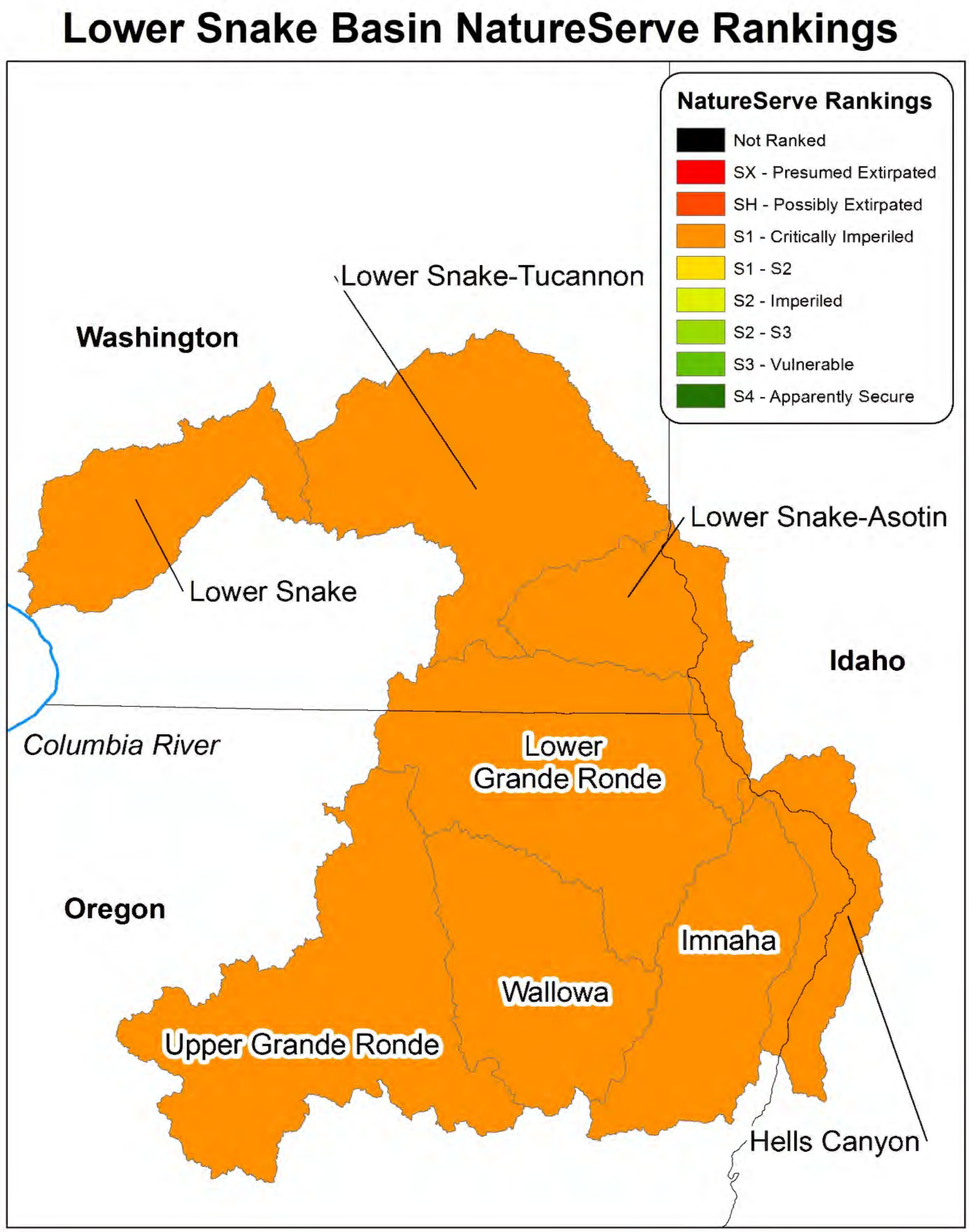

Figure 17-4. Final Conservation status ranks for the Lower Snake Basin in the Snake River RMU 2017.

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

There were not as many participants reviewing threats for the current assessment, compared to the 2011 assessment. Participants in the current assessment only rated threats in watersheds that they were familiar with, so there were several cases where only one agency or tribe rated threats in a watershed. Threat ranks of scope and severity are based on knowledge of the watershed and professional opinion, and are largely subjective.

Summary

The Federal Columbia River Power System dams on the mainstem Snake and Columbia rivers are the highest threat to the persistence of Pacific Lamprey in the Snake River watersheds. Concurrently, the scope and severity of small effective population size was also identified as a priority threat in each of the watersheds reviewed (Table 17-2). Individual RMUs and HUCs that are not in wilderness are impacted in various degrees by stream degradation, passage and water quality. See Table 17-2 for individual threat ranks for all watersheds in the Snake River Region.

Passage.--Tributary passage issues were identified in 18 out of 23 watersheds, but passage overall in these watersheds was rated as low in scope and severity. There has been good progress in the past five years correcting passage issues for anadromous salmonids, with likely some benefit to Pacific Lamprey. Culverts in tributaries and scattered irrigation diversions could be full or partial passage barriers for lamprey in the Lower Snake RMU, and in watersheds of the Clearwater and Salmon RMU's outside of wilderness. Aside from Starbuck Dam on the Tucannon River, no specific barriers were identified in the threat assessment.

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

Stream and Floodplain Degradation.--Across all watersheds, stream and floodplain degradation were rated low in scope and severity. Watersheds in the Lower Snake RMU were ranked as moderate in scope and severity for this threat factor. Channelization due to mining (Upper Grande Ronde, South Fork Clearwater, South Fork Salmon, Middle Salmon-Chamberlain, Middle Salmon-Panther and Upper Salmon) and road construction were the main causal factors, with grazing, timber harvest, agriculture, private development and recreation cited as secondary mechanisms impacting stream and floodplain integrity. Within a watershed scope could be rated as low or moderate but localized impacts could make the severity high.

Water Quality.--Poor water quality was given a rating of low in scope and severity across all watersheds. However, several watersheds have issues with temperature, sediment and heavy metals (due to mining) so that individual watershed scores were rated as moderate. This occurred in the Lower Clearwater, Little Salmon, Lemhi, Pahsimeroi, Lower Snake-Asotin and Lower Snake-Tucannon.

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

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

Climate change was also rated as low in scope and severity across watersheds, but rated moderate to high in watersheds that occur in the lower reaches of the Snake River Region. These watersheds occur in low elevations or are highly impacted by human activities. It is in these areas where changes in climate would have the most adverse impact on Pacific Lamprey as they are less resilient.

Predation rated low across all watersheds, but low to moderate in the Lower Snake RMU, primarily by Smallmouth Bass and Northern Pikeminnow which occur in greater numbers there.

Harvest and disease rated as insignificant across all watersheds. Harvest does not occur, and the occurrence and prevalence of disease in Pacific Lamprey is believed to be rare.

Completed and ongoing conservation measures in the Snake Region are listed in Table 17-3.

Table 17-2. Threats to Pacific Lamprey and their habitats within the Clearwater, Salmon, and Lower Snake River drainages, 2017.High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Clearwater Drainage												
Lower Clearwater	2.17	2.17	2.33	2.33	2.5	2.67	2.67	2.83	1	1	2	2.33
Middle Fork Clearwater	2	2	1.67	1.67	1.83	2	2	2.17	1	1	2	2.33
South Fork Clearwater	2.33	2.17	1.5	1.5	2.83	3.0	2.33	2.17	1	1	2	2.33
Lochsa	1.67	1.67	1.33	1.33	1.67	1.67	1.33	1.33	1	1	1.33	1
Lower Selway	1	1	1	1	1.33	1.33	1	1	1	1	1	1
Upper Selway	1	1	1	1	1	1	1	1	1	1	1	1
Mean	1.66	1.62	1.34	1.34	1.85	1.93	1.59	1.60	1	1	1.47	1.51
Rank	L	L	I	I	L	L	L	L	I	I	I	L
Mean Scope & Severity	1.64		1.34		1.89		1.59		1.0		1.49	
Drainage Rank	L		I		L		L		I		I	

2017	Disease		Small Population Size		Lack of Awareness		Climate Change		Mainstem Passage	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Clearwater Drainage										
Lower Clearwater	1	1.33	4	4	2.83	2.83	2.67	3.0	4	4
Middle Fork Clearwater	1	1	4	4	2.83	2.83	2.33	2.33	4	4
South Fork Clearwater	1	1	4	4	2.83	2.83	2.33	2.33	4	4
Lochsa	1	1	4	4	2.17	2.17	1.33	1.33	4	4
Lower Selway	1	1	4	4	1.83	1.83	1.33	1.33	4	4
Upper Selway	1	1	4	4	1.83	1.83	1.33	1.33	4	4
Mean	1	1.01	4	4	2.22	2.22	1.74	1.76	4	4
Rank	I	I	H	H	L	L	L	L	H	H
Mean Scope & Severity	1.01		4		2.22		1.75		4	
Drainage Rank	I		H		L		L		H	

Table 17-2. Continued.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Salmon Drainage												
Lower Salmon	2	2	2	2	2	2	2	2.33	1	1	2	2
Little Salmon	2	2.33	2.17	2.17	2.17	2.17	2.67	2.67	1	1	2	1.67
South Fork Salmon	1.67	1.67	1	1	2.17	2.17	2.17	2.17	1	1	2	1.67
Mid. Salmon-Chamberlain	1	1	1	1	1.67	1.67	2	2.17	1	1	2	2
Low. Middle Fk. Salmon	1	1	1	1	1	1	1	1	1	1	1	1
Up. Middle Fk. Salmon	1	1	1	1	1	1	1	1	1	1	1	1
Middle Salmon-Panther	2.5	2.5	2.5	3	2.5	2.5	2.5	2	1	1	2	1
Lemhi	2.75	3	3	3	2.5	2.5	2.5	2	1	1	2	1
Pahsimeroi	3	3.33	3.33	3.33	3.33	2.67	2.67	2	1	1	2	1
Upper Salmon	2.67	2	2.67	2	2.67	2.67	2	2	1	1	2	1
Mean	1.98	2.01	1.99	1.97	2.16	2.08	2.08	1.92	1	1	1.77	1.30
Rank	L	L	L	L	L	L	L	L	I	I	L	I
Mean Scope & Severity	1.99		1.98		2.12		2		1		1.54	
Drainage Rank	L		L		L		L		I		L	

2017	Disease		Small Population Size		Lack of Awareness		Climate Change		Mainstem Passage	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Salmon Drainage										
Lower Salmon	1.33	1.67	4	4	2.83	2.83	2.33	2.5	4	4
Little Salmon	1.33	1.67	4	4	2.83	2.83	2	2.5	4	4
South Fork Salmon	1	1.33	4	4	2.83	2.83	2	2.17	4	4
Mid. Salmon-Chamberlain	1	1.33	4	4	2.83	2.83	2	2.17	4	4
Low. Middle Fk. Salmon	1	1	4	4	1.83	1.83	1.33	1.33	4	4
Up. Middle Fk. Salmon	1	1	4	4	1.83	1.83	1.33	1.33	4	4
Middle Salmon-Panther	1.5	1.5	4	4	2.75	2.75	1.5	1.5	4	4
Lemhi	1.5	1.5	4	4	2.75	2.75	1.5	1.5	4	4
Pahsimeroi	1.67	1.67	4	4	3	3	1.33	1.33	4	4
Upper Salmon	1.67	1.67	4	4	2.83	2.83	2	2.17	4	4
Mean	1.23	1.53	4	4	2.6	2.6	1.92	2.09	4	4
Rank	I	L	H	H	M	M	L	L	H	H
Mean Scope & Severity	1.38		4		2.6		2		4	
Drainage Rank	I		H		M		L		H	

Table 17-2. Continued.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Harvest		Predation	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Lower Snake												
Lower Snake-Asotin	2	1.5	1.5	1.5	3	3.5	2.5	2.5	1	1	3	3
Lower Grande Ronde	2	2	1	1	2	2	2	2.5	1	1	2	2.5
Upper Grande Ronde	2	3	3	3.5	3.5	3.5	3	3.5	1	1	2	2
Imnaha	2	3.5	2	3	3.5	3.5	2	2	1	1	2	2
Wallowa	2	3.5	3	3.5	3	3.5	2	3.5	1	1	2.5	2.5
Lower Snake-Hells Canyon	2	3	3	3	2	2.5	1.5	1.75	1	1	2.5	2.5
Lower Snake-Tucannon	2.25	3.5	1.5	2	3.25	3	3	2.5	1	1	2.25	3
Mean	2.04	3.1	2.24	2.64	2.7	2.93	2.24	2.51	1	1	2.15	2.43
Rank	L	M	L	M	M	M	L	M	I	I	L	L
Mean Scope & Severity	2.57		2.44		2.82		2.38		1		2.29	
Drainage Rank	M		L		M		L		I		L	

2017	Disease		Small Population Size		Lack of Awareness		Climate Change		Mainstem Passage	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Lower Snake										
Lower Snake-Asotin	1	1	4	4	3.5	3.5	3	3	4	4
Lower Grande Ronde	1	1	4	4	4	4	4	4	4	4
Upper Grande Ronde	1	1	4	4	4	4	3	3	4	4
Imnaha	1	1	4	4	4	4	3	3	4	4
Wallowa	1	1	4	4	4	4	3	3	4	4
Lower Snake-Hells Canyon	1	1	4	4	3	3	3	3	4	4
Lower Snake-Tucannon	1	1	4	3.75	3	2.75	3.25	3.25	4	4
Mean	1	1	4	3.96	3.64	3.61	3.24	3.24	4	4
Rank	I	I	H	H	H	H	M	M	H	H
Mean Scope & Severity	1.00		3.98		3.63		3.24		4.00	
Drainage Rank	I		H		H		M		H	

Table 17-2. Continued.

2017	Passage	Dewatering and Flow Management	Stream and Floodplain Degradation	Water Quality	Harvest	Predation
Upper Snake Region						
Mean Scope & Severity	2.07	1.92	2.28	1.99	1	1.77
Overall Threat Rank	L	L	L	L	I	L

2017	Disease	Small Population Size	Lack of Awareness	Climate Change	Mainstem Passage
Upper Snake Region					
Mean Scope & Severity	1.21	4	2.54	2.17	4
Overall Threat Rank	I	H	M	L	H

Table 17-3. Conservation actions specifically for or substantially benefitting lampreys that were initiated or completed in the Snake RMU from 2012-2017.

HUC	Threat	Action Description	Type	Status
RMU	Population	Environmental DNA, smolt trapping and occupancy sampling to better understand lamprey distribution.	Survey	Ongoing
Upper and Lower Grande Ronde	Population	Oregon Department of Fish and Wildlife drafting a conservation plan for 4 species of lampreys.	Assessment	Ongoing
Clearwater	Population	Translocation/reintroduction of adult Pacific Lamprey in Little Canyon, Orofino and Lolo creeks. (NPT)	Instream	Ongoing
South Fork Clearwater	Population	Translocation/reintroduction of adult Pacific Lamprey in Newsome Creek. (NPT)	Instream	Ongoing
South Fork Salmon	Population	Translocation/reintroduction of adult Pacific Lamprey In South Fork Salmon River and Johnson Creek. (NPT)	Instream	Ongoing
Lower Grande Ronde	Population	Translocation/reintroduction of adult Pacific Lamprey in Wallowa River and Minam Creek. (NPT)	Instream	Ongoing
Upper Grande Ronde	Population	Translocation/reintroduction of adult Pacific Lamprey in Upper Grande Ronde River and Catherine Creek. (CTUIR)	Instream	Ongoing
Lower Snake-Asotin	Population	Translocation/reintroduction of adult Pacific Lamprey in Asotin Creek. (NPT)	Instream	Ongoing
South Fork Clearwater	Passage	Aquatic Organism Passage restoration in American River. The project improved access to 10+ miles of potential lamprey habitat.	Instream	Complete
South Fork Clearwater	Stream and Floodplain	Over 3 miles of channel reconstruction and riparian restoration in a previously dredged mine section of Newsome Creek	Instream	Ongoing
South Fork Clearwater	Stream and Floodplain	Three miles of stream and riparian area in Red River were restored from conditions created with past dredge mining activity.	Instream	Completed
South Fork Clearwater	Stream and Floodplain	Over three miles of stream and riparian area in Crooked River are being restored from impacts of past dredge mining activity.	Instream	Ongoing
Lower Clearwater	Stream and Floodplain	One mile of stream in the Collette Mine area of Lolo Creek is being reconstructed and the floodplain restored.	Instream	Ongoing

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18. MAINSTEM COLUMBIA AND SNAKE RIVERS REGION

Summary

Historically, the range of Pacific Lamprey extended into tributaries high up into the Columbia and Snake River drainages. As part of completing their anadromous life history, adults need to migrate through these mainstem corridors to reach the spawning grounds, and, subsequently, juveniles need to migrate from the spawning areas to the ocean through the same corridors. Pacific Lamprey originating in the Snake River basin would migrate through eight mainstem hydroelectric dams as juveniles during their seaward migration and again as returning adults. Pacific Lamprey originating in the upper Columbia River basin would migrate through between four and nine mainstem hydroelectric dams. Pacific Lamprey originating from the middle Columbia River basin would migrate between one and four mainstem hydroelectric dams. Moser and Mesa (2009) found that hydropower dams can delay or obstruct adults, and turbine entrainment or screen impingement can kill or injure juveniles. In order to assess the impacts of the configuration and continued operation of the hydroelectric dams on Pacific Lamprey, we divided the mainstem areas ion to four sub-regions, but focused the threats assessment on the three sub-regional areas above Bonneville dam, the most downstream facility in the Federal Columbia River Power System (Figure 18-1). The mainstem Snake and Columbia River Region consists of the following areas:

Snake Basin – Mainstem habitats of the Snake River. Major tributaries to this area include the Salmon and Clearwater rivers. See Chapter 17 for geographic descriptions on the Snake River Region.

Upper Columbia – Mainstem Columbia River above the confluence of the Snake River. Major tributaries to this area include the Yakima, Naches, Wenatchee, Entiat, Methow, and Okanogan Rivers. See Chapter 16 for geographic descriptions on the Upper Columbia River Region

Mid-Columbia – Mainstem Columbia River from Bonneville Dam to the confluence of the Snake River. Major tributaries to this area include the Hood, Klickitat, Umatilla, Walla Walla, John Day, and Deschutes rivers. See Chapter 15 for geographic descriptions on the Mid-Columbia River Region.

Lower Columbia – Mainstem Columbia River below Bonneville Dam. Major tributaries to this area include the Sandy, Lewis, Cowlitz, and Clatskanie rivers. The threats assessment is not addressed in this chapter. See Chapter 14 for geographic descriptions on the Lower Columbia River Region.

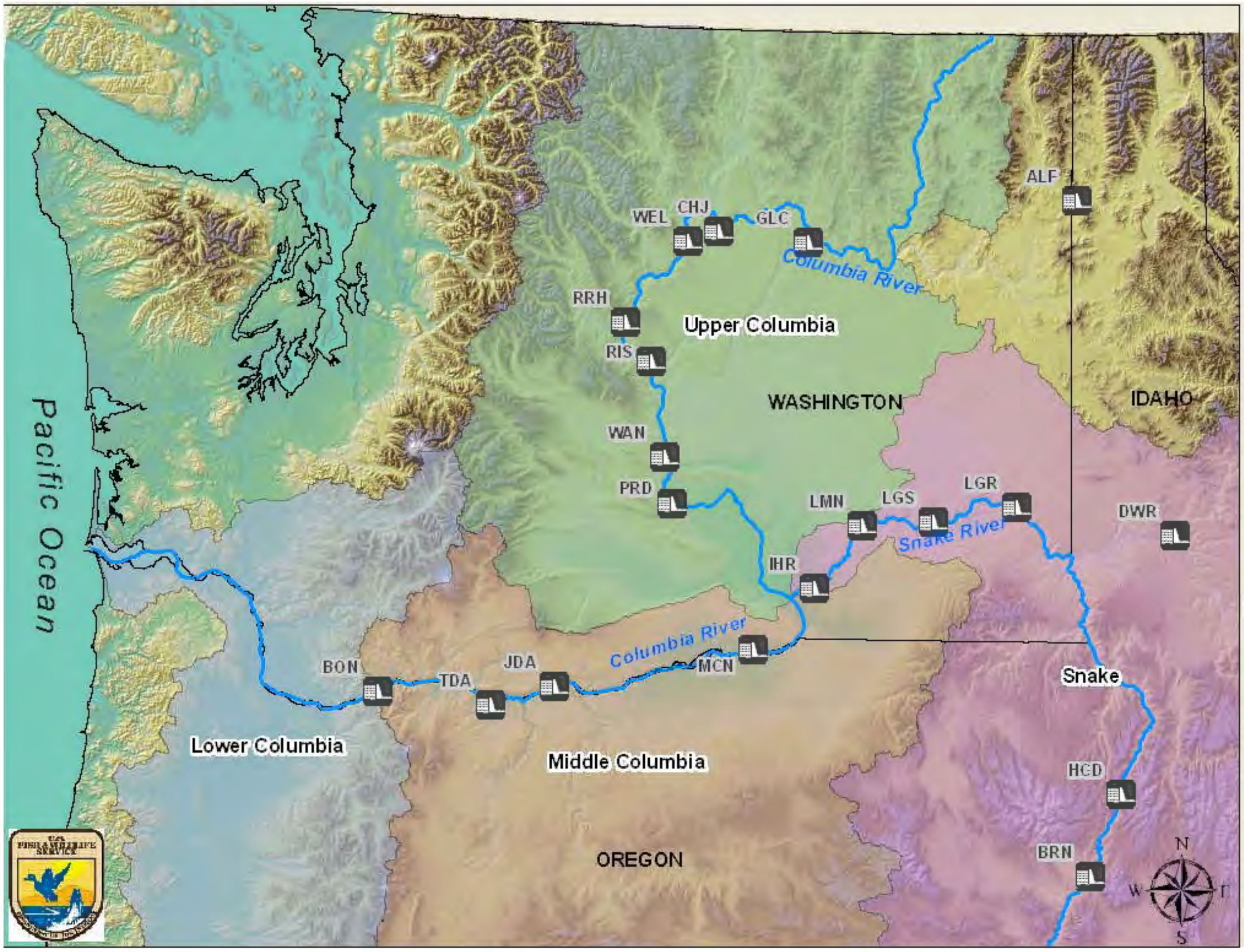

Figure 18-1. Map of four sub-regional areas of mainstem Columbia and Snake Rivers.

Ranked Population Status of Pacific Lamprey

The population status of Pacific Lamprey in the mainstem was not ranked because there is no obvious geographic separation of populations. There is evidence of rearing in the mainstem and some overwintering of larvae and juveniles (Jolley et al. 2012), but it is unknown whether or not spawning occurs in mainstem habitats. The purpose of ranking the threats in the mainstem, by geographic sub-region, was to assess the risk for the various population groupings during their seaward migration as juveniles and the adult migration to the spawning grounds through the hydrosystem. Therefore, the scope and the severity of mainstem threats were ranked for each of the three Columbia River geographic sub-regions. The mainstem threats are described and ranked in this chapter, but also influence the status rankings for RMU's that rely upon mainstem passage.

Threats and Limiting Factors to Pacific Lamprey

Two joint web conferences on March 8th and May 1st, 2018 were held to assess the mainstem threats to Pacific Lamprey. The mainstem threats and limiting factors were identified during these built upon the 2011 assessment, but additional threats were ranked and are included in the summary below. The categories of threats and limiting factors include:

Passage

Passage in the mainstem is affected by nine Federal Columbia River Power System (FCRPS) dams and five Public Utility District dams. No passage is provided upstream of Chief Joseph Dam on the Columbia River or Hells Canyon Dam on the Snake River. The overall scope and severity of passage did not change from the 2011 assessment and was ranked high in all three mainstem areas. The meeting participants did acknowledge the efforts conducted since 2011 to improve passage conditions; they however agreed that despite the improvements made the scope and severity of the passage threat still warrants a high ranking of 4. Of particular note is the work in research, design, and installation of Lamprey Passage Systems that allow adult Pacific Lamprey an alternate pathway over the dams than the existing fish ladders. A complete description of the impacts of the hydropower system on passage of adult and juvenile lamprey can be found in the 2011 assessment (Luzier et al. 2012).

Dewatering and Flow Management

The discussion on dewatering and flow management led to a distinction between long term ongoing impacts, and that can be adjusted by current management decisions. The creation of reservoirs along the mainstem resulted in dramatic change to the river including increased depth flooding of shallow water areas and change to the flow dynamics. These are long term changes largely unaffected by current management decisions. Management actions such as reservoir level, drawdown rates, and reservoir turnover, however, are management decisions that can have an impact on conditions for lamprey, but are unlikely to overcome the long term impacts of the construction of the dams themselves.

The overall scope of this threat increased slightly from low to low/moderate; however, the severity ranking decreased slightly from moderate/high to moderate. The scope ranking remained consistent across sub-regions, but the severity was ranked lower (2.5 vs. 3) in the upper Columbia partly due to higher turnover rates in the upper Columbia sub-region that leads to less of a delay in juvenile migration. Prolonged dewatering can leave ammocoetes stranded in the sediments can lead to desiccation and mortality, but the proportion of the potential total available habitat impacted by the drawdowns can be relatively small. With a limited understanding of how much of the potential habitat is actually occupied by lamprey, it is difficult to assess the population level affects.

Stream and Floodplain Degradation

The scope and severity of stream and floodplain degradation in the mainstem Columbia River and Snake River Region decreased from a high overall rank to moderate Vegetation has been inundated by reservoirs and the mainstem channel constrained by extensive levees and dikes, highway and railroad construction. For this assessment, the meeting participants separated out the direct impacts of dredging into a separate category, to allow a better evaluation of direct mortality due to dredging versus indirect impacts of habitat degradation.

Water Quality
Water quality decreased slightly from a rank of high to moderate/high for scope. Additionally, severity was ranked as moderate/high compared to unknown in 2011. Water temperatures for migrating fish were seen as a primary water quality issue. Severity of water quality was ranked lower for the Upper Columbia subunit because of lower water temperatures in that area. Contaminants also contribute to this threat category in some areas. Pulp mill discharge near Lewiston was specifically mentioned as a concern for the Snake River subunit.

Predation
Consistent with the 2011 assessment, predation ranked high for both scope and severity primarily because of increased exposure due to reservoir operation, tailraces, delayed migration, and large numbers of warm water predators in reservoirs. Although the threat was ranked high in all units, the predation pressures are different. The Mid-Columbia subunit has higher adult lamprey predation pressure due to pinnipeds than the 2 upper subunits. Sturgeon predation on adult occurs in all sub units. In the upper subunits the primary predation concern is for juveniles in reservoirs that can result in slower migration and larger predator populations than a free flowing river. Even though predation was ranked high for both scope and severity; there are many unknowns regarding this threat.

Dredging (Direct Take)
The inclusion of direct take fromfrom dredging was added to the 2018 list of threats during the assessment meetings. The removal of sediment will result in mortality of ammocoetes present at that location. Jolley et al. (2011) confirmed that ammocoetes are present in mainstem habitat, but the relative importance of the mainstem and the portion of ammocoetes in a basin that use the mainstem is unknown and densities by site are variable. Dredging may result in high mortality of ammocoetes at that site, but the portion of habitat affected is very small compared to the quantity of suitable sediments in the mainstem reaches. Further, dredging activities are limited. In the Mid-Columbia region dredging takes place on a 5-7 year rotation, and no dredging has occurred in the Upper Columbia subunit in the past 15 years and negligible levels in at least the the past 20 years. Overall, the scope of direct impacts was considered insignificant and the severity considered low at a population level.

Climate Change
Climate change was ranked as a moderate threat overall for both scope and severity compared to be unranked in 2011. The severity score is slightly lower (2.5) for the Upper Columbia Subunit due to the presence of the coldwater pool at Grand Coulee that will moderate the potential temperature and flow impacts to some degree.

Impact to the water supply and higher water temperatures projected from climate change would have negative impacts to Pacific Lamprey. This threat would also interact with other threats such as water quality, flow management and predation. All participants agreed that climate change impacts for lamprey in the mainstem is difficult to assess with a specific rank and had a great degree of uncertainty.

Disease
The participants agreed to give disease an overall score of insignificant for both scope and severity. However, it was noted that furunculosis is commonly observed in adult lamprey

collected at the dams. It is not clear, however, if the disease is the direct cause of mortality or is due to other stressors of water temperature and stress from the difficulties of passage.

Prioritization of Limiting Factors and Threats

Number values, 1−4, were assigned to ranks, insignificant to high, respectively. An average was calculated to determine the priority order of threats. The highest priority threats in the mainstem Columbia River and Snake River Region is passage and predation, stream and floodplain degradation, followed by dewatering and flow management (Table 18-1). Water quality, translocation and disease all had unknown rankings and thus an overall numerical rank for scope and severity could not be calculated.

Again, these mainstem threat ranks were then integrated with the watershed threat rankings to calculate an overall threat ranking for each watershed unit for both scope and severity. These overall threat rankings were evaluated for each of the watersheds comprising a geographic sub-region, and the results are summarized and contained in Chapters 14-17 of this plan.

Table 18-1. Threats to Pacific Lamprey and their habitats within the Mainstem Columbia River and Snake River Region. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

Drainage/HUC	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Snake Basin	4	4	2.5	3	3.5	3.5	4	3.5
Upper Columbia – Above Priest	4	4	2.5	2.5	3	3	4	3
Mid Columbia – Bonneville to Priest	4	4	2.5	3	3	3	3.5	3.5
Mean	4	4	2.67	2.83	3.17	3.17	3.83	3.33
Rank[a]	H	H	L/M	M	M	M	M/H	M/H
Mean Scope and Severity	4		2.75		3.17		3.58	
Drainage Rank	H		M		M		M/H	

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

Table 18-1. Continued.

Drainage/HUC	Predation		Dredging (Direct Take)		Climate Change		Disease	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Snake Basin	4	4	1	2.5	3	3	1	1
Upper Columbia – Above Priest	4	4	1	1	3	2.5	1	1
Mid Columbia – Bonneville to Priest	4	4	1	2.5	3	3	1	1
Mean	4	4	1	2	3	2.83	1	1
Rank[a]	H	H	I	L	M	M	I	I
Mean Scope and Severity	4		1.50		2.92		1.00	
Drainage Rank	H		L/M		M		L	

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19. WASHINGTON COAST REGION

Summary

The Washington Coast Regional Management Unit is bordered by the Pacific Ocean to the West, Cape Flattery to the North, Olympic Mountain Range and Willapa Hills to the East, and the Columbia River to the South. It includes 6 4th field HUCs ranging in size from 1,471 – 3,393 km^2: Hoh-Quillayute, Queets-Quinault, Upper and Lower Chehalis, Grays Harbor, and Willapa Bay (Table 19-1; Figure 19-1).

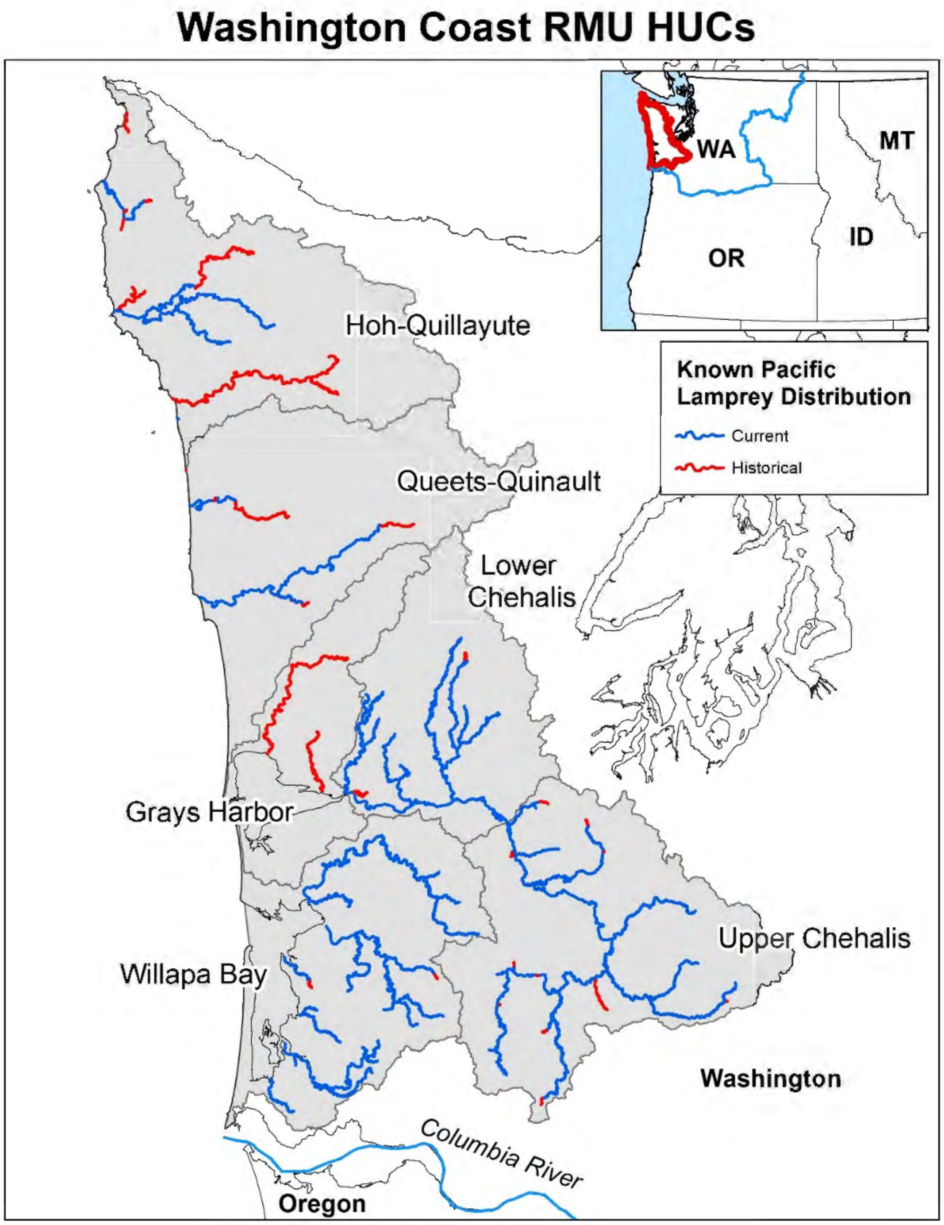

Figure 19-1. Current Pacific Lamprey distribution and location of 6 4th Field HUCs in the Washington Coast RMU (USFWS Data Clearinghouse 2017).

Ranked Population Status of Pacific Lamprey in the Washington Coast RMU

NatureServe status conservation status ranks have been calculated for two of six HUCs in 2017. Conservation status ranks have not been calculated for Pacific Lamprey populations in four HUCS in this RMU because many of the population parameters and the threats to the species have not been ranked (Figure -2).19-2). An increase in available data from the Pacific Lamprey Distribution database and updates to the calculated range extent were used to rank current occupancy and calculate ratio ranks for all six HUCs, however the minimum required parameters to calculate a conservation status rank were not met in four HUCs, these HUCs do not have a conservation status rank (Table 19-1).19-1). The historical and current occupancy for the four HUCs without a conservation status rank still need to be finalized by the RMU work group.
The Upper Chehalis and Lower Chehalis HUCs now have enough information from partners to be assigned a conservation status rank. Information provided allowed population size, short term trend, and threats to be ranked for these two HUCs. Upper Chehalis is ranked as Imperiled (S2?). The question mark qualifier (?) indicates that the assigned rank is imprecise. The rank is most likely an S2, but the degree of uncertainty surrounding the ranks is higher than other units ranks in this assessment, and, therefore, more likely to change with additional data. Graphs from the NatureServe Conservation Status Factors document and further explain the question mark qualifier (Master et al. 2012). The Lower Chehalis was ranked as Vulnerable (S3).

Table 19-1. Population demographics of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the Washington Coast Region, 2011. S1 = Critically Imperiled. S2 = Imperiled.

Watershed	HUC Number	Conservation Status Rank	Occupancy (km^2) Historical	Occupancy (km^2) Current	Current Population Size (Adults)	Short Term Trend
Hoh-Quillayute	17100101		1,000–5,000	100-500	No rank	No rank
Queets-Quinault	17100102		1,000–5,000	100-500	No rank	No rank
Upper Chehalis	17100103	S2?	1,000–5,000	100-500	250–2,500	Stable
Lower Chehalis	17100104	S3	1,000–5,000	100-500	1,000–2,500	Stable
Grays Harbor	17100105		1,000–5,000	Zero	No rank	No rank
Willapa Bay	17100106		1,000–5,000	100-500	No rank	No rank

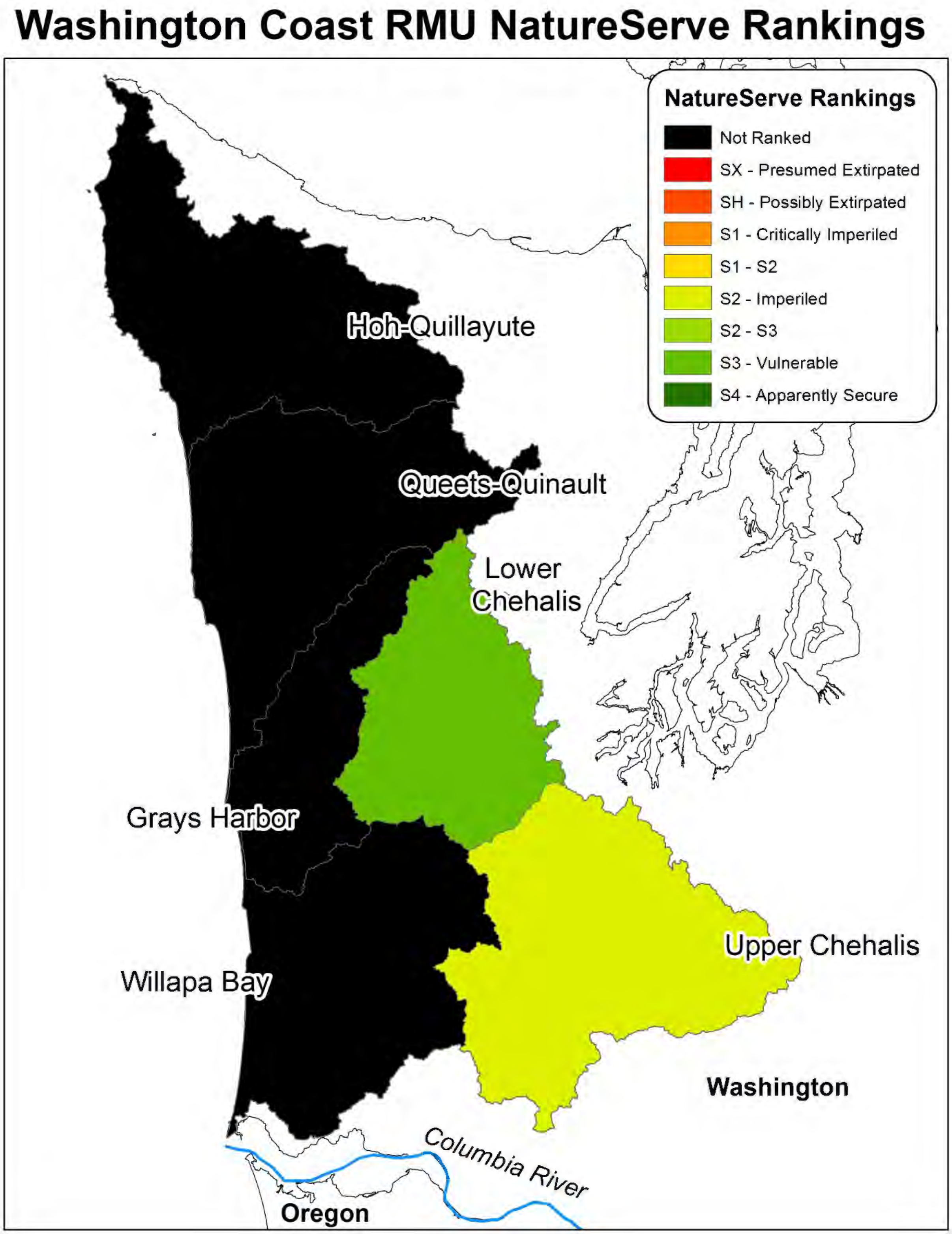

Figure 19-2. Final Conservation status ranks for Washington Coast RMU 2017.

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

Pacific Northwest Threats

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

Washington Coast Region Threats

No specific information on threats was gathered for the Washington Coast RMU. In 2011, it was suggested that threats listed in existing salmonid limiting factors analysis and recovery plans be used to identify lamprey threats within these watersheds. Limiting factors analyses and recovery and restoration plans were reviewed and an unranked summary of threats identified is found below and in Table 19-3. The documents reviewed for threat information include the draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout, the salmonid habitat limiting factors reports for WRIAs 20−24, and the Chehalis Restoration and preservation report.

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

Passage

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

Dewatering and Flow Management

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

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

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

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

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

Table 19-2. Threats to Pacific Lamprey and their habitats within the Washington Coast Region. These threats to fishery resources were identified in limiting factors analyses and recovery and restoration plans that focus on salmonids.

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

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

20. PUGET SOUND/STRAIT OF JUAN DE FUCA REGION

Summary

The Puget Sound/Strait of Juan de Fuca Region is bordered by the Strait of Juan de Fuca to the west, the Cascade Range to the east, Puget Sound systems to the south, and the U.S.–Canada border to the north (Figure 20-1). The Puget Sound/Strait of Juan de Fuca Region includes all Washington river basins flowing into the Puget Sound, Hood Canal, and Strait of Juan de Fuca.. The major river basins in the Puget Sound initiate from the Cascade Range and flow west, discharging into Puget Sound, with the exception of the Fraser River system, which flows northwest into British Columbia. All of the major river basins in Hood Canal and the Strait of Juan de Fuca originate in the Olympic Mountains. This region is comprised of 20 4th field HUCs ranging in size from 435-6,604 km^2 (Table 20-1; Figure 20-1).

There were relatively few additions to Puget Sound/Strait of Juan de Fuca NatureServe risk rankings in the 2017 Assessment. Much is still unknown about the watersheds in this region. Final Conservation Status Ranks changed in three HUCs. All three HUCs with Pacific Lamprey occupancy were categorized as Critically Imperiled (S1). Information availability and data quality were highest in the Elwha. The status of Pacific Lamprey in Sumas River, Strait of Georgia, San Juan Islands, Upper Skagit, Sauk, Lower Skagit, Stillaguamish, Skykomish, Snoqualmie, Snohomish, Lake Washington, Duwamish, Nisqually, Deschutes, Skokomish, Hood Canal, Puyallup and Puget Sound HUCs are still unknown, however with increased distribution data historical and current occupancy were calculated for these HUCs. These calculations should be considered preliminary until final approval from the RMU work group. The following are key outcomes of the 2017 Assessment.

- NatureServe conservation status ranks changed in four Puget Sound/Strait of Juan de Fuca HUCs in 2017. Dungeness-Elwha, Crescent-Hoko, and Nooksack all ranked as Critically Imperiled (S1). Changes in these areas are likely the result of using an improved approach to more accurately calculate historical range extent combined with more detailed information from regional partners.
- Information on population abundance of Pacific Lamprey in the Puget Sound/Strait of Juan de Fuca RMU is largely unchanged since the 2011 Assessment. The Elwha is the only watershed that has observed an increase in adult populations over the last 5-10 years.
- Dewatering and stream flow management, stream and floodplain degradation, lack of awareness of the status of Pacific Lamprey, and climate change were identified as threats in 2017 in the Puget Sound/Strait of Juan de Fuca RMU.

Table 20-1. Population demographic and Conservation Status Ranks of the 4th Field Hydrologic Unit Code (HUC) watersheds located within the Puget Sound/Strait of Juan de Fuca Region. S1 = Critically Imperiled. Ranks highlighted in yellow indicate a change in 2017 whem all HUCs were unranked.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km2)	Current Occupancy (km2)	Current Population Size (adults)	Short-term Trend (% decline)
Sumas River	17110001		250-1,000	Zero		
Strait of Georgia	17110002		250-1,000	Zero		
San Juan Islands	17110003					
Nooksack	17110004	S1	1,000-5,000	20-100	1,000-10,000	-Stable
Upper Skagit	17110005		1,000-5,000	Zero		
Sauk	17110006		1,000-5,000	Zero		
Lower Skagit	17110007		250-1,000	20-100		
Stillaguamish	17110008		1,000-5,000	100-500		
Skykomish	17110009		1,000-5,000	20-100		
Snoqualmie	17110010		1,000-5,000	20-100		
Snohomish	17110011		250-1,000	20-100		
Lake Washington	17110012		250-1,000	Zero		
Duwamish	17110013		250-1,000	20-100		
Puyallup	17110014	S1	1,000-5,000	20-100	Unknown	

Nisqually	17110015		1,000-5,000	20-100		
Deschutes	17110016		250-1,000	Zero		
Skokomish	17110017		250-1,000	4-20		
Hood Canal	17110018		1,000-5,000	20-100		
Puget Sound	17110019		1,000-5,000	20-100		
Dungeness-Elwha	17110020	S1	1,000-5,000	20-100	Unknown	Increasing
Crescent-Hoko	17110021	S1	250-1,000	20-100	Unknown	

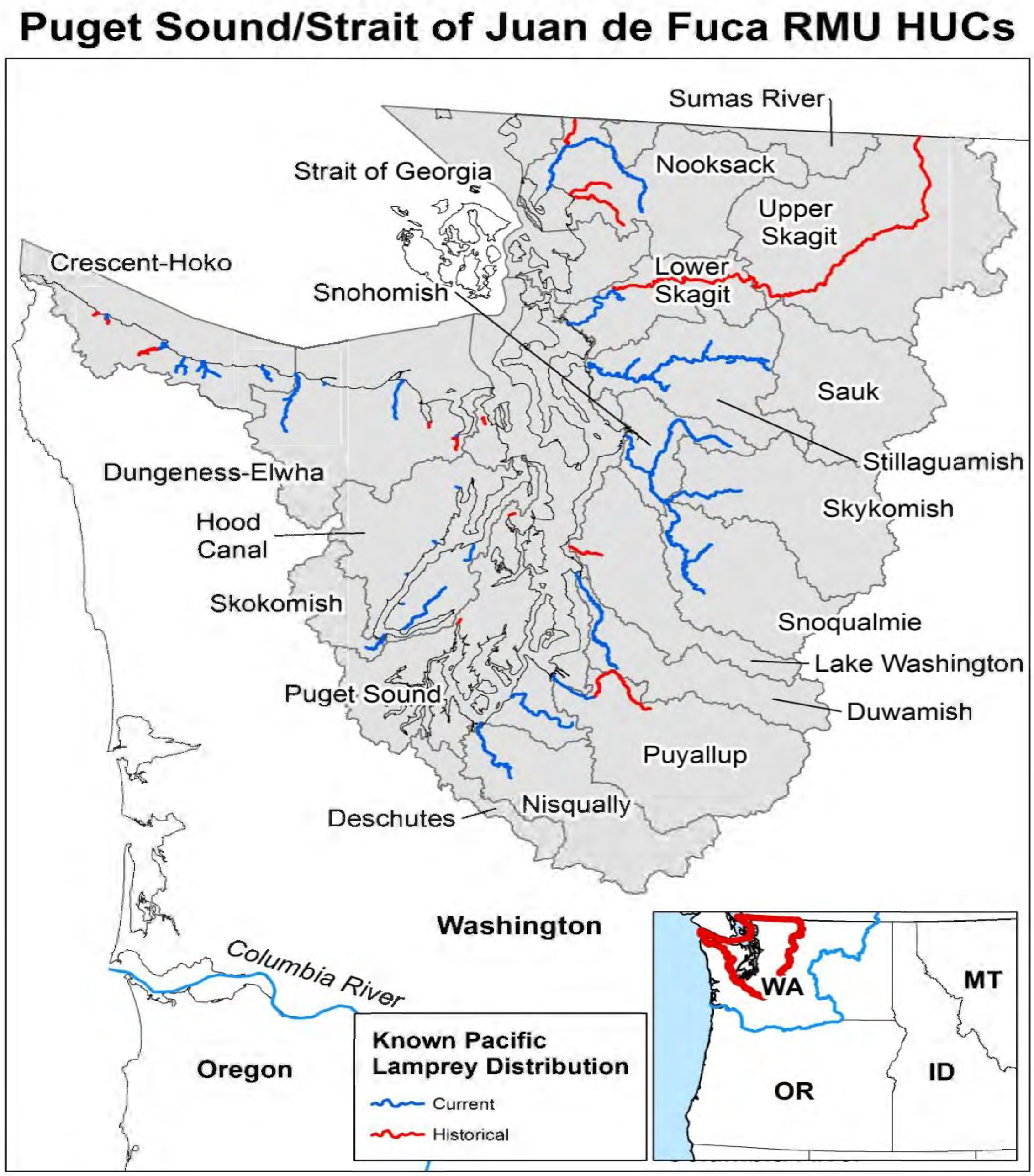

Figure 20-1. Current Pacific Lamprey distribution and location of 20 4th Field HUCs in Puget Sound/Strait of Juan de Fuca RMU (USFWS Data Clearinghouse 2017).

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

NatureServe conservation status ranks were calculated in four of twenty HUCs in 2017. With limited data, all status ranks were S1 (Critically Imperiled) in the Nooksack, Puyallup, Dungeness-Elwha, and Crescent-Hoko. Steelhead Intrinsic Potential (SIP) modeling was used as a surrogate for Pacific Lamprey range extent and NatureServe ranks were estimated by overlaying the SIP GIS layer with a 1 km^2 grid to calculate a numeric area of historical range extent (see Chapter 3).

The population status of Pacific Lamprey in the Puget Sound/Strait of Juan de Fuca Region remains difficult to assess because data are often incidental to salmon monitoring programs and there are no historical datasets on lamprey populations in existence. Due to this lack of information population parameters have not been ranked and NatureServe status ranks have only been calculated for 4 of the 20 HUCs (Table 20-1). When data was available an attempt was made to rank the range extent, occupancy, current population size, and recent trend of Pacific Lamprey in the watersheds. Hayes et al.(2013) provides information on distribution of Pacific Lamprey in the Puget Sound based on fish collected during monitoring for salmonid smolts. Pacific Lamprey were documented in 12 of 18 watersheds sampled.

In the Elwha River and its tributaries, Pacific Lamprey have started re-colonizing the watershed since the Elwha Dam removal in 2012 (Moser and Paradis 2017, and R. Paradis, personal communication). Unpublished data from various sources in Moser and Paradis (2017) indicate that Pacific Lamprey abundance is increasing in the watershed. Pacific Lamprey have also been documented in a small tributary to the Strait of Juan de Fuca in the Dungeness-Elwha HUC, Tumwater Creek.

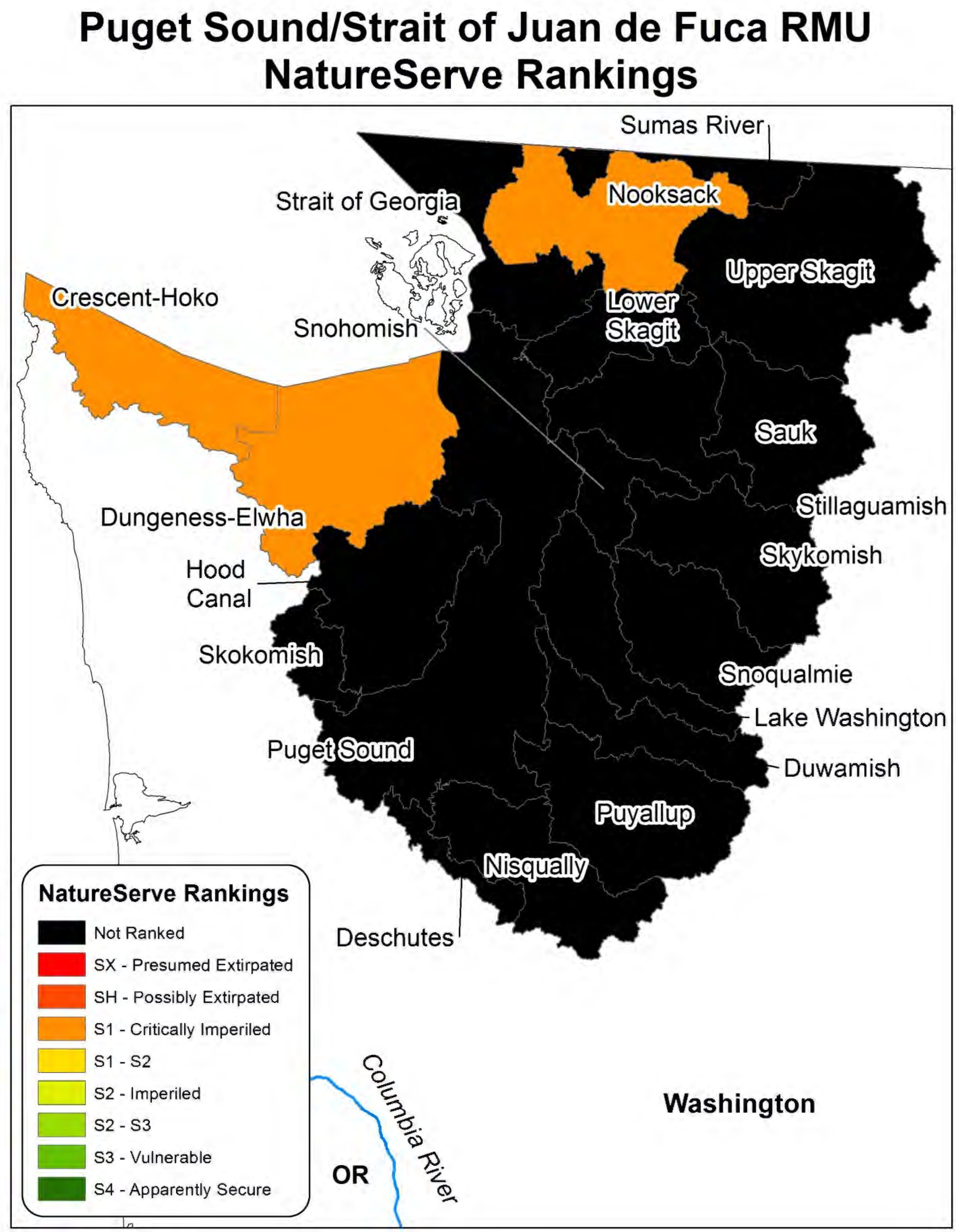

Figure 20-2. Final Conservation status ranks for Puget Sound/Strait of Juan de Fuca RMU 2017.

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

Summary

Lack of awareness, stream and floodplain degradation, dewatering and flow management, and climate change were identified as threats to Pacific Lamprey in the four HUCs ranked in the Puget Sound/Strait of Juan de Fuca RMU in 2017. Lack of awareness ranked as the greatest threat with moderate scope and severity. Stream and floodplain degradation were moderate threats with moderate scope and severity. Dewatering and flow management were moderate threats with low scope and moderate severity. Finally, climate change was identified as a low threat in the Dungeness-Elwha HUC with low scope and low severity. Passage was identified as a threat in the Puyallup River but was not ranked in severity or scope. More information from all HUCs need to be collected and analyzed before threats are ranked and prioritized.

Table 20-2. Threats to Pacific Lamprey within the Puget Sound/Strait of Juan de Fuca RMU, as identified and ranked via partner information. High = 3.5-4.0, Medium = 2.5-3.4, Low = 1.5-2.4, Insignificant = ≤1.4, Unknown = No value.

2017	Passage		Dewatering and Flow Management		Stream and Floodplain Degradation		Lack of Awareness		Climate Change	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Nooksack	U	U	2	3	2	2	2	3	U	U
Dungeness-Elwha	U	U	U	U	3.5	3	3.5	3	2	2
Crescent-Hoko	U	U	U	U	3.5	3	3.5	3	2	2
Mean	U	U	2	3	3	2.67	3	3	2	2
Rank	U	U	L	M	M	M	M	M	L	L
Mean Scope & Severity	U		2.5		2.84		3.0		2.0	
Drainage Rank	U		M		M		M		L	

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Dr. Evelyn Brown	Lummi Nation
Eric Marks	Puyallup Tribe
Andrew Berger	Puyallup Tribe

21. Alaska

A risk assessment and query of ongoing and needed actions and research was not conducted for Pacific Lamprey RMU of Alaska during 2018. Alaska has six species of lampreys. Minimal research related to the species has occurred and their full distribution, status and trends remain unknown.

A small winter commercial harvest of Yukon River Arctic Lamprey has served as the only index of abundance of anadromous lamprey. The ADF&G uses the commercial fishery in part to better understand lamprey distribution and abundance. Fishermen are required to complete a Commercial Lamprey Dip Net Fishery catch log each time they fish. The harvest is limited to 20 metric tons (44,080 pounds) of lamprey.

Arctic and Pacific Lamprey are harvested for subsistence along the Yukon River in Interior Alaska. A subsistence lamprey survey postcard is mailed in November to residents located in Yukon River communities from Mountain Village to Grayling. The intent of this survey is to better inform future fishery management decisions. Fishermen are encouraged to complete and return the prepaid postcard to ADF&G once they finished subsistence fishing.

Recent updates related to the marine phase of Pacific Lamprey can be found in the North Pacific Ocean Regional Management Unit Implementation Plan found at: https://www.fws.gov/pacificlamprey/Documents/RIPs/2017.11.13%20North%20Pacific%20Ocean%20RIP.pdf

For species freshwater life phase, the Alaska State Comprehensive Wildlife Conservation Strategy (CWCS; ADF&G 2015; ADF&G 2008) outlines the known distribution, abundance, concerns, level of protection, conservation status rankings and potential conservation and management actions for all of the state's lamprey species and are available at: http://www.adfg.alaska.gov/static/species/wildlife_action_plan/cwcs_full_document.pdf Appendix 4 and http://aknhp.uaa.alaska.edu/zoology/Zoology_adfg.htm

In 2005, the Alaska Natural Heritage Program (AKNHP) species tracking list ranked Pacific Lamprey as S4S5 (S4= not rare, long term concern; uncommon but not rare; some cause for long term concern due to declines or other factors; S5 = widespread, abundance, secure). Arctic Lamprey are ranked by the AKNHP as S4 (http://accs.uaa.alaska.edu/education-and-outreach/species-lists/ (AKNHP 2012)). In the Comprehensive Wildlife Conservation Strategy the Alaska Department of Fish and Game (ADF&G) lists Pacific and Arctic Lamprey along with other species of lamprey known to occur in Alaska (River, Western Brook and Alaskan Brook) as Species of Greatest Conservation Need (SGCN).

Template conservation action plans were developed by ADF&G (ADF&G 2006) for SGCN. Below is the excerpted plan for Alaska's six species of anadromous and resident lamprey:

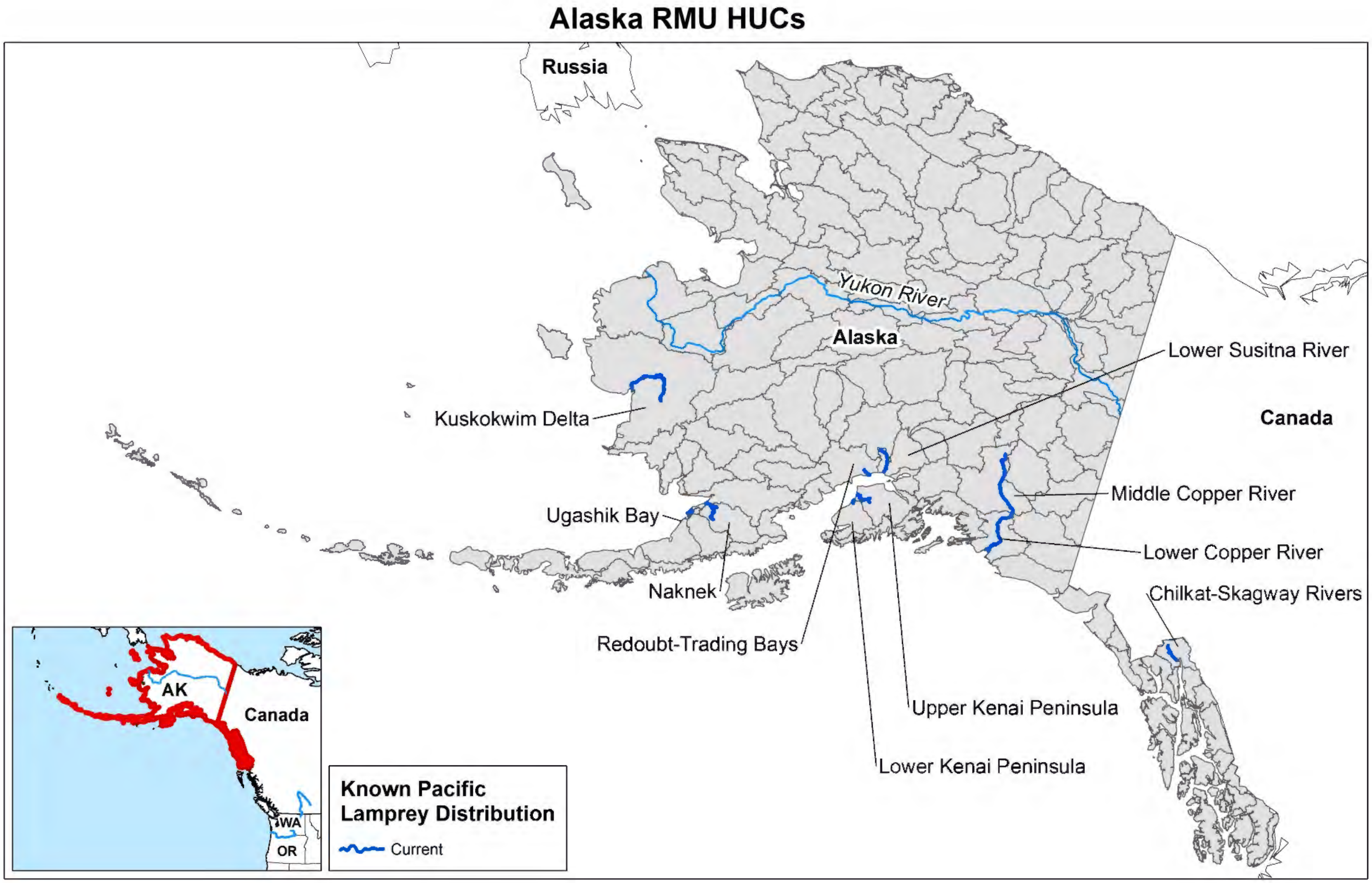

Figure 21-1. Current known Pacific Lamprey distribution and location of 4th Field HUCs in the Alaska RMU

Lamprey Species in Alaska

There are six species of lampreys in Alaska. They are often colloquially/locally referred to as "eels" in Alaska (and elsewhere): Pacific Lamprey (Entosphenus *tridentatus);* western brook lamprey (*Lampetra richardsoni);* river lamprey (*Lampetra ayresii*); Arctic lamprey (*Lampetra camtschatica*, *Lampetra japonica; Lentheron camtschatica*); and Alaskan brook lamprey (*Lampetra alaskense; and* Siberian (brook) lamprey (*Lethenteron kessleri), Lampetra kessleri, Lampetra japonica kessleri*).

Distribution and Abundance

Distribution of Pacific Lamprey and relationships with other lamprey species are very poorly known in Alaska. Pacific lamprey are found in Pacific drainages up to at least the Bering Sea with records into lower Yukon/Kuskokwim. Abundance is unknown, but often found in Alaska with some local abundance.

Key or important habitat areas are largely undescribed and unknown in Alaska. While it is believed that adult lampreys have similar habitat/spawning needs as salmon (e.g., Vadas 2000), a 2003 Bristol Bay inventory found adult Alaskan brook lamprey in locations not occupied by salmon. Alaskan brook lamprey appear to have greater tolerance for streams with low gradient, fine substrate, and low dissolved oxygen than do salmon (M. Wiedrner, pers. comm.). In the 2003 Bristol Bay inventory, juvenile lamprey were often found in headwater habitats, if suitable habitat (soft bottoms) was available (M. Wiedmer, pers. comm.).

Threats

There is a paucity of information about lamprey species in Alaska and their habitats. We lack much basic information on such topics as abundance, age structure, diet, trophic ecology, homing/migration, species identification, range, instream flow/water volume and habitat needs (Beamish and Levings 1991; Beamish and Youson 1987; Vladykov and Follett 1965; Young et al. 1990).

The systematics of Alaska's diverse lamprey species is difficult to determine. Lamprey species can be hard to identify, especially in juvenile stages (McPhail and Carveth 1994). Systematics of lamprey in Alaska is very incomplete and poorly understood; needs research and inventory. Lampreys are classically thought of as occurring in "species pairs" or "satellite pairs" (Mecklenburg et. al. 2002) with one species parasitic (and anadromous) and its "congener species" nonparasitic derivative (and a freshwater resident) (Beamish 1987, Beamish and Neville 1992; Vladykov and Kott 1979; Vladykov 1985) (e.g., Arctic lamprey (parasitic) and Alaskan brook lamprey (nonparasitic).

Populations that are isolated or with unusual life histories are described as distinct species elsewhere in the Pacific (Docker et al. 1999; Haas 1998; Klamath-Siskiyou et al. 2003; Kostow 2002). The taxonomic status of lamprey species is unresolved due to differing viewpoints on significance of life history types, and the complexities of relationships between species (Mecklenburg et al. 2002). Alaska likely has many populations with possibly rare or unique life-history characteristics. Confusing parasitic and non-parasitic "paired species" relationships exist due to unresolved genetic analyses, and degenerative changes with maturation resulting in inconsistent taxonomic identification (McPhail and Lindsey 1970, Mecklenburg et. al. 2002; Morrow 1980). Non-parasitic freshwater forms are believed to have evolved from parasitic anadromous forms, but unusual "intermediates," such as freshwater parasitic forms, exist. Geological isolates are not uncommon and are found in Alaska (Hastings and Haas 2002).

Serious lamprey conservation/management issues exist elsewhere and the extent and nature of those issues in Alaska are unknown. Lamprey are taken as a food fish in the lower Kuskokwim and Yukon Rivers and possibly elsewhere in Alaska. Subsistence harvest locations, levels, species, etc., are poorly documented or unknown. An emerging commercial fishery is possible in at least some regions, with unknown impacts. Lampreys are possibly an important forage fish for species of conservation concern.

Concerns for habitat destruction and degradation include effects originating instream (channelization, instream flow/water volume alteration, temperature, impoundment, passage, sedimentation) and those influences originating from outside the stream (pollution, riparian zone loss, ocean [or lake] conditions, and climate change).

The goal in Alaska is to conserve and manage populations of Alaska lamprey species throughout their natural range to ensure sustainable use of these resources.

22. NORTH PACIFIC OCEAN

The North Pacific Ocean RMU is vast, encompassing all populations of Pacific Lamprey originating from various rivers across all other RMUs (Luzier et al. 2011), from Baja, Mexico north to the Bering and Chuchki seas off Alaska and Russia (Renaud 2008), and south to Hokkaido and Honshu Islands, Japan (Yamazaki et al. 2005). A number of research, monitoring, and management needs have been identified in pre-existing, land-based RMUs, several which have been or are being addressed. However, the foci of these projects are only on the freshwater life stages of the Pacific Lamprey life cycle. The marine phase of the Pacific Lamprey is clearly an important stage of the Pacific Lamprey life cycle because it is where they attain their adult body size (Beamish 1980; Weitkamp et al. 2015) — and body size is directly proportional to the number of eggs female Pacific Lamprey produce (Clemens et al. 2010; Clemens et al. 2013). Further, the ocean phase of the Pacific Lamprey life cycle may be as or even more important than the freshwater life stages for population recruitment (e.g., see Murauskas et al. 2013).

Conservation Assessment

Status of Pacific Lamprey in the North Pacific Ocean RMU is unknown. Research using neutral genetic markers on collections of Pacific Lamprey from British Columbia, Washington, Oregon, and California indicates that they exhibit a low level of genetic stock structure, with high but somewhat limited rates of gene flow across large geographical areas (Goodman et al. 2008; Spice et al. 2012). The presence of some allelic diversity in Pacific Lamprey from the Salish Sea vs. southern California suggests limited dispersal by lamprey at sea (Spice et al. 2012). If there is a limitation on dispersal abilities of Pacific Lamprey at sea, the North Pacific Ocean RMU may contain more than one genetic grouping (albeit not distinct "populations" per se) throughout its distribution. Information from genetic studies using neutral genetic markers suggests at least three groupings: 1) Northern British Columbia, 2) Vancouver Island and Puget Sound, and 3) the Columbia River basin and West U.S. coast (Hess et al. 2013). By contrast, research using adaptive genetic markers on Pacific Lamprey indicates high levels of genetic structuring with regards to body size and geography across locations in British Columbia, Washington, Oregon, and northern California (Hess et al. 2013). Adaptive genetic markers suggest that Pacific Lamprey with particular genotypes may segregate in the lower Columbia River, with some adult Pacific Lamprey from the Willamette River Basin exhibiting genetic differences from those destined for the interior Columbia River Basin. This could suggest some common evolutionary selective force(s) operating at the general geographical demarcation of the Cascade Mountain Range (Hess et al. 2013; 2015). Adaptive genetic markers suggest that Pacific Lamprey from the interior Columbia River Basin and Willamette were each genetically different from Pacific Lamprey from the southern coast of Oregon (Coquille and Rogue rivers) and northern California (Klamath River; Hess et al. 2013; 2015).

Distribution and Connectivity

In Alaska, the highest occurrences of Pacific Lamprey is in the slope area of the Bering Sea, with some occurrences in the Gulf of Alaska, from southeast Alaska to the eastern Aleutian Islands across and into Russian waters off the Kamchatka peninsula (Orlov et al. 2008). In addition, NOAAs Alaska Fisheries Science Center consistently catches Pacific Lamprey in bottom trawl surveys on the Bering Slope, but rarely on the Bering shelf or Gulf of Alaska (Siwicke and Seitz 2017). Pacific Lamprey caught by NOAAs Northwest Fisheries Science Center marine surveys indicates they are distributed from roughly San Francisco Bay in California (38'N) north to Haida Gwaii, British Columbia (54'N).

Statistically significant associations have been reported between the relative abundance of Pacific Herring, Chinook Salmon, Pacific Cod, Walleye Pollock, and Pacific Hake in the Pacific Ocean and the abundance of adult Pacific Lamprey returning to the Columbia River Basin (Murauskas et al. 2013). These relationships may provide evidence that adult Pacific Lamprey entering the Columbia River to spawn had previously migrated with their hosts in the ocean northward of the Columbia River mouth, to feed on the aforementioned fish stocks off Vancouver Island, British Columbia. Further, Pacific Lamprey observed in the Bering Sea off Alaska and Russia may have originated from rivers in Canada and the U.S. (Murauskas et al. 2013). Recently an adult Pacific Lamprey originating from the Bering Sea (where it was PIT-tagged) was detected at Bonneville Dam on the Columbia River, and then again in the Deschutes River (J. Murauskas and A. Orlov, unpubl. data).

In the ocean, Pacific Lamprey are found throughout the water column. Pacific Lamprey have been found in bottom trawls at depths of 16 – 1,193 m (52 – 3,914 ft), and in the open ocean, they have been found between the surface and 1,485 m (4,872 ft; Orlov et al. 2008). However, Pacific Lamprey are most often found between the surface and 500 m (1,640 ft; Orlov et al. 2008; Wade and Beamish 2016). In the Straits of Georgia and near Vancouver Island, Pacific Lamprey were most commonly found at 31 – 100 m (102 – 328 ft), followed by 101 – 500 m (331 – 1,640 ft; Wade and Beamish 2016). Pacific Lamprey have also been found at depths of 100 – 250 m (328 – 820 ft), where they may be associated with some of their prey items, including Walleye Pollock and Pacific Hake (Beamish 1980). Recently a very large catch of adult Pacific Lamprey was made in association with a school of Walleye Pollock at a depth of 45 m (148 ft; Wade and Beamish 2016). Taken together, this information strongly suggests that the depth of occurrence of Pacific Lamprey is associated with where Walleye Pollock and Pacific Hake occur, and their preference for each of these prey species relative to other prey species. For instance, Walleye Pollock appears to be the preferred prey item for juvenile Pacific Lamprey in the Strait of Georgia, whereas Pacific Hake may be the preferred prey item elsewhere on the Pacific Coast of North America (Orlov et al. 2008; Wade and Beamish 2016). Pacific Lamprey make daily vertical migrations in the water column, being shallower at night and deeper by day. These vertical migrations by juvenile Pacific Lamprey in the ocean have been linked with movements of their prey, Walleye Pollock (Orlov et al. 2008).

Some topics relative to distribution and connectivity that are not well studied include when Pacific Lamprey enter into and return from marine waters, how entry to and exit from the ocean relates to feeding, recruitment to the population, dispersal at sea, and observed patterns in genetic diversity. Evidence suggests that juvenile Pacific Lamprey move downstream to the ocean in response to river discharge, particularly during late fall, winter and early spring for populations from southern British Columbia to California (Beamish 1980; Beamish and Levings, 1991; van de Wetering, 1998; Moyle 2002; Weitkamp et al. 2015). The timing of re-entry into freshwater is poorly documented due to lack of sampling during late fall and winter. However, the limited information available suggests that the reported re-entry timing as adults occurs during winter and spring (Dawley et al. 1985; Chase 2001, Moyle 2002, Moyle et al. 2009, Weitkamp et al. 2015). The timing of ocean entry and subsequent return to freshwater define the end-points for the marine residence period. Timing of entry and return may influence migrations by Pacific Lamprey across the North Pacific Ocean.

Summary of Major Threats

Research, Management, & Evaluation to fill information gaps
The biggest threat to the marine phase of Pacific Lamprey is a lack of detailed biological information (Clemens et al. 2010) that can inform scientists, conservationists, and fisheries managers. Whereas we know some things about where Pacific Lamprey are found in the north Pacific Ocean, we do not know what particular streams they originated from or where they will return to spawn. For example, little information exists on where they go, and much less information exists on the biological history of individual lamprey (e.g., how, why, when and where they switch host species), or what particular risks they face in the various areas of the ocean inhabit. Empirical data on growth rates, duration on particular prey items, details on prey switching, host impacts, and duration of this phase of their life history is needed (Clemens et al. 2010).

RM&E to assess abundance and status
Abundance trend data for Pacific Lamprey suggest they exhibits ten year cycles of abundance, which has been attributed to their approximate life span (Murauskas et al. 2013). Many data gaps exist for Pacific Lamprey in the North Pacific Ocean, and the survival rate from larval to adult life stages is not known. Standardized applications of tagging technology to lampreys has not progressed towards widespread, rigorous, and consistent use by fisheries biologists (Moser et al. 2007; Clemens et al. 2017), so even though we can use catch data as an index of abundance, we cannot estimate actual population size. No relationship between adult and larval counts has been established for Pacific Lamprey, making it difficult to identify at which life history stages mortality is greatest (Clemens et al. 2017).

Climate change/Global warming effects on ocean conditions
Science is increasingly revealing complex and myriad changes to the ecology and distribution changes of many species, worldwide. These changes may include prey availability, the feeding behavior by lamprey on these prey, and subsequent lamprey growth may be threats to Pacific Lamprey.

Harvest
Harvest and bycatch in ocean fishing may be a concern if there is ocean harvest of lamprey because their final spawning destinations may not be random. For instance, if substantial ocean harvest occurs in the Bering Sea, but most spawning occurs south — in British Columbia and the continental United States — then this would be a conservation concern for population(s) of Pacific Lamprey that might otherwise return to these areas south of the Bering Sea.

Prey availability
Ocean survival of Pacific Lamprey may be limited by prey availability, which is influenced by environmental conditions and therefore may be the determining factor for abundance of return spawners (Murauskas et al. 2013, 2016).

Predators
The caloric content of Pacific Lamprey is significantly higher than salmon (Close et al. 2002), which may explain why they have been documented to be consumed by so many animals within estuaries and the Pacific Ocean. Documented predators of Pacific Lamprey in estuaries and the ocean (Orlov 2016):

White Sturgeon
Lingcod
Sablefish
Bluntnose Sixgill Shark
Blue Shark
Spiny Dogfish Shark
Sablefish
Osprey
Caspian Tern
Double Crested Cormorant
Brandt’s Cormorant
Western Gull
Steller Sea Lion
California Sea Lion
Northern Fur Seal
Pacific Harbor Seal
Sperm Whale
Mink

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