Pacific Lamprey

2022 Regional Implementation Plan

for the

Lower Columbia/Willamette

Regional Management Unit

Lower Columbia Sub-Region

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I. Status and Distribution of Pacific lamprey in the RMU

A. General Description of the RMU

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. It is comprised of six 4th field HUCs ranging in size from 1,753−3,756 km^2 (Table 1). Watersheds within the Lower Columbia River sub-region include the Lower Columbia-Sandy, Lewis, Upper and Lower Cowlitz, Lower Columbia-Clatskanie, and Lower Columbia River (Figure 1).

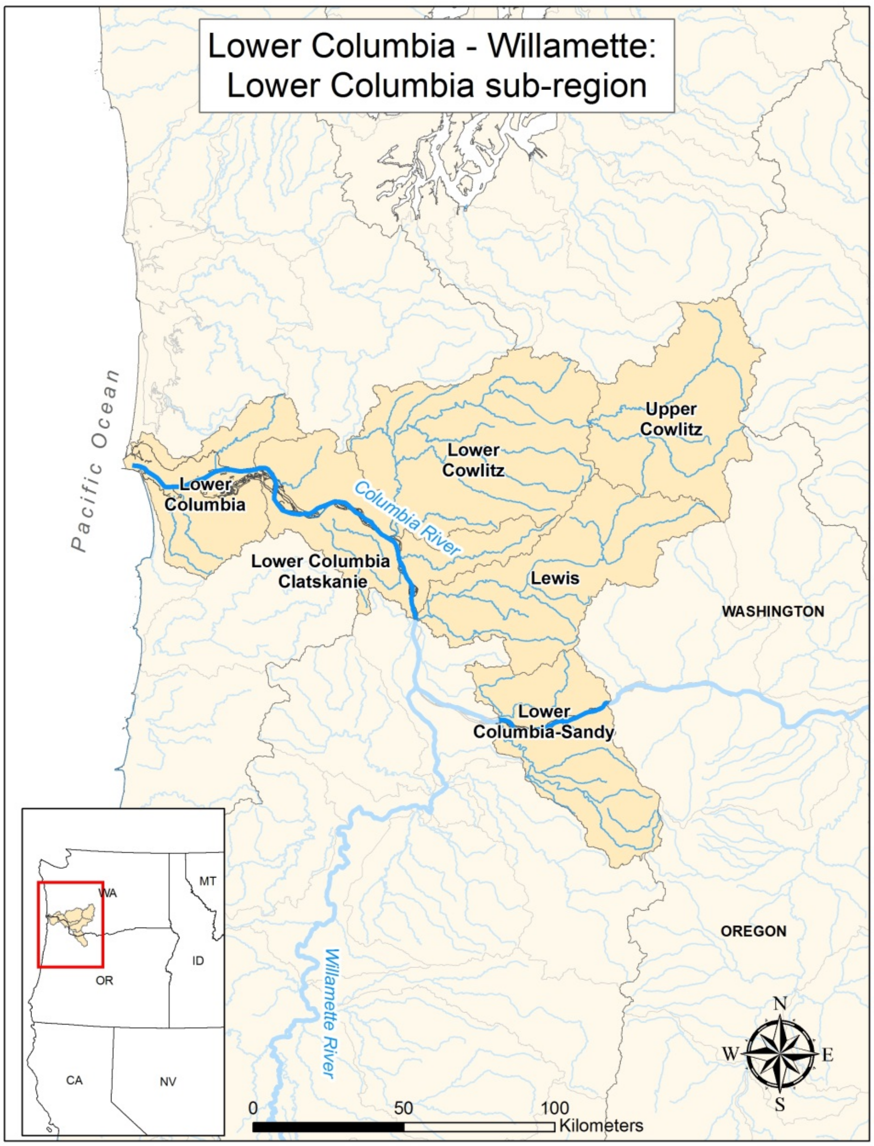

Figure 1. Map of watersheds within the Lower Columbia/Willamette RMU, Lower Columbia sub-region.

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

Watershed	HUC Number	Drainage Size (km^2)	Level III Ecoregion(s)
Lower Columbia-Sandy	17080001	2,263	Willamette Valley, Cascades
Lewis	17080002	2,719	Puget Lowland, Willamette Valley, Cascades
Upper Cowlitz	17080004	2,654	Puget Lowland
Lower Cowlitz	17080005	3,756	Puget Lowland, Cascades
Lower Columbia-Clatskanie	17080003	2,349	Coast Range, Willamette Valley
Lower Columbia	17080006	1,753	Coast Range

B. Status of Species

Pacific Lamprey Assessment and New Updates

Every five years the Pacific Lamprey Conservation Initiative (PLCI), through the RMUs, revise the Pacific Lamprey Assessment (USFWS 2018). The Assessment utilizes local stakeholder knowledge and expertise to evaluate Pacific Lamprey distribution, population demographics and threats at the 4th field HUC watershed level. This information is used to inform NatureServe, a diagnostic tool that characterizes the conservation risk of Pacific Lamprey across their historical range. Information about current Pacific lamprey distribution, population size, trends, and watershed threats were collected from stakeholders in the Lower Columbia sub-region through an online Assessment questionnaire and virtual meeting held on March 15th 2022. The following is a brief summary of key findings from the 2022 Pacific Lamprey Assessment.

NatureServe conservation status ranks changed in three of six HUCs in 2022 (Table 2). Status ranks fell from Imperiled (S2) to Critically Imperiled (S1) in the Lower Columbia-Sandy, Lewis, and Lower Columbia. The decline in status ranks was generally due to an increase in the scope or severity of threats facing Pacific Lamprey in these watersheds (see Threats below).

Distribution

The Pacific Lamprey Assessment ranking of current distribution increased in all but a single HUC in 2022 (Table 2). Overall, understanding of Pacific Lamprey distribution has expanded considerably in both Oregon and Washington State tributaries due to increased awareness and sampling effort (e.g., smolt trapping, redd surveys, occupancy sampling, fish salvages). Washington Department of Fish and Wildlife (WDFW) recently compiled a summary of adult and juvenile lamprey data collected incidentally during various WDFW monitoring programs and projects over the years. This information helped to expand known Pacific Lamprey distribution in several southwest Washington tributaries. A compilation of all known larval and adult Pacific Lamprey occurrences in the Lower Columbia sub-region are displayed in Figure 2, which is a product of the

USFWS Data Clearinghouse.

Abundance

Pacific Lamprey population abundance was estimated in five HUCs using consolidated data from redd surveys conducted by Oregon Department of Fish and Wildlife (ODFW) and WDFW personnel. Both agencies record counts of adult Pacific Lamprey spawners and redds as part of annual winter steelhead spawning ground surveys. Pacific Lamprey abundance indices are considered conservative estimates, because they incorporate only a portion of potential lamprey spawning habitat, surveys are focused primarily on winter steelhead and end before the completion of lamprey spawning. Oregon Department of Fish and Wildlife personnel estimated the range of Pacific Lamprey abundance in the Lower Columbia-Sandy and Lower Columbia-Clatskanie (Oregon tributaries only) for years 2017-2021 using extrapolations of published information on the average number of Pacific Lamprey per redd, average peak redd counts per kilometer, multiplied by the total length of potential habitat (see Clemens et al. 2021). Pacific Lamprey abundance in southwest Washington tributaries (i.e., lower Columbia-Sandy, lower Columbia-Clatskanie, Lewis, Lower Cowlitz and Grays River) was estimated using the methods described in Clemens et al. (2021) for years 2017-2020. ODFW and WDFW abundance indices were combined in the lower Columbia-Sandy and lower Columbia-Clatskanie to produce a single estimate. Median abundance of adult Pacific Lamprey ranged from 42-288 fish in the Sandy Basin (median of mean 157 fish), 24-161 fish in the Lewis (median of mean 88 fish), 155-1048 fish in the Lower Cowlitz (median of mean 572 fish), 149-1034 fish in the Clatskanie River (median of mean 564 fish), and 31-209 fish in the Grays River (median of mean 114). Pacific Lamprey are still believed to be extirpated from the Upper Cowlitz River. The Cowlitz Salmon Hatchery Barrier Dam and Mayfield Dam effectively block access to the upper portion of the Lower Cowlitz River (above RM 49.6) and upper Cowlitz basin.

Short-term Population Trend

Mainstem dam counts provide one of the only long term records of adult Pacific Lamprey numbers in the Columbia River basin. Despite data gaps and monitoring inconsistencies, counts of adult Pacific Lamprey at Bonneville Dam (rkm 235) indicate a significant downward trend in abundance over time. The 10-year median day time count of adult Pacific Lamprey prior to 1970 was over 106,000 fish (1960-1969), while the recent 10-year median is just over 30,000 fish (Columbia River DART 2022). Since 2010, the Confederated Tribes of Warm Springs have collected information to estimate Pacific Lamprey abundance at Willamette Falls (see Baker and McVay 2018; Gray et al. 2021). Estimated total abundance at Willamette falls has ranged from 64,388 to 336,305 fish (average 185,825) from 2010-2017 with periodic peaks in abundance every few years. Short-term population trend which is defined as the degree of change in population size over three lamprey generations (≈36 years), was ranked as unknown in all Lower Columbia watersheds in 2022 due to a lack of continuous long-term population trend data in the region (Table 2). Pacific Lamprey populations are believed to be declined from historical levels, but adequate information does not exist to estimate the magnitude of the decline. Although ODFW estimates provide approximately 10 years of good abundance information for the Lower Columbia-Sandy and Lower Columbia-Clatskanie, this data set is not long enough to infer population trends.

Table 2. Population demographic and conservation status ranks (see Appendix 1) of the 4th Field HUC watersheds located within the Lower Columbia sub-region. Note – steelhead intrinsic potential was used as a surrogate estimate of historical lamprey range extent in areas where historical occupancy information was not available. Ranks highlighted in yellow indicate a change from the 2018 Assessment.

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	S1↓	1000-5000	100-500	50-1000	Unknown
Lewis	17080002	S1↓	250-1000	100-500	50-250	Unknown
Upper Cowlitz	17080004	SH	250-1000	Zero	Zero	Unknown
Lower Cowlitz	17080005	S2	1000-5000	500-2000	250-2500	Unknown
Lower Columbia-Clatskanie	17080003	S1S2	1000-5000	500-2000	250-2500	Unknown
Lower Columbia	17080006	S1↓	1000-5000	100-500	250-1000	Unknown

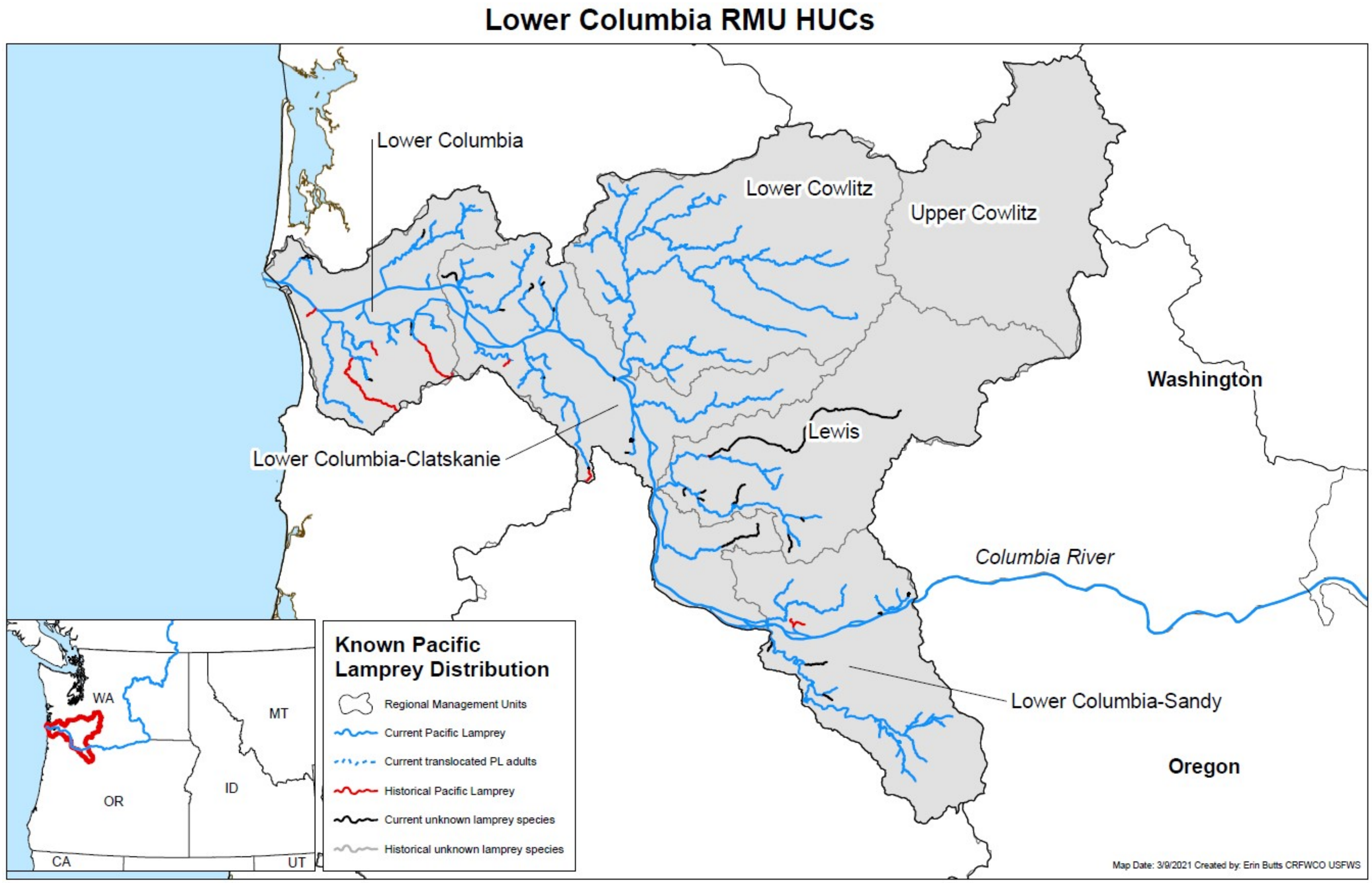

Figure 2. Current and historical known distribution for Pacific Lamprey: Lower Columbia/Willamette Regional Management Unit, Lower Columbia sub-region (USFWS Data Clearinghouse 2021). Historical Pacific Lamprey distribution depicted in map was obtained from published literature, tribal accounts and state and federal agency records.

Distribution and Connectivity

Passage was ranked a moderate threat in the Lower Columbia sub-region (Table 3). NatureServe Scope and Severity ranks were largely unchanged from the 2018 Assessment. Ranks declined slightly in the Lower Columbia-Clatskanie (from High to Moderate) and rose modestly (from Low to Low/Moderate) in the Lower Columbia, but changes reflect a refinement of stakeholder knowledge rather than an actual change in passage conditions.

While adult passage is not impeded by dams of the Federal Columbia River Power System (FCRPS) in the Lower Columbia River and its tributaries, lamprey in these HUCs are affected by other large hydroelectric dam including Merwin, Swift, and Yale Dams in the Lewis Basin, and Mayfield, Mossy Rock and Cowlitz Falls in the Lower and Upper Cowlitz Basins. These dams were built without fish passage and completely block upstream migration and access to hundreds of miles of spawning and rearing habitat. To compensate for loss of passage, salmon and steelhead are diverted into a collection facility where they are sorted, hauled by truck and released above dams. Downstream passage for juveniles is accomplished using floating surface collectors. It is unknown whether Pacific Lamprey have ever been collected at Cowlitz Salmon Hatchery or Merwin adult fish collection facilities. No trap-and-haul of lamprey currently takes place above these dams. Other significant passage barriers in the Lower Columbia sub-region include the multi-dam complex on the Bull Run River in the Sandy basin, and Sediment Retention Structure on the North Fork Toutle River. Culverts, tide gates, and small dams/weirs are also a concern throughout the sub-region.

Road crossing culverts are prevalent in the Lower Columbia sub-region. Poorly designed or installed culverts may fragment aquatic habitat and impede the migration of fish. Culverts with excessive water velocity (>0.86 m/s), inadequate attachment points, perched outlets, or abrupt 90 degree angles (e.g., baffles, fish ladder steps, outlet aprons), may obstruct passage of adult lamprey (Moser et al. 2002; Mesa et al. 2003; Keefer et al. 2003; Stillwater Sciences 2014; Crandall and Wittenbach 2015; LTWG 2020a). Many impassable culverts occur low in watersheds (near tributary outlets), preventing access to miles of potential habitat. Projects addressing passage barriers are on-going throughout the Lower Columbia sub-region, but more effort is needed to address the passage needs of adult Pacific Lamprey and other native fish species (see LTWG 2020a). There are still a number of basins within the lower Columbia with no barrier assessments.

Tide gates are broadly distributed in tidally influenced tributaries of the Lower Columbia sub-region (see https://oregontidegates.org/tide-gate-inventory/). Estuarine wetlands and floodplains were historically constrained by dikes and gated culverts to prevent flooding and drain land for agriculture, livestock grazing, and/or residential development. Traditional top-hinge tide gates do not allow tidal backflow and thus provide few (if any) passage opportunities for fish. Furthermore, many of the older wood and cast iron tide gates have become damaged or corroded over time and need maintenance. The Oregon Tide Gate Partnership recently completed an inventory of existing tide gates throughout the Oregon Coast and is working with stakeholders to facilitate the removal, repair or replacement of failing structures to restore more natural conditions. Although physical and ecological effects of tide gates are well documented, more research is needed to better understand how tide gates may influence the migration and passage of Pacific Lamprey (PLCI 2021).

Fish hatcheries in the lower Columbia River basin often use barrier dams and fish ladders to divert adult salmon into the hatchery during brood collection, or regulate fish passage above the hatchery. Most structures were designed to pass salmonids, but limit or impede passage of Pacific Lampreys and other native fish due to high velocities (>5ft/sec) and significant jump heights. Additionally, reduced passage efficiency at these structures can delay migration or increase predation on adult lamprey. The USFWS in partnership with ODFW and WDFW recently conducted inspections of fishways and barrier dams at 13 salmon hatcheries in the Lower Columbia sub-region using Pacific Lamprey specific passage guidelines (LTWG 2017). Many structures were found to have significant passage deficiencies and work is underway to recommend possible solutions (e.g., smooth attachment surfaces, round 90°corners, etc.) to facilitate passage of adult Pacific Lampreys (Joe Skalicky, USFWS, personal communication).

C. Threats

Summary of Major Threats

The following table summarizes the known key threats (i.e., mean Scope & Severity ≥2.50) within the Lower Columbia sub-region tributaries as identified by RMU participants during the Risk Assessment revision meeting in March 2022. The highest priority threat in the Lower Columbia watersheds is Climate Change followed by Lack of Awareness, Dewatering and Flow Management, Stream and Floodplain Degradation, Water Quality and Passage.

Table 2~~3~~. Key threats to Pacific Lamprey and their habitats within the Lower Columbia River sub-region, 2017. High = 4; Moderate/High = 3.5; Moderate = 3; Low/Moderate = 2.5; Low = 2; Unknown = no value

	Climate Change		Lack of Awareness		Dewatering and Flow Management		Stream and Floodplain Degradation		Water Quality		Passage	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Sandy	4	4	4	3	3	2	2.5	3	3	4	2.5	3
Lewis	4	4	4	3	4	4	3	3	3	3	3	3
Upper Cowlitz	4	4	4	3	4	4	3	3	1	1	4	4
Lower Cowlitz	4	4	4	3	3	4	3.5	3.5	2.5	4	3	3
Clatskanie	4	4	4	3	3	3	4	3	3.5	4	3	3
Lower Columbia	4	4	4	3	2.5	2	3.5	3	3.5	4	2.5	2
Mean Scope & Severity	4.00		3.50		3.21		3.17		3.04		3.04	
Drainage Rank	H		H		M		M		M		M	

Current Threats

Climate Change

Climate Change was the highest ranking threat in the Lower Columbia sub-region (Table 3). NatureServe Severity ranks increased (from Unknown to High) in all watersheds in 2022, and is the primary reason Conservation Status Ranks fell from Imperiled (S2) to Critically Imperiled (S1) in the Lower Columbia-Sandy, Lewis, and Lower Columbia (Table 2). Climate change is happening faster and more intensely than anticipated and the combined effects of climate change (e.g., changes to ambient temperature, precipitation, and streamflow patterns) and predicted rise in human population will likely exacerbate other threats within the sub-region. Climate change is likely to alter the amount, timing, and type of precipitation with decreases in snowpack, earlier snow melt, and more winter precipitation falling as rain. This will contribute to earlier peak streamflows and lower summer baseflows. Changes in the magnitude and timing of peak streamflows combined with projected sea level rise may increase the frequency and intensity of flooding in the Lower Columbia sub-region (Helaire et al. 2020; Queen et al. 2021). Warmer ambient temperatures and low summer flows may increase water temperatures to the detriment of Pacific Lamprey. Low water levels may restrict lamprey habitat availability, hinder adult migration, reduce reproductive capability, or contribute to increased mortality if incubating eggs, burrowing larvae or migrating juveniles are exposed to warm temperatures (>20°C) for an extended duration (Clemens et al. 2016). Warm water temperatures can increase vulnerability to pathogens and predation and may shift or expand the range of nonnative predatory fish, putting further stress on larval and adult lamprey (Lawrence et al. 2014). Climate change is identified as a critical threat across the range of Pacific Lamprey, but the feasibility of making tangible changes will be challenging and require large scale institutional changes. Focusing stream restoration efforts on actions that improve instream complexity and floodplain connectivity, restore tidal wetland habitats, remove unneeded impoundments, or revegetate riparian areas, can provide multiple benefits to the aquatic ecosystem (e.g., improve water quality, reduce flooding, increase channel stability, etc.) and can help make systems more resilient to climate change in the future (Justice et al. 2017).

Lack of Awareness

Lack of Awareness was also ranked a high threat in the Lower Columbia sub-region (Table 3). NatureServe Severity ranks rose (from Unknown to Moderate) in all watersheds in 2022. Pacific Lamprey awareness is slowly becoming more widespread among stakeholders and the public. Tribes, state and federal agencies, watershed councils and others have played a significant role in improving awareness through targeted outreach, youth education events, informational brochures and webinars. Nevertheless, it's unclear how improved awareness translates to on-the-ground actions that incorporate or benefit lamprey such as lamprey specific fish salvage, design of fish screens, passage improvements, habitat restoration, permitting (e.g., Section 404 permits), etc. For example, instream water work, whether for restoration activities or maintenance of diversions, can dewater areas or remove sediments in which larval lamprey are burrowed. Such actions without first salvaging lamprey may result in the death of hundreds to thousands of larvae. Increasing public and agency awareness about the presence of larval lamprey in the sediments, adult lamprey spawning habitats and timing during in-water work, and education on actions to minimize these impacts, could greatly decrease localized mortality and injury to lamprey populations. For more information about how to minimize impact to native lampreys during in-water work, please consult LTWG (2020b).

Dewatering & flow management

Dewatering and Flow Management was ranked a moderate threat in the Lower Columbia sub-region. NatureServe Scope and Severity ranks remained unchanged in the majority of watersheds in 2022. Low seasonal streamflow and hydropower operations were identified as key issues in the region. Low flow conditions occur naturally in many watersheds during summer months (e.g., Grays River), but land use practices and consumptive water use may exacerbate conditions further. Water withdrawals for irrigation, livestock, municipal, or industrial purposes leave many watersheds in the Lower Columbia sub-region dewatered or with inadequate flow during summer and fall months (e.g., Sandy River, Washougal River, East Fork Lewis River, Kalama River, Clatskanie River, Lewis and Clark River, Youngs River, Big Creek, and the South Fork Klaskanine River). Low flows can impact fish by reducing spawning and rearing habitat availability, creating low water passage barriers, or impairing water quality. The effects of climate change (i.e., elevated temperature, decreased surface water availability, altered flow regimes) and continued population growth will likely increase water demand and compound low flow conditions the future.

The mainstem Columbia River downstream from Bonneville Dam is 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 (LCFRB) 2010). These changes can negatively impact aquatic species that rely on environmental cues (i.e., temperature, photoperiod, flow) to trigger important developmental or behavioral events such as emergence, growth, maturation or migration. In the Columbia River basin, the spring freshet takes place an average of two weeks earlier and flow volume is reduced from historical levels as a result of reservoir management, changes in precipitation and consumptive water use (LCFRB 2010; Naik and Jay 2011). Diminished spring flows may increase the duration of fish migration, potentially increasing exposure to predators and other threats. Additionally, the shift of peak flows to earlier in the spring could result in even longer periods of low flow and warm water temperatures during summer and fall months (Naik and Jay 2011). Rapid water level fluctuations below Bonneville Dam (i.e., hydropeaking) repeatedly inundate and dewater shallow water areas, directly impacting the quantity, accessibility and suitability of spawning and rearing habitat. Larval lamprey may be especially vulnerable to dewatering events as they often rear in fine sediments along river margins and delta regions. As habitat is dewatered, larvae may be susceptible to stranding, desiccation, or predation if they emerge to find water (Mueller et al. 2015). Although impacts related to frequent, short-term dewatering events are not well understood, recent laboratory and field studies indicate that larval lamprey survival and response to dewatering events may depend on dewatering rate, duration, fish size, sediment particle size, or other variables (Leitke et al. 2015; Harris et al. 2020; Leitke et al. 2020). Dewatering due to hydropeaking also occurs below Merwin Dam on the North Fork Lewis River, but potential impacts to lamprey are unknown.

Stream & floodplain degradation

Stream and Floodplain Degradation was also ranked a moderate threat in the Lower Columbia sub-region. NatureServe Scope and Severity ranks rose slightly in the Lower Cowlitz (from Moderate to Moderate/High), but remained the same in all other watersheds. Change in the Lower Cowlitz reflects an increased understanding of the magnitude of degradation in the system rather than an actual change in habitat conditions over the last five years. Channel confinement, channel manipulation, and floodplain development are the primary concerns in the Lower Columbia sub-region. Human settlement and land development have greatly altered the physical habitat of tributaries in the region. 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. 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. Large wood can benefit streams by influencing the structural complexity of the channel (i.e., creating pools or undercut banks), increasing the deposition of fine substrate and organic matter, thereby providing important rearing habitat for juvenile salmonids and larval lamprey (Gonzalez et al. 2017). 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 floodplain 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. The U.S. Army Corps of Engineers conducts channel maintenance dredging in the lower Columbia River to maintain a 43-foot-deep and 600-foot-wide navigation channel used by commercial vessels to transport cargo to and from the Pacific Ocean (see https://www.nwp.usace.army.mil/lcrchannelmaintenance/). 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; LTWG 2021). Preliminary deep water larval sampling in the Lower Columbia River downstream from the City of Skamakawa (RM 33.5) did not detect larval lamprey in the 15 quadrats surveyed (Jolley et al. 2011a), though multiple size class and species of lamprey have been observed in other areas within the Columbia River mainstem (Jolley et al. 2011b; Jolley et al. 2012). An improved understanding of lamprey habitat use and distribution within the lower Columbia River and estuary could help inform pre-dredging salvage, improve mitigation measures, and provide further insight into the extent of dredging impacts on all life stages of Pacific Lamprey (LTWG 2021).

Water quality

Water quality was ranked a moderate overall threat with NatureServe Scope and Severity ranks increasing in the Lower Columbia-Sandy, Lower Cowlitz and Lower Columbia. Elevated water temperature is still the primary water quality concern in Lower Columbia tributaries. Lower and mainstem reaches regularly experience prolonged warming often starting in late spring, extending into fall. Factors contributing to excessive water temperatures generally include increased air temperature, lack of riparian cover (in response to past logging, fires and land clearing activities), stream channelization, loss of floodplain connectivity, and reduced instream flows. The impacts of warm water temperatures (e.g., ≥20°C) on Pacific Lamprey embryonic development, physiology, adult migrations, reproductive capability and evolutionary pressures can be multitudinous and substantial (Clemens et al. 2016). Other water quality concerns in tributaries include low dissolved oxygen, pH extremes, and presence of bacteria (e.g., fecal coliform, e coli), that may be associated with elevated water temperatures and agricultural or urban runoff.

Major water quality concerns in the Lower Columbia 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; Merz et al. 2019). 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. Total dissolved gas (TDG) 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. Short-term exposure to TDG levels <120% has minimal ill effects for juvenile salmonids. However, long term or repeated exposure to sublethal levels (<110%) may increase susceptibility to predation, disease, toxins, or other environmental stressors (McGrath et al. 2006). Furthermore, aquatic organisms inhabiting shallow water habitats or exposed during vulnerable life stages (e.g., incubating embryos, sac fry, or larvae) may be more sensitive to sublethal effects. The United States Geological Survey (USGS) is currently conducting a study to assess the effects of TDG supersaturation (125% and 130%) on larval lamprey. Preliminary results showed that larvae developed visible bubbles in the gut, became positively buoyant and had difficulty burrowing into sediments (as a result of increased buoyancy). Positive buoyancy could make larvae more vulnerable to predation or inhibit the fishes ability to hold station, potentially causing the fish to be swept downstream (Marty Leitke, USGS, personal communication). 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. Toxins and heavy metals may be a particular concern for Pacific Lamprey because direct exposure in water, sediment, or through dietary intake can result in high concentrations of contaminants accumulating in fatty tissues that may compromise development, reproduction and survival (Nilsen et al. 2015; Clemens et al. 2017; Madenjian et al. 2021).

Restoration and Research Actions

To date, the primary lamprey restoration activities that have occurred or are occurring within this RMU are being performed by organizations focused on salmon and steelhead recovery on both the Oregon and Washington side of the river. Many instream and floodplain habitat restoration activities have been identified in subbasin and watershed management plans (e.g., Oregon Lower Columbia River Conservation and Recovery Plan (2010), Washington Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (2010), Lower Columbia River Recovery Plan for Salmon and Steelhead (2013)). The vast majority of these actions have been funded and designed for salmon recovery, but work may improve habitat conditions for lamprey as well. Current Pacific Lamprey research has focused on gaining a better understanding of distribution and habitat use within the Columbia River mainstem and tributaries. The following lamprey research and restoration actions were initiated or recently completed by RMU partners in the Lower Columbia sub-region from 2012-2021.

HUC	Threat	Action Description	Status
RMU	Population	Environmental DNA, spawning ground surveys, smolt trapping and occupancy sampling to better understand lamprey distribution.	Ongoing
RMU	Stream Degradation	Implementation of instream and floodplain habitat restoration activities and culvert removal/replacement projects where lamprey salvage efforts occurred.	Ongoing
RMU	Passage	Evaluation of adult Pacific Lamprey passage efficacy at fishways and barrier dams associated with salmon hatcheries.	Complete
RMU	Population	Distribution surveys in mainstem and principal tributaries	Ongoing
RMU	Population	Use of eDNA to monitor effectiveness of large wood placement projects and recolonization of larval lamprey following restoration	Proposed
RMU	Lack of Awareness	Consideration of lamprey when planning and implementing instream habitat restoration work (see LTW 2020b)	Ongoing
RMU	Passage	Map, assess and prioritize passage barriers in tributaries and evaluate available lamprey habitat upstream	Ongoing
RMU	Population	Adult/Juvenile Pacific Lamprey data summary for Southwest Washington tributaries	Complete
RMU	Population	Oregon Department of Fish and Wildlife Conservation Plan for Lampreys in Oregon *https://www.dfw.state.or.us/fish/CRP/coastal_columbia_snake_lamprey_plan.asp*	Complete
RMU	Population	Ongoing lamprey genetics work (CRITFC)	Ongoing
Sandy	Stream Degradation	Sandy River floodplain reconnection, gravel augmentation in Bull Run River.	Complete
Sandy	Stream Degradation	Large wood augmentation, side channel reconnection in upper Sandy River.	Complete

Sandy	Stream Degradation	Evaluation of new and past restoration projects to determine if projects benefit Pacific Lamprey or may be a barrier (e.g., log weirs)	Complete
Clatskanie	Population	Conduct adult spawning ground surveys to monitor Pacific Lamprey distribution, timing, and number of redds to develop relative abundance indexes.	Ongoing
Clatskanie	Population	Deep water sampling to document distribution and habitat use of larval lamprey in Columbia River mainstem.	Complete
Clatskanie	Passage	Tide gate and culvert modification and removal projects to restore access to spawning and rearing habitat.	Ongoing
Clatskanie	Passage	Removal of 3 passage barriers that will restore 200-300 acres and increase habitat connectivity for native fish	Underway
Clatskanie	Stream Degradation	Assessment of larval lamprey use in areas of salmonid restoration vs no restoration (Abernathy Creek).	Complete
Lower Columbia	Stream Degradation	Floodplain reconnection on Lewis and Clark & junctions of Big and Little Creeks	Proposed
Lower Columbia	Stream Degradation	Whole habitat watershed restoration initiative on Grays R. will incorporate habitat needs for lamprey and other native fish	Proposed
Lower Columbia	Passage	Pilot test of acoustic telemetry array to monitor movement of juvenile lamprey	Proposed
Lower Columbia	Passage	Lamprey friendly passage improvements at 3 dams at North Fork Klaskanine Hatchery. The smallest dam was completely removed in 2020	Ongoing
Lower Columbia	Passage	Evaluation of passage constraints for lamprey at fish hatcheries in Washington State	Complete
Lower Columbia	Population	Conduct adult spawning ground surveys to monitor Pacific Lamprey distribution, timing, and number of redds to develop relative abundance indexes.	Ongoing
Lower Columbia	Population	Study looking at effects of dredging on larval lamprey occupancy and abundance at 4 different locations in lower Columbia R.	Proposed
Lower Columbia	Passage	Tide gate and culvert modification and removal projects to restore access to spawning and rearing habitat.	Ongoing
Lower Columbia	Population	Investigation of salinity tolerance and larval lamprey occurrence in tidally influenced estuarine stream.	Complete

Lower Columbia	Population	UC Santa Barbara Master's group looking at juvenile Pacific Lamprey use of Columbia River estuary and how changes in environmental conditions effect habitat for Pacific Lamprey	Complete
Lower Columbia	Passage	Formation of Oregon Tide Gate Partnership Group	Ongoing
Lower Columbia	Passage	Tide gate inventory in lower Columbia River	Complete
Lower Cowlitz	Stream Degradation	Restoration work implemented in Coweeman (7 miles) and SF Toutle (14 miles) watersheds have shown great results at aggrading channels and retaining both fine and coarse sediments, likely benefiting resident and anadromous lamprey.	Ongoing
Lower Cowlitz	Stream Degradation	Study to look at effects of installing beaver dam analogs on larval lamprey presence and distribution	Ongoing

III. Literature Cited

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Appendix 1

The following are the definitions for interpreting the NatureServe conservation status ranks in Table 2.

> ***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.