Pacific Lamprey

2023 Regional Implementation Plan

for the

Puget Sound/Strait of Juan de Fuca

Regional Management Unit

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I. Status and Distribution of Pacific lamprey in the RMUs

A. General Description of the RMUs

The Puget Sound/Strait of Juan de Fuca Region includes watersheds that drain into the Salish Sea (Figure 1). This region comprises a broad range of geological and hydrological conditions, from snow-dominated or mixed snow and rain watersheds with alpine glaciers in the Cascade Range and Olympic Mountains to low-elevation, rain-dominated Puget Sound lowlands. These watersheds are bordered by the Strait of Juan de Fuca, the Strait of Georgia, and the U.S.-Canada border to the north. The major river basins along the region's eastern side initiate from the Cascade Range and flow west, draining into Puget Sound and the Strait of Georgia, except for the tributaries that flow north into the Fraser River in British Columbia. All the major river basins along the western side of Puget Sound flow into the Hood Canal and originate in the Olympic Mountains. The watersheds along the northern Olympic Peninsula also originate in the Olympic Mountains, draining north to flow into the Strait of Juan de Fuca. This region comprises 21 watersheds, delineated by the 4th field hydrologic unit code (HUC), ranging in size from 435-6,604 km^2 (Table 1).

Figure 1. Map of watersheds within the Puget Sound/Strait of Juan de Fuca RMU.

Table 1. Drainage Size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the Puget Sound/Strait of Juan de Fuca Region.

Watershed	HUC Number	Drainage Size (km^2)	Level III Ecoregion(s)
Fraser	17110001	645	Puget Lowland, North Cascades
Strait of Georgia	17110002	2,473	Puget Lowland, North Cascades
San Juan Islands	17110003	1,621	Puget Lowland
Nooksack	17110004	1,282	Puget Lowland, North Cascades
Upper Skagit	17110005	4,222	North Cascades
Sauk	17110006	1,919	North Cascades
Lower Skagit	17110007	1,158	Puget Lowland, North Cascades
Stillaguamish	17110008	1,823	Puget Lowland, North Cascades
Skykomish	17110009	2,209	Puget Lowland, North Cascades
Snoqualmie	17110010	1,795	Puget Lowland, Cascades, North Cascades
Snohomish	17110011	720	Puget Lowland, North Cascades
Lake Washington	17110012	1,603	Puget Lowland, Cascades, North Cascades
Duwamish	17110013	1,261	Puget Lowland, Cascades, North Cascades
Puyallup	17110014	2,580	Puget Lowland, Cascades
Nisqually	17110015	1,880	Puget Lowland, Cascades
Deschutes	17110016	435	Puget Lowland, Cascades
Skokomish	17110017	642	Coast Range, Puget Lowland, North Cascades
Hood Canal	17110018	2,479	Coast Range, Puget Lowland, North Cascades
Puget Sound	17110019	6,604	Coast Range, Puget Lowland
Dungeness-Elwha	17110020	3,289	Coast Range, Puget Lowland, North Cascades
Crescent-Hoko	17110021	2,005	Coast Range, Puget Lowland

B. Status of Species

Conservation Assessment and New Updates

Pacific Lamprey have not been a management priority for federal or state agencies in the Puget Sound/Strait of Juan de Fuca RMU. However, over the past few years, there have been steps toward a more focused and collaborative approach to collecting targeted Pacific Lamprey data and incorporating lamprey into management activities. The Puget Sound/Strait of Juan de Fuca RMU, along with the Washington Coast RMU, held inaugural annual meetings in 2021 to discuss and coordinate lamprey conservation needs. This collaboration continued in 2022 and 2023 and facilitated a substantial increase in understanding Pacific Lamprey distributions and evaluating their conservation status. The 2023 RMU meeting had participants from tribes, local, state, and federal agencies, and non-profits. Additional conservation collaboration was continued with state and federal coordination through the Interagency Special Status/Sensitive Species Program (ISSSSP), facilitated by the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS) staff with participation from US Fish and Wildlife Service (USFWS), and Washington Department of Fish and Wildlife (WDFW). These meetings aim to collaboratively manage rare aquatic species that are not managed under the Endangered Species Act and Pacific Lamprey was a particular focus of these meetings. The Washington Department of Natural Resources (WA DNR) is also researching actions to protect and conserve Pacific Lamprey on WA DNR land across the state.

There is still a significant need for targeted lamprey data collection, lamprey identification, field methods training for biologists and managers, sharing of best management guide resources, and continued collaboration in these RMUs. However, some progress on these fronts has been made over the past several years. To facilitate the 2022 update to the Pacific Lamprey Assessment (Luzier et al., 2011), a focused effort was made by partners to collate and share information regarding Pacific Lamprey distributions, population trends, and local threats. Every five years, the Pacific Lamprey Conservation Initiative (PLCI), through the RMUs, revises the Pacific Lamprey Assessment. The Assessment utilizes local partners' knowledge and expertise to evaluate Pacific Lamprey distribution, population demographics, and threats at the 4^{th} field HUC (watershed) level. This information is used to inform NatureServe, a diagnostic tool that characterizes the conservation risks of Pacific Lamprey across their historical range. Information about current Pacific lamprey distribution, population size, trends, and watershed threats was collected from partners in the Puget Sound/Strait of Juan de Fuca region through an online Assessment questionnaire and virtual meeting held on March 22, 2022. A summary of these key findings is included in this Regional Implementation Plan, and a complete analysis will be included in the 2022 Pacific Lamprey Assessment (anticipated publish date March 2024). Additional distribution data has been collected in 2023 including eDNA samples in watersheds where limited to no Pacific Lamprey data exists.

This partner-driven data collection and subsequent NatureServe evaluation have resulted in updates to the four watersheds where the conservation status rank was evaluated in 2018, as well as the completion of the initial ranking status for an additional 15 watersheds (Table 2).

Compiling enough data to run the model and derive the initial conservation status ranking was the primary goal for the RMU and has advanced our understanding of Pacific Lamprey populations in this region. Significant data gaps still exist, including in two watersheds with insufficient data to be evaluated and another two watersheds where threat analysis has yet to be conducted. Based on the data collected, we have identified areas to focus outreach efforts and increased participation, as well as locations where more data or increased survey precision could result in future gains for the next Assessment.

Within the RMU, 15 watersheds were found to have a conservation status rank of Critically Imperiled (S1): Strait of Georgia, Upper Skagit, Lower Skagit, Stillaguamish, Skykomish, Snoqualmie, Snohomish, Duwamish, Puyallup, Nisqually, Skokomish, Puget Sound, Hood Canal, Dungeness-Elwha, and Crescent-Hoko. The Nooksack was ranked between Critically Imperiled and Imperiled (S1/S2), and the Sauk River was ranked as Imperiled (S2). The Lake Washington and the Deschutes watersheds were ranked as Possibly Extirpated (SH) due to a lack of observations above the tidewater barrier in both watersheds; see the distribution discussion below.

The San Juan Island and Fraser River HUCs still need to be ranked due to a lack of information on Pacific Lamprey populations and threats. The San Juan Island HUC has no historical documentation of Pacific Lamprey. A few drainages on the two largest islands, Orcas and the San Juan Islands, have hosted anadromous salmonids and could potentially contain Pacific Lamprey. However, we are unaware of any lamprey data collection on the islands. The section of the Fraser River watershed within Washington includes the upper reaches of the Sumas River, several tributaries to the Chilliwack River, and the Chilliwack River upstream of Chilliwack Lake. Both river systems in British Columbia have documented lamprey presence; however, they have yet to be identified for the parts of the rivers within Washington or summarized at the watershed scale using the NatureServe model. Future collaboration with partners in British Columbia and targeted lamprey surveys could shed light on Pacific Lamprey status in this watershed.

Distribution

Lamprey distribution information is currently being gathered by several tribes, agencies, and non-profits (e.g., environmental DNA (eDNA) sampling, occupancy sampling, and spawning data) in western Washington tributaries. Existing lamprey distribution and occupancy information are primarily based upon anecdotal observations or collected incidentally while monitoring for salmonid species. Most lamprey data in the Puget Sound has been collected through WDFW’s Spawning Ground Surveys (SGS, https://data.wa.gov/Natural-Resources-Environment/WDFW-SGS/idwx-fext), which are conducted for steelhead during the winter and spring (typically January-June). This timing broadly overlaps with Pacific Lamprey spawning timeframes, though in most watersheds, Pacific Lamprey continues to spawn into the summer months after steelhead spawning and associated surveys have concluded. The SGS steelhead surveys record lamprey nest information for multiple species; however, this data varies by watershed, year, and crew. Due to the variability in the data and not capturing the entire spawning timeframe, the distribution information and the population estimate likely underestimate the entire RMU. However, without more uniform and targeted surveys, the SGS database was the primary data source to inform the NatureServe models distribution information. Other data sources included observations from WDFW's Scientific Collection Permit process, observations submitted by tribes, agencies, and other entities to PLCI, as well as eDNA samples collected by various projects.

In 2019, an eDNA sampling protocol was piloted in the Sauk River, Skykomish River, Nisqually River, and Hood Canal watersheds led by the USFS Rock Mountain Research Station (RMRS, Carim et al., 2015). In 2021 and 2022, the project expanded and sampling eDNA along the east side Puget Sound watersheds. Fourteen watersheds were sampled along the mainstem rivers and at tributary mouths that an occupancy model developed by the RMRS predicted the presence of Pacific Lamprey. This data was added to the distribution information in the region, and in the case of two watersheds, the Upper Skagit and the Sauk River, the eDNA data is the only Pacific Lamprey distribution information that has been collected to date.

From 2017 to 2021, the known distribution of Pacific Lamprey almost doubled from 819 sq/km to 1521 sq/km (45% increase). However, this only represents roughly 7% of the estimated historic Pacific Lamprey extent for the RMU. Though this is likely an underestimate of distributions, it also highlights that large portions of the basins are currently inaccessible to Pacific Lamprey in many watersheds. This underscores the need for further targeted Pacific Lamprey surveys as well as the need to train survey crews that are already monitoring watersheds across the Puget Sound and Strait of Juan de Fuca to be able to identify Pacific Lamprey, their habitats, and their nests.

The Possibly Extirpated (SH) rankings in the Lake Washington and Deschutes watersheds were related to barriers at tidewater that may block Pacific Lamprey from migrating into the watersheds. Lake Washington's barrier is the Hiram M. Chittenden/Ballard Locks and associated salmon fishway. There are sporadic observations of Pacific Lamprey within the fishway; however, there are no counts of lamprey at the facility and no recent documented presence of Pacific Lamprey in the Lake Washington watershed. Locks have the potential to facilitate the passage of fish, such as lampreys, that have poor swimming performance (Silva et al., 2017). In 2022, 17 eDNA samples were collected around the Lake Washington watershed and none of them returned a positive detection for Pacific Lamprey (personal communication with Kellie Carim, USFS). Passage conditions at the Ballard Locks Fishway, designed solely to pass adult salmonids, should be evaluated for lamprey passage. It is highly likely that the locks and fishway impede or preclude passage of Pacific Lamprey (and Western River Lamprey).

The barrier on the Deschutes is a bedrock falls, Tumwater Falls, which historically blocked anadromous salmon from entering the watershed, along with extensive infrastructure that was built to support a hydroelectric power plant, and later, a fish ladder. The fishway is built into the bedrock and designed solely for salmonid passage. There is no historical documentation of Pacific Lamprey in the watershed but the falls may have been passible by burst-and-attach climbing. Two studies conducted at screw trap locations across Puget Sound, one based on visual observations of lamprey species in 2011 (Hayes et al., 2013) and one based on eDNA detections in 2014-2015 (Ostberg et al., 2018), did not document Pacific Lamprey in either watershed. In 2022, six sites were sampled for Pacific Lamprey eDNA in the watershed. No positive detections were found upstream of the falls, but there was a positive detection downstream of the falls (personal communication with Kellie Carim, USFS). Further occupancy surveys and barrier assessments will be necessary to confirm these rankings' status and evaluate the potential for retrofitting the Pacific Lamprey passage.

Abundance

Pacific Lamprey abundance within the RMU was determined by expert opinion in combination with estimates from available spawning ground survey (SGS) observations made by the Washington Department of Fish and Wildlife (WDFW, https://wdfw.wa.gov/fishing/management/sgs-data). Lamprey nest and adult counts are made by crews conducting spawning surveys for steelhead, typically from January –June. However, this lamprey data in many watersheds are more limited for population abundance estimates than the equivalent data collected for salmon and steelhead in the same areas. The lamprey data is not collected as consistently and are mostly incidental observations. Depending on the location, year, and crew, different data is recorded with varying degrees of detail and therefore is difficult to evaluate over time.

Additionally, some watersheds do not have steelhead SGS every year, so the lamprey data is likewise not collected. Still, other watersheds do not have any records for SGS, such as the Upper Skagit and Sauk watersheds. Though there is an overlap in Pacific Lamprey and steelhead spawning timing, Pacific Lamprey tends to continue spawning later into the summer than steelhead. A pilot study in 2010 and 2012 surveyed the full extent of the Pacific Lamprey spawning window in the Willapa Bay watershed. WDFW crews documented 36 - 70% of the Pacific Lamprey nests after the steelhead SGS concluded for the year (unpublished data, personal communication C. Holt WDFW 2021). Given all these caveats, the estimates for Pacific Lamprey population abundance in the Puget Sound/Strait of Juan de Fuca are likely underestimates across all watersheds. Improved training and consistency of nest identification would significantly increase the ability to estimate abundance within this RMU.

Short-term Population Trend

There is broad consensus that lamprey populations have declined significantly compared to historic returns approximately 50-60 years ago (Close et al., 2004; Columbia River Inter-Tribal Fish Commission, 2011; Luzier et al., 2011; Clemens et al., 2017). However, short-term population trend, defined as the degree of change in population size over three lamprey generations (≈36 years), was ranked as 'Unknown' in all but three watersheds for the Puget Sound/Strait of Juan de Fuca watersheds in 2022. This is due to the region's lack of continuous long-term population trend data. The Elwha watershed has seen an increase in population in recent years due to two large-scale dam removals on the mainstem Elwha River that has reconnected miles of anadromous habitat, which lamprey have begun to recolonize (Hess et al., 2020). The short-term trends for the Nooksack (Stable) and Stillaguamish (Declining 10-30%) watersheds were based on expert opinion but do not have continuous data collection to substantiate these observations further.

Table 2. Population demographic and Conservation Status Ranks of the 4th Field HUC watersheds in the Puget Sound/Strait of Juan de Fuca Region. SU = Unrankable, SH = Possibly Extirpated, S1 = Critically Imperiled, S2 = Imperiled, S3 = Vulnerable. The ranks highlighted in Yellow are new in 2022.

Watershed	HUC Number	Conservation Status Rank	Historical Occupancy (km2)	Current Occupancy (km2)	Current Population Size (adults)	Short-term Trend (% decline)
Sumas River	17110001	SU	250-1,000	Unknown	Unknown	Unknown
Strait of Georgia	17110002	S1	250-1,000	20-100	50-250	Unknown
San Juan Islands	17110003	SU	Unknown	Unknown	Unknown	Unknown
Nooksack	17110004	S1/S2	1,000-5,000	100-500	250-2,500	Stable
Upper Skagit	17110005	S1	1,000-5,000	20-100	Unknown	Unknown
Sauk	17110006	S2	1,000-5,000	20-100	Unknown	Unknown
Lower Skagit	17110007	S1	250-1,000	100-500	50-250	Unknown
Stillaguamish	17110008	S1	1,000-5,000	100-500	1-50	Declining 10-30%
Skykomish	17110009	S1	1,000-5,000	20-100	1-50	Unknown
Snoqualmie	17110010	S1	1,000-5,000	100-500	50-250	Unknown
Snohomish	17110011	S1	250-1,000	20-100	50-1,000	Unknown
Lake Washington	17110012	SH	250-1,000	Zero	Zero	Unknown
Duwamish	17110013	S1	250-1,000	20-100	Unknown	Unknown
Puyallup	17110014	S1	1,000-5,000	20-100	50-250	Unknown
Nisqually	17110015	S1	1,000-5,000	20-100	1-50	Unknown
Deschutes	17110016	SH	250-1,000	Zero	Unknown	Unknown
Skokomish	17110017	S1	250-1,000	4-20	50-250	Unknown
Hood Canal	17110018	S1	1,000-5,000	20-100	50-250	Unknown
Puget Sound	17110019	S1	1,000-5,000	20-100	Unknown	Unknown
Dungeness-Elwha	17110020	S1	1,000-5,000	20-100	250-1,000	Increasing
Crescent-Hoko	17110021	S1	250-1,000	100-500	Unknown	Unknown

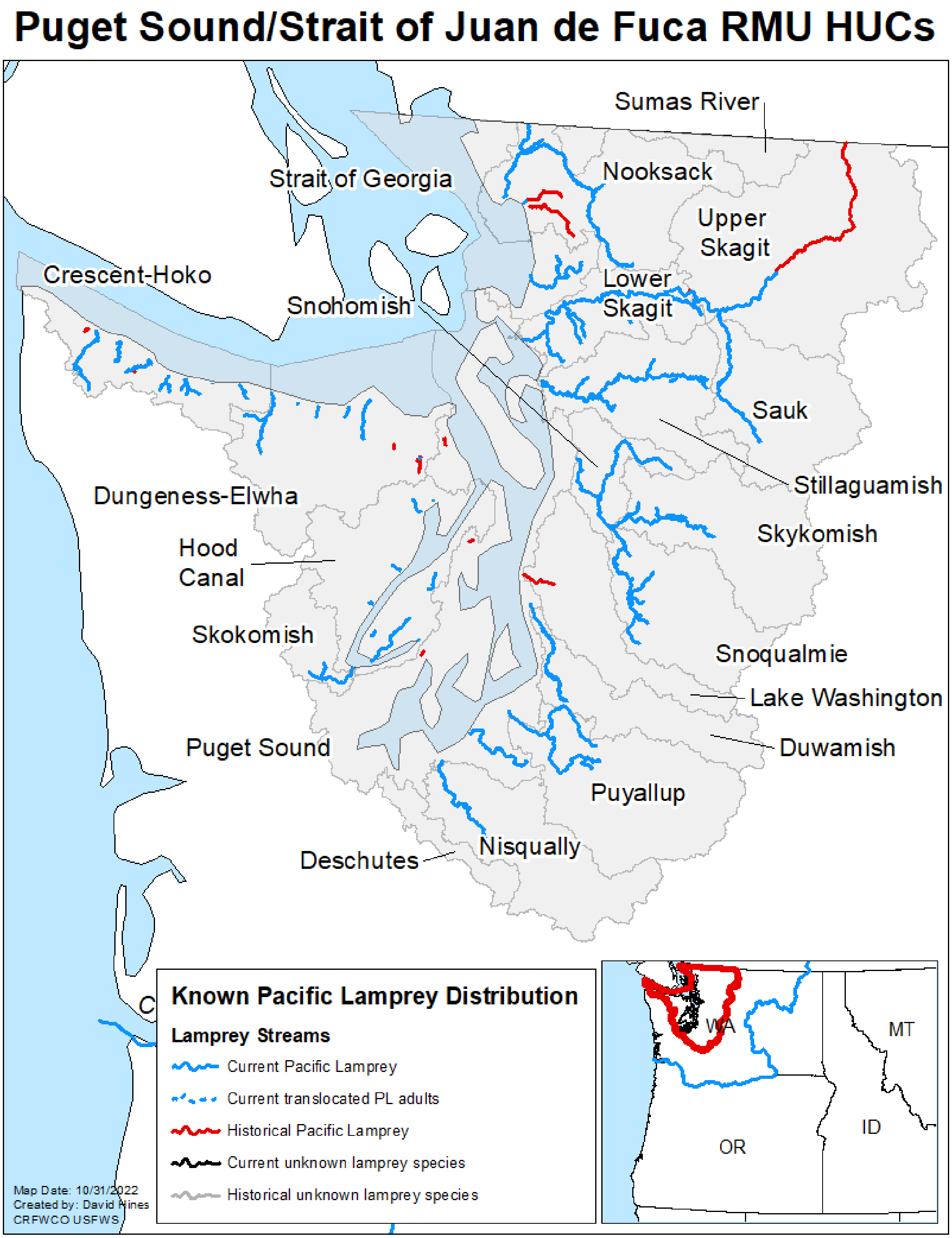

Figure 4. Current Pacific Lamprey distribution and location of 20 4th Field HUCs in the Puget Sound/Strait of Juan de Fuca RMU (USFWS Data Clearinghouse 2017).

Table 3: Summary of the Assessment results for the key threats (Mean Scope/Severity ≥ 2.5) of the Puget Sound/Strait of Juan de Fuca region. Insignificant 0-1.49, Low 1.5-2.49, Moderate 2.5-3.49, High 3.5-4. U = unknown threat or impact.

	Passage		**Stream and Floodplain Degradation**		**Lack of Awareness**		**Climate Change**	
Watershed	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Sumas River	U	U	U	U	U	U	U	U
Strait of Georgia	U	U	3	2	4	2	4	3
San Juan Islands	U	U	U	U	U	U	U	U
Nooksack	2	2	3	3	4	4	4	3
Upper Skagit	3	3	2	2	U	U	3	3
Sauk	U	U	2	2	U	U	3	3
Lower Skagit	2	3	2	3	4	2	4	4
Stillaguamish	2	2	3	3	4	2	3	3
Skykomish	U	U	3	3	U	U	4	3
Snoqualmie	3	3	4	3	4	1	4	3
Snohomish	2	2	4	2	4	3	4	3
Lake Washington	4	4	3	3	U	U	4	3
Duwamish	3	3	3	3	U	U	4	3
Puyallup	3	2	2	2	2	2	3	3
Nisqually	3	3	2	2	2	2	3	3
Deschutes	U	U	U	U	U	U	U	U
Skokomish	2	3	3	4	2	2	3	3
Hood Canal	3	2	3	3	2	2	3	3
Puget Sound	U	U	U	U	U	U	U	U
Dungeness- Elwha	2	2	2	3	4	4	3	3
Crescent-Hoko	1	1	4	3	4	4	4	3
Average Scope/Severity	2.50	2.50	2.81	2.69	3.33	2.5	3.53	3.06
Rank	M	M	M	M	M	M	M	M
Mean Scope and Severity	2.50		2.75		2.92		3.29	
Watershed Rank	**Moderate**		**Moderate**		**Moderate**		**Moderate**	

Current Threats

Threats were evaluated using the NatureServe Model to define the scope and severity of each of the seven threats identified for the region. The scope is the proportion of the watershed or population affected by the threat. Severity is the degree to which the impacts are irreversible or the time scale needed for recovery. Both scope and severity were ranked from Insignificant (1) to High (4). If there was insufficient information to quantify the scope and/or severity, it was ranked Unknown (0). The Unknown ranking does not mean the threat is not present on the landscape, but it does highlight a data gap and potential area to focus future investigations. This was the first attempt to rank these threats for this RMU. In some cases, the better-understood influences of these threats on salmonid were the only available information and used instead of lamprey-specific data. Over the next five years, the goal will be to expand awareness of how these threats impact lamprey and hone these threat rankings to reflect lamprey characteristics and responses.

Climate Change, lack of awareness, stream and floodplain degradation, and passage were identified as the key threats to Pacific Lamprey for the RMU (Table 3). All four threats at the RMU level were ranked as moderate (2.5-3.49) for Mean Scope and Severity and overall Average Scope/Severity. Additionally, water quality, flow management, dewatering, and predation were also recognized as threats but were ranked low (1.5-2.49) or insignificant (<1.5) for Mean Scope and Severity and not considered key threats at the RMU level. However, these three threats may have significant local impacts and received a moderate ranking for scope and/or severity in some watersheds. Below is a brief description of the threats within the RMU in order of rank, from highest to lowest.

Climate Change (3.29):

Climate Change received the highest threat ranking for the RMU and was the highest or tied for the highest threat in ten of the 17 watersheds where threats were ranked. When ranking this threat in the RMU, contributors were asked to consider whether climate change would result in a potential increase in summer maximum water temperature [1° to 3°], alterations in precipitation patterns/intensity, diminished snowpack, shifts in the timing of snowmelt and peak flows, more extreme high and low flows, and/or an increase in the risk and extent of wildfires, which would have an impact on Pacific Lamprey populations. Across all watersheds, climate change received a moderate to high rank for Average Scope/Severity. Changes to snowpack, stream flow patterns, and stream temperatures were the primary concerns in these watersheds. The *State of Knowledge: Climate Change in the Puget Sound* (Mauger et al., 2015) details trends and model predictions for watersheds and is a valuable tool for evaluating watershed-scale changes. Some of these changes are already being observed on the landscape, especially changes in snowpack and runoff timing; the region's historically mixed rain and snow watersheds are transitioning to rain dominate, while the snow-dominant watersheds are shifting to mixed rain and snow (Mauger et al., 2015).

Climate change acts as a positive feedback cycle for many other threats, increasing their impacts on the region. More severe winter rainfall events may increase the frequency and intensity of flooding, bank erosion, and scouring of streambeds. Warmer summer temperatures and low summer base flows increase water temperatures to the detriment of Pacific Lamprey. These conditions may restrict lamprey habitat availability, hamper adult migration, reduce reproductive capability, or contribute to increased mortality if incubating eggs, burrowing larvae, or migrating juveniles are exposed to relatively warm temperatures (>20°C) for an extended duration (Clemens et al., 2016). Temperature increases could also shift or expand the range of non-native predatory fish, putting further stress on larval and adult lamprey (Lawrence et al., 2014). In addition to temperature concerns, water withdrawals for irrigation, municipal, or residential uses further depress already low summer stream flows. Low flow levels can reduce habitat availability, prevent lamprey access to backwater or side channel habitats, and may contribute to mortality if incubating eggs or burrowing larvae are dewatered or exposed to a high temperature or low oxygen environment. 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 other identified threats, including instream complexity and floodplain connectivity, restoring tidal wetland habitats, removing unneeded impoundments, or revegetating riparian areas, can provide multiple benefits to the aquatic ecosystem (e.g., improving water quality, reducing 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 (2.92):

Pacific Lamprey have not been a focus of broad conservation efforts in the RMU, and information about their presence, basic biology, habitat needs, passage requirements, are not widely known and considered in management decisions. In watersheds in the North Sound and along the Strait of Juan de Fuca, lack of awareness was highlighted as more of a threat than in the South Puget Sound watersheds. This threat can also act as a positive feedback cycle with other threats. The more significant the lack of awareness is in a watershed, the greater the likelihood that the other issues (passage, screening, habitat protection/restoration) are not incorporate lamprey-specific requirements. The need to educate biologists, managers, permit reviewers, funding sources, and the general public is essential to the Pacific Lamprey recovery in this region.

Stream and Floodplain Degradation (2.75):

Floodplain development, stream channelization, road building (e.g., channel confinement, simplification, habitat fragmentation), flood reduction (e.g., channel straightening, levees), dredging, mining, and vegetation removal (e.g., grazing, deforestation, agriculture) contribute to Pacific Lamprey habitat degradation. Nine watersheds ranked this threat as moderate to high for scope and severity. For three of those watersheds (Snoqualmie, Skokomish, and Hood Canal), stream and floodplain degradation was the highest or tied for the highest threat on the landscape. The Sauk, Upper Skagit, Puyallup, and Nisqually watersheds had the lowest ranks for this threat. In every watershed draining directly into the Salish Sea, degradation is highest in the lower reaches of the watershed, where most of the population centers are located and where most of the agricultural development has occurred. These lower reaches are the sections of streams the majority of migrating Pacific Lamprey must navigate to and from the ocean. Timber harvest practices have also resulted in stream and floodplain degradation in this region and were highlighted in discussion for several watersheds, the Sauk, Hood Canal, and Crescent-Hoko. In some watersheds, the most pristine waterways and highest quality spawning reaches are inaccessible due to barriers, and thus the degraded reaches of the watershed are the only habitat available.

Passage (2.50):

In the 14 watersheds that had enough information to rank passage, nine considered the scope and/or severity ranking to be moderate to high. Passage impediments to Pacific Lamprey range from small road crossings and private tide gates to large-scale hydroelectric facilities. The watersheds with the highest passage threat rankings were large dams that block upstream migration and those with more densely populated areas.

There are several examples of dam removals in this RMU, at least two of which are the Elwha and Glines Canyon dams on the Elwha River, where lamprey populations have been documented recolonized post-dam removal (Hess et al., 2020). At other locations, such as the Middle Fork Nooksack River and Pilchuck River, dam removals can improve or restore Pacific Lamprey access in conjunction with the focal species of salmon and steelhead.

Several hydroelectric facilities provide truck and haul access for salmonids to river reaches above passage barriers. However, it is unclear and unlikely that Pacific Lamprey are getting moved above the barriers with other anadromous species. This is probably due to a combination of the traps not being designed to capture lamprey and the lack of obligation to move lamprey. Moving salmonids above these barriers allow them to access more intact habitat and, in some cases, the preferred spawning reaches. Without the benefit of assisted passages, Pacific Lamprey are unable to access these habitats.

In some cases, adult salmonid passage in the form of a fishway is present at a barrier, such as the Ballard Locks. However, at many of these locations, the ability of Pacific Lamprey to pass through the fishway has yet to be assessed, and likely some elements reduce lamprey success. Lamprey-specific passage at these large facilities is an element of the passage threat that warrants future evaluation, both for upstream and downstream migration, in many watersheds, including the Upper Skagit, Duwamish, Puyallup, and Deschutes. Fishway guidelines for improving lamprey passage at fishways can be found in the Lamprey Technical Workgroup (2022) whitepaper.

Since 2013, in Western Washington, there has been a concentrated effort to evaluate state-owned salmonid passage barriers and increase efforts to remove prioritized barriers to comply with a federal court injunction that requires that the state fulfill the treaty-based duty to preserve fish runs. Hundreds of culverts still need to be assessed for providing anadromous salmonid passage (https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html). Overall, this effort and other culvert replacement projects will likely improve lamprey passage in many places, primarily if stream-simulation culvert designs are employed or bridges replace culverts. However, during the assessment process, barriers that block lamprey, but not salmonid passage, are not identified, prioritized, or replaced; therefore, the documented fish passage barriers underestimate the barriers that exist for lamprey. In most cases, lamprey's specific swimming and climbing capabilities are not explicitly considered when designing or evaluating passage structures. Culverts with excessive water velocity (>0.86 m/s), inadequate attachment points, perched outlets, or added features with abrupt 90-degree angles (e.g., baffles, fish ladder steps, outlet aprons), may obstruct the passage of adult lamprey (Lamprey Technical Workgroup, 2022., Moser et al., 2002; Mesa et al., 2003; Stillwater Sciences, 2014; Crandall & Wittenbach, 2015). Many impassable culverts and tide gates occur low in watersheds where there are higher concentrations of urban and agricultural land use, preventing access to a large portion of the habitat. Expanding understanding of lamprey passage requirements and assessing smaller-scale road crossings, tide gates, and dams using lamprey-specific criteria is another area that merits focus throughout the RMU. Guidelines for evaluating and providing Pacific Lamprey passage at road crossings can be found in the Lamprey Technical Workgroup (2020a).

Water Quality (2.25):

Though not a key threat for the RMU, water quality was ranked as the top threat or tied with climate change as the top threat in three watersheds, Stillaguamish, Snohomish, and Puyallup. It also had moderate ranks in the Snoqualmie, Lake Washington, Duwamish, and Skokomish watersheds. High water temperatures and impacts from urban and agricultural runoff were identified as the primary water quality issues in these watersheds. Though our understanding of water quality impacts on lamprey is still evolving, the limited information points to toxins and high water temperatures having negative impacts on lamprey (Nilsen et al. 2015 and Clemens 2022). Data gathering and documentation regarding water quality issues related to Pacific Lamprey populations will be important in the highly urbanized watersheds in the Puget Sound/Strait of Juan de Fuca, and future temperature monitoring relative to climate change will also be essential across the RMU.

Dewatering and Flow Management (2.02):

Rapid fluctuations in reservoir and stream water levels from irrigation diversions, power hydropeaking operations, and instream activities (e.g., channel reconstruction, barrier removals, habitat restoration) can isolate or dewater stream habitats. These unnatural water level fluctuations can impede migration or strand eggs and larval lamprey in the substrate. Additionally, the screens and pumps associated with water management infrastructure and dewatering activities can lead to the impingement or entrainment of lamprey. Two watersheds that ranked this threat scope moderate have dams that can cause fluctuations downstream, the Upper Skagit and Skokomish. The Strait of Georgia also ranked the scope moderate, though this ranking was due to smaller scale diversions and instream activities. Recommendations for reducing impacts on lamprey during in-water work can be found in Lamprey Technical Workgroup (2020b) whitepaper.

Predation (1.40):

In two watersheds, the Snoqualmie and Stillaguamish, predation was discussed as a threat and ranked low to moderate. This was due to non-native species being present in the lower reaches of both systems. For all other watersheds, predation was ranked insignificant or unknown, reflecting a need for more information in many watersheds. Future investigations could focus on non-native species known to predate on lamprey at various life stages, e.g., bass species. Likewise, evaluations of passage barriers could be paired with predation assessments; predation by native predators can be exacerbated by passage impediments that delay or prevent migration. This is a threat where more information is needed across the RMU, but to date is not a significant contributor to Pacific Lamprey population declines in the Puget Sound/Strait of Juan de Fuca.

Restoration and Research Actions

Significant data gaps persist across most of the watersheds in this RMU. However, there are a few watersheds where there has been an increased effort to explicitly document and monitor lamprey, including the Elwha-Dungeness following dam removal and the eastside Puget Sound watersheds eDNA surveys. However, most data collected is still incidental and surfers from inconsistencies. Lack of awareness of Pacific Lamprey's presence, migration requirements, swimming capacity, and habitat utilization inhibits the incorporation of lamprey into monitoring (e.g., Stream Typing), evaluations and prioritizations (e.g., passage), and restoration actions (stranding from dewatering). Even the widespread data collection efforts across the region through SGS and at smolt traps often only report "lamprey." The critical data regarding species and/or life stage used to inform population assessments and management discissions is often not recorded. Expanded efforts to train partners to identify lamprey species and life stage is needed in this region. This has begun in the region and will expand in 2023 with PLCI funding to support training.

The Puget Sound and Deschutes watersheds still needed to complete threat evaluation as there was no input from partners that work in these watersheds. This is partly due to the lack of salmonid-focused efforts in these watersheds; thus, that data cannot be leveraged for Pacific Lamprey. Future efforts will focus on finding partners in these watersheds who have information to contribute to the threat table and any distribution and abundance of information. eDNA sampling is currently the only Pacific Lamprey data available in both these watersheds.

To date, the lamprey restoration activities that have occurred or are occurring within these RMUs are being performed by organizations focused on salmon and steelhead recovery in Puget Sound/Strait of Juan de Fuca RMU. Many instream and floodplain habitat restoration activities have been identified in watershed management plans (e.g., Puget Sound Salmon Recovery Plan 2007), and culvert replacements driven by the federal court injunction are reconnecting miles of streams to anadromous salmonids. The vast majority of these actions have been funded and designed for salmon recovery, but this work may improve habitat conditions for lamprey as well. The following lamprey research and restoration actions were initiated by RMU partners in the Puget Sound/Strait of Juan de Fuca RMU (Table 4). Partners that participated in 2022 questionnaire and annual meeting are listed in Table 5.

Table 4. Conservation actions implemented that specifically target or impact Pacific Lamprey in the Puget Sound/Strait of Juan de Fuca RMUs.

HUC	Threat	Action Description	Status
RMU	Population	Coordinate lamprey conservation and data sharing through RMU.	Ongoing
RMU	Population	Environmental DNA sampling to better understand lamprey distribution.	Ongoing
RMU	Lack of Awareness	Consideration of lamprey when planning and implementing instream habitat restoration work.	Ongoing
Snoqualmie, Snohomish, Skykomish, Nooksack, Skagit, Stillaguamish	Lack of Awareness	Multiple presentations to partners about incorporating lamprey into assessments, salvage, and restoration projects. Outreach to the community about surveys and lamprey https://content.govdelivery.com/ accounts/WAKING/bulletins/31487b2	Ongoing
RMU	Population	Spawning ground surveys, smolt trap monitoring, and fish distribution surveys	Ongoing
Hood Canal and Dungeness-Elwha	Population	DNA sample and photo collection at smolt traps for ongoing genetics work (CRITFC)	Ongoing
RMU	Population	eDNA sample analysis on Federal Land in partnership with USFS.	Ongoing
RMU	Population	State and Federal agency collaboration on rare aquatic species management, focusing on Pacific Lamprey	Ongoing
Sauk, Upper Skagit, Stillaguamish	Population Lack of Awareness	Partnership with Glacier Peak Institute to incorporate lamprey into youth science and outdoor education programs	Ongoing
RMU	Populations	USFS and Trout Unlimited are developing a multi-species eDNA assay that would detect nine salmonid species and Pacific Lamprey	Completed
Dungeness-Elwha	Population	Survey lamprey distributions and abundance in urban streams on the Olympic Peninsula – NFHP funding	Ongoing
RMU	Passage	Culvert replacements on state land across the Puget Sound	Ongoing
Dungeness-Elwha, Snohomish, Nooksack	Passage	Dam removal, multiple projects across several RMUs	Completed

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