# Pacific Lamprey

# 2020 Regional Implementation Plan

*for the*

# North Pacific Ocean

# Regional Management Unit

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# I. Status and Distribution of Pacific Lamprey in the RMU

## A. General Description of the RMU

The North Pacific Ocean RMU is vast, encompassing all populations of Pacific Lamprey originating from various rivers across all 15 of the other RMUs in California, Oregon, Idaho, Washington, and Alaska (USFWS 2018), and other international areas, from Baja, Mexico north to the Bering and Chuchki seas off Alaska and Russia (Renaud 2008; Orlov et al. 2009; Renaud 2011), 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 of these needs have been or are being addressed (USFWS 2018). However, the foci of these projects are only on the freshwater life stages of the Pacific Lamprey life cycle. The marine (juvenile) phase of the Pacific Lamprey is clearly an important stage because it is where they attain their maximum body size which correlates with behavior and fitness in freshwater (including passage efficiency at dams, upstream migration distance, and the number of eggs a female produces; reviewed in Clemens et al. 2019). 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).

## B. Status of Species

### Conservation Assessment and New Updates

The 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). And, 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 Alaskan waters, the highest occurrences of Pacific Lamprey are 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 (Murauskas et al. 2019).

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, and in the open ocean, they have been found between the surface and 1,485 m (Orlov et al. 2008). However, Pacific Lamprey are most often found between the surface and 500 m (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, followed by 101 – 500 m (Wade and Beamish 2016).

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 (= marine survival), dispersal at sea, and observed patterns in genetic diversity.

### C. Threats

#### Summary of Major Threats

Key limiting factors and threats have been reviewed and identified by Clemens et al. (2019). Key limiting factors include: 1) availability of host species, 2) contaminant loads of hosts, and 3) predation and fisheries bycatch. Key threats include: 1) climate change, 2) unfavorable oceanographic regimes, 3) influences of interactions between climate change and oceanographic regimes, and 4) pollution. Pacific Lamprey are not targeted for ocean harvest for recreational or commercial uses. However, this species is harvested for cultural use in at least one estuary (e.g., see Peterson-Lewis 2009). At least 15 species of mammals, birds, and fishes have been documented to prey upon Pacific Lamprey in estuaries and the Pacific Ocean, and Pacific Lamprey has been documented to prey upon 32 species of mammals and fishes in these habitats (Clemens et al. 2019).

The lack of recreational and commercial harvest for Pacific Lamprey may explain why this species has not been monitored consistently. Information on the effects of the aforementioned limiting factors and threats to Pacific Lamprey in the ocean are lacking (Clemens et al. 2019).

Clemens et al. (2019) concluded: "*Many data gaps remain regarding the biology, limiting factors, and threats to Pacific lamprey in the marine environment…Therefore research may be the most important goal towards furthering science and management of Pacific lamprey.*"

## II. Restoration and Research Actions

Since 2017, coordinated research on Pacific Lamprey in the ocean has been undertaken by members of the Ocean Phase subgroup of the Lamprey Technical Workgroup. This research is detailed in Table 1. In collaborative efforts, Pacific Lamprey have been, and are being collected from the ocean by NOAA Fisheries staff and shared with interested researchers. The Alaska Fisheries Science Center (AFSC) and Northwest Fisheries Science Center (NWFSC) of NOAA Fisheries both conduct fishery-independent research cruises that have caught Pacific Lamprey. These surveys include the AFSC groundfish trawl surveys for the Gulf of Alaska and Bering Sea shelf and slope, the NWFSC surveys for groundfish, Pacific hake (whiting), and pelagic surveys for juvenile salmon. Fisheries observer data also exists for catch by commercial fisheries that can include lamprey (although lamprey may not always be identified to species). Surveys by Russian biologists also occur in the North Pacific that collect information on Pacific Lamprey (e.g., Orlov et al. 2008). These surveys provide biological specimens and data for monitoring the genetic diversity of Pacific Lamprey in the ocean (by the Columbia River Inter-Tribal Fish Commission), and their general body sizes, growth (NWFSC), and diets (Oregon State University/NWFSC and Hampton University) of Pacific Lamprey. Other, as yet unidentified opportunities exist to monitor the health and abundance of Pacific Lamprey populations that seed watersheds in each of the 15 land-based RMUs (and international areas) in the North Pacific Ocean. Research has the potential to fill the many data gaps on Pacific Lamprey during a key stage of their life cycle. This information can inform resource managers on the relative contributions of the marine phase in comparison with freshwater restoration efforts for Pacific Lamprey.

**Table 1.** Inventory and description of oceanic research conducted on lampreys, primarily Pacific Lamprey (but also Western River Lamprey).

| Title | Dates | Scientific scope | Geographic scope | Partners |
|---|---|---|---|---|
| Document hosts of Pacific Lamprey | 2014 – present | Document species, size, and location of fish with lamprey wounds caught by commercial fisheries (Pacific Hake) and stock assessment surveys (Pacific Hake, groundfish). | North Pacific Ocean | Laurie Weitkamp (NOAA); Dan Kamikawa (NOAA); Alicia Billings (NOAA) |
| Characterization of ocean-phase migration patterns of mixed-natal-origin Pacific Lamprey | 2017 – 2018 | Ocean migration patterns appear to vary among lamprey from different natal origins. Exploration of these patterns has required extensive baselines of full-sibling families collected among larval and juveniles from rotary screw traps. Full-sibling baselines can then be used to identify natal-origins to precise locations upstream of screw trap sites. | Natal origins among Pacific Lamprey collected from Pacific Hake surveys and fisheries in 2017 and 2018 along the U.S. West Coast | Jon E. Hess (CRITFC); Laurie A. Weitkamp (NOAA) |
| Genetic methods to elucidate natal origins and document recolonization in Pacific lamprey | 2017 – 2018 | Demonstration of three genetic methods and their effectiveness for determination of natal origins of Pacific Lamprey: Genetic Stock Identification, Parentage Analysis, and Sibship Analysis. Used a case study in the Elwha River post dam-removal to document the reintroduction and accomplish natal origin objectives relevant to management. | Fine spatial scale (natal origins within the Elwha River Basin); intermediate spatial scale (natal origins among basins of the Olympic Peninsula, WA); broad spatial scale (natal origins along the U.S. West Coast) | Jon E. Hess (CRITFC); Rebecca L. Paradis (LEKT); Mary L. Moser (NOAA); Laurie A. Weitkamp (NOAA); Thomas A. Delomas (IDFG); Shawn R. Narum (CRITFC) |
| PIT tagging ocean-caught lamprey | 2017 – present | Lamprey in good condition caught by the NOAA/NWFSC hake survey are anesthetized, tagged with a PIT tag, allowed to recover, and released back into the ocean. To date 5 lamprey have been tagged but none have been subsequently detected. | North Pacific Ocean | Laurie Weitkamp (NOAA); Alicia Billings (NOAA); Christina Wang (USFWS) |
| Size, condition, gut | 2017 – | Size, gut fullness, timing, and location of | North Pacific Ocean | Laurie Weitkamp (NOAA); |

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|---|---|---|---|---|
| fullness, and distribution of Pacific Lamprey and Western River Lamprey | present | Lampreys caught by commercial fisheries (hake, shrimp) and stock assessment surveys (hake, ground fish, salmon). | | Jessica Miller (OSU) |
| Trophic biomarkers of Pacific Lamprey | 2019 – present | Using trophic biomarkers (stable isotopes, fatty acids) to explore feeding histories of lamprey and determine the importance of lamprey body size and where and lamprey was caught (which fishery, location, season, etc.). | North Pacific Ocean | Laurie Weitkamp (NOAA); Louise Copeman (NOAA) |
| Natal origins of Pacific Lamprey | 2020 – 2021 | Isotopic signatures in statoliths and eye lenses of out-migrating juveniles have the potential to define natal origin of Pacific lamprey. Goals are to identify: 1) biogeochemical tracers to ascertain Pacific Lamprey natal origin; and 2) some potential natal areas or characteristics of natal areas of Pacific Lamprey returning to the Columbia River. Understanding natal areas that contribute to adult production will help assess population dynamics and population structure. Results could guide conservation and translocation decisions for Pacific lamprey from local to landscape scales, and could inform stream management decisions. | Samples are collected from the Columbia River Basin and elsewhere in Oregon and Washington. Additional samples of out-migrating juveniles are welcomed from other locations in WA, OR, and CA. | Julianne Harris (USFWS); Jessica Miller (OSU); Thomas Evans (St. Mary's College of Maryland); Mary Moser (NOAA); Jon E. Hess (CRITFC) |

# III. Selection of Priority Actions

## A. Prioritization Process

Proposals were solicited for consideration of prioritization.

## B. High Priority Proposed Project Information

No proposals were identified at this time.

# IV. Status for the RMU

Not yet applicable.

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