Pacific Lamprey

2017 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 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).

B. Status of Species

Conservation Assessment and New Updates

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 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.

C. Threats

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.

Availability of prey resources and ocean conditions leading to the production of forage fishes

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 (Table 1).

Table 1. Documented predators of Pacific Lamprey in estuaries and the ocean.

Predators
Fishes [a]
White Sturgeon
Lingcod
Sablefish
Bluntnose Sixgill Shark
Spiny Dogfish Shark
Birds [b]
Osprey
Caspian Tern
Double Crested Cormorant
Brandt's Cormorant
Western Gull
Mammals [c]
Steller Sea Lion
California Sea Lion
Northern Fur Seal
Pacific Harbor Seal
Sperm Whale

[a] References: Semakula and Larkin (1968); Beamish (1980); Beach et al. (1985); Close et al. (1995); Cochran (2009); Renaud (2011)

[b] References: Merrell (1959); Wolf and Jones (1989); Close et al. (1995); Collis et al. (2002); Don Lyons and Kirsten Bixler, Oregon State University (unpubl. data)

[c] References: Scott and Crossman (1973); Beamish (1980); Roff and Mate (1984); Riemer and Brown 1987; Laake et al. 2002; Riemer et al. 2011; Wright et al. 2016

II. Restoration and Research Actions

The Alaska Fisheries Science Center (AFSC) and Northwest Fisheries Science Center (NWFSC) both conduct fish 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. There is also fisheries observer data 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).

III. Selection of Priority Actions

A. Prioritization Process

Members of the Ocean workgroup met in October 2017 to discuss current threats to Pacific Lamprey, and identify specific actions and research needed to address threats and uncertainties within the RMU. Members suggested four potential proposals (all on monitoring and evaluation), based on a number of criteria (e.g., readiness of project, threat(s) and biological uncertainties addressed by project, and partner participation). Members were supportive of the following unified proposal that utilized an available 2017 collection of Pacific Lamprey samples from an ocean hake survey to perform four types of analyses: Pacific Lamprey ocean distribution relative to hake survey sites, population genetic structure and relatedness, statolith-derived age and natal origin, and eDNA-derived species identification of prey from gut contents.

B. High Priority Proposed Project Information

High Priority Proposed Project Information

Monitoring and Evaluation

Advancing Pacific Lamprey Marine Ecology: Analysis of Fish Collected by the Pacific Hake Fishery

Project Description:

Fishery observers on the commercial at-sea Pacific Hake (*Merluccius productus*) fishery opportunistically collected hundreds of Pacific Lamprey caught by the fishery in 2017. These fish were collected off the coasts of Washington, Oregon, and California, where the fishery is active. This collection likely represents the single largest collection of Pacific Lamprey in marine waters and an untapped gold mine of potential information about Pacific Lamprey marine biology.

The objectives of this project are threefold: 1) to provide as much information as possible about the distribution, abundance, size, condition, and feeding success of the collected lamprey; 2) provide tissue samples for proposed analyses (see projects below), including genetic stock information (for fish origins), statolith analysis (age and origins), and stomach content eDNA (prey consumed); and, 3) prepare and archive samples for future analyses, including stable isotopes (to determine prey use), lipid analysis, and contaminants.

The bulk of this project will involve processing the collected lamprey and analysis of the generated data set, which covers everything from collection location (lat/long) to size of fish (length, weight, oral disc diameter) to an estimate of stomach/intestine fullness. This dataset will greatly expand our knowledge of the marine ecology of Pacific Lamprey in marine waters off the West Coast, including their distribution (by size and time), abundance, size and condition, and feeding success (how much material was in their stomachs/intestines). This project will also collect tissue samples for proposed (see below) and potential future analyses, all of which will likely use specific subsets of the fish to address particular questions.

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- **HUC 5 *Locations*:** North Pacific Ocean

- ***Facilities ownership:*** NOAA Fisheries/NWFSC Newport Research Lab has the facilities and equipment to process and analyze the samples.

- ***Rationale and linkage to the ocean:*** Very little is known about Pacific Lamprey in marine waters. This extensive collection provides a unique opportunity to learn a huge amount about Pacific Lamprey in marine waters of the West Coast. The fact that we already have the fish in hand means that all costs can go directly to analysis and preparing samples for proposed or future analysis. The large number of individual fish collected also allows us to select particular groups of fish to address specific questions, such as whether fish caught together share common characteristics (origins, age, stomach fullness) than fish caught at different locations or times.
- ***Expected outcome (threats addressed)***. The biggest threat to the marine phase for Pacific Lamprey is a surprising lack of detailed biological information (Clemens et al. 2010). This study will greatly increase the information available on all aspects of lamprey in the marine realm, both by generating a unique dataset for the largest single collection of lamprey off the West Coast, but also through proposed and potential analysis of tissues from the fish. Analysis of the generated dataset will provide basic collection information ranging from size- or date-specific distributions along the West Coast, to documenting how condition (length to weight ratio) varies by location or time, to whether fish caught in some areas/times have more in their stomachs/intestines than other areas/times. Proposed analysis of tissues collected by this project for genetic, age (statoliths), and stomach eDNA analysis will also increase our understanding of lamprey genetics, age, and prey.

- ***Identification and coordination with relevant stake holders:*** Fishery observer program, federal biologists (NOAA Fisheries/NWFSC), Jessica Miller (Oregon State University), Jon Hess (Columbia River Inter-Tribal Fish Commission), and Trent Sutton (University of Alaska).
- ***Feasibility and expected timeframes:*** Feasibility is extremely high because the fish have already been collected and NWFSC has the staff, database, and expertise to process and analyze the samples, distribute tissues for further analysis, and archive samples for future analyses.
- ***Proponent Role and Responsibilities:*** Laurie Weitkamp (NOAA Fisheries/NWFSC) will lead the project and oversee all aspects of the study, including distribution of tissue samples to appropriate stakeholders. She will also supervise a contract employee who will do most of the lab work and analysis.

- ***Budget and identification of potential funding source***The total cost for this project is $20,000. This will cover 2 months of time for a contract employee (plus NOAA overhead), 2 weeks salary for Laurie Weitkamp, and a small amount for supplies. NOAA will provide workspace and facilities to conduct the work and do the analysis.
    - Total Cost: **$20,000**

- ***Project Lead:*** Laurie Weitkamp - NOAA Fisheries/NWFSC

Monitoring and Evaluation

Spatial Autocorrelation of Pacific Lamprey Adaptive Genetic Composition and Relatedness from Hake Surveys along Coastal Washington, Oregon and California

Project Description:

The primary goals of this project are to: 1) Use 308 SNP loci to genotype Pacific Lamprey that represent a random, representative sample of fish collected in the hake survey of 2017; 2) characterize adaptive and neutral genetic variation of these ocean phase adults and relate this genetic variation to an available genetic rangewide baseline of adult and larval collections of Pacific Lamprey, 3) estimate relatedness among specimen, and 4) use spatial autocorrelation analysis to characterize the spatial distribution of relatedness and genetic variation within and among survey hauls. This research and monitoring information will address threats identified by the Ocean Workgroup "*The biggest threat to the marine phase for Pacific Lamprey is a surprising lack of detailed biological information (Clemens et al. 2010). For example, very little to no information exists on where Pacific Lamprey go, or what they do, 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). 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).*" This research addresses critical biological information related to the ocean phase of Pacific Lamprey through relevance to determination of natal origins and the effects of natal origins on ocean distribution.

- **HUC 5 *Locations*:** North Pacific Ocean

- ***Facilities ownership:*** Columbia River Inter-Tribal Fish Commission owns the Genetics laboratory in Hagerman, Idaho where the samples would be processed for DNA analysis.

- ***Rationale and linkage to the ocean:*** As part of the genetic monitoring for Pacific Lamprey in the Columbia River Basin, Columbia River Inter-Tribal Fish Commission has compiled a baseline of genetic information from 308 Single Nucleotide Polymorphism (SNP) markers for a set of samples of adults and larval Pacific Lamprey across its Northeastern Pacific range. Sample sites include streams and rivers in Northern British Columbia, Vancouver Island and Puget Sound, the lower and interior portions of the Columbia River basin, and coastal streams and rivers of Oregon and Northern California. Neutral population structure can distinguish these collections into three broad populations: Northern B.C., Vancouver Island/Puget Sound, and the Columbia River Basin/Oregon/California coasts. Adaptive variation can further distinguish the lower Columbia River, Interior Columbia, and Oregon/California coasts. Using this population genetic baseline we can determine approximations of the likely natal origins/ultimate destinations of individual Pacific Lamprey

found at sea. This collection of Pacific Lamprey from the hake survey of the U.S. West coast may be comprised of different genetic compositions of Pacific Lamprey as compared to ocean surveys from the Bering Sea. These broad scale patterns and comparisons of genetic composition will be addressed in this analysis to elucidate information on natal origins and likely destinations of these Pacific Lamprey caught at sea.

- ***Expected outcome (threats addressed):*** The Columbia River Inter-Tribal Fish Commission will estimate relatedness and genetic composition of Pacific Lamprey caught at sea in the hake survey and relate these metrics to the rangewide genetic baseline of Pacific Lamprey to elucidate information on natal origins and likely destinations of these Pacific Lamprey caught at sea.
- ***Identification and coordination with relevant stake holders:*** NOAA hake survey, federal biologists, and Columbia River Inter-Tribal Fish Commission.
- ***Feasibility and expected timeframes:*** Feasibility is high. The Lamprey Genetic Monitoring project within the Columbia River Inter-Tribal Fish Commission already possesses the administrative, database, laboratory and analytical expertise and infrastructure to conduct the analysis.
- ***Proponent Role and Responsibilities:*** The Lamprey Genetic Monitoring project within the Columbia River Inter-Tribal Fish Commission already possesses the administrative, database, laboratory and analytical expertise and infrastructure to conduct the analysis. Salary for fishery scientist/geneticist and laboratory technician positions will need to be funded to support the additional sample processing and analysis that these objectives would require.

- ***Budget and identification of potential funding source:*** Funding from BPA has been funding CRITFC Lamprey Genetic Monitoring to date. The potential for continuation of funding for this project is unknown, and potentially uncertain. Below are approximate costs for funding 1000 genotypes.
    - Total Cost: **$15,217**

- ***Project Lead:*** Jon Hess – CRITFC

Monitoring and Evaluation

Natal Origins and Ages Derived by Statolith Microchemistry and Structure of Pacific Lamprey from Hake Surveys along Coastal Washington, Oregon and California

Project Description:

The primary goals of this project are to: 1) Characterize multi-elemental composition and stable isotopic ratios of the statoliths of Pacific Lamprey that represent a random, representative sample

of fish collected in the hake survey of 2017; 2) relate this microchemistry variation to an available statolith microchemistry baseline of adult and larval collections of Pacific Lamprey, 3) characterize patterns of microstructure of the statolith to estimate age, and 4) use spatial autocorrelation analysis to characterize the spatial distribution of microchemistry composition within and among survey hauls. This research and monitoring information will address threats identified by the Ocean Workgroup "*The biggest threat to the marine phase for Pacific Lamprey is a surprising lack of detailed biological information (Clemens et al. 2010). For example, very little to no information exists on where Pacific Lamprey go, or what they do, 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). 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).*" This research addresses critical biological information related to the ocean phase of Pacific Lamprey through relevance to determination of natal origins and the effects of natal origins on ocean distribution, and duration of the ocean phase.

- **HUC 5 *Location*:** North Pacific Ocean
- ***Facilities ownership:*** Oregon State University (OSU, Newport, OR)
- ***Rationale and linkage to the watershed:*** As part of the genetic monitoring for Pacific Lamprey in the Columbia River Basin, Columbia River Inter-Tribal Fish Commission has collaborated with Dr. Jessica Miller (OSU) to compile a baseline of statolith microchemistry from multi-elements and stable isotopic ratios for a set of samples of adults and larval Pacific Lamprey across its Northeastern Pacific range. Sample sites include streams and rivers in the interior portion of the Columbia River basin (Snake River basin), lower Columbia River (Willamette Falls), and Northern California (Klamath River), as well as a mixture of ocean-phase Pacific Lamprey from the Bering Sea. Using this statolith microchemistry baseline we can compare the composition of each survey site to understand the number of different natal origins a group of adults may represent. These broad scale patterns and comparisons of statolith microchemistry composition will be addressed in this analysis to elucidate information on natal origins and possibly duration of time spent at sea.
- ***Expected outcome (threats addressed):*** Comparisons of statolith microchemistry composition among baseline statolith samples will elucidate information on natal origins and possibly duration of time spent at sea.
- ***Identification and coordination with relevant stake holders:*** OSU (for microchemistry analysis)
- ***Feasibility and expected timeframes:*** Feasibility is high. The Lamprey Genetic Monitoring project within the Columbia River Inter-Tribal Fish Commission is already in collaboration with Jessica Miller to compile a statolith baseline of data, and Jessica Miller brings the laboratory and analytical expertise and infrastructure to conduct the analysis.
- ***Proponent Role and Responsibilities:***

The Lamprey Genetic Monitoring project within the Columbia River Inter-Tribal Fish Commission is already in collaboration with Jessica Miller to compile a statolith baseline of data, and Jessica Miller brings the laboratory and analytical expertise and infrastructure to conduct the analysis. Salary for Jessica Miller and laboratory technician positions as well as laboratory materials and equipment time will need to be funded to support the additional sample processing and analysis that these objectives would require.

- ***Budget and identification of potential funding source:*** Funding from BPA has been funding CRITFC Lamprey Genetic Monitoring to date, and statolith research has been a subcontract under this funding. The potential for continuation of funding for this project is unknown, and potentially uncertain. Below are approximate costs for funding 200 statoliths.
    - Total Cost: **$31,600**
- **Project Lead:** Jessica Miller – OSU

Monitoring and Evaluation

Using eDNA to Determine Marine Prey Use by Pacific Lamprey from Hake Surveys along Coastal Washington, Oregon and California

Project Description:

One of the big unknowns about Pacific Lamprey in marine waters is the species of fish they parasitize. While most fishes consume whole prey that can be visually identified to species, the parasitic habits of lamprey result in stomach/intestine contents consisting of coagulated blood, which is impossible to visually identify to species. However, recent work with Arctic and Pacific Lamprey collected in Alaskan waters has shown that it is possible to extract eDNA from the stomachs/intestines of the fish to determine what species they are parasitizing (Shink 2017).

We propose to use eDNA to 1) refine the technique of eDNA extraction from lamprey stomach contents, and 2) to determine the food habits of Pacific Lamprey collected from the at-sea Pacific hake fishery off the coasts of Washington, Oregon, and California (see project above). These fish were collected by the hake fishery (a commonly parasitized species), therefore we expect that most (but perhaps not all) stomachs will contain hake eDNA, although other species may also be present. Because of the large number of lamprey available for analysis, we will select fish that have the fullest stomachs/intestines, and represent a variety of sizes, locations, and dates. This will allow us to explore spatial, temporal, or life history (i.e., size-specific) variation in lamprey prey use.

- **HUC 5 *Location*:** North Pacific Ocean
- ***Facilities ownership***: Both the University of Alaska Fairbanks (UAF) and NOAA Fisheries/NWFSC have facilities and equipment to conduct this work.

- ***Rationale :*** Very little is known about Pacific Lamprey in marine waters, including which species of fish they parasitize, or whether there are spatial, temporal, and life-history trends associated with their prey use. This analysis will to allow us to greatly increase our knowledge regarding prey use by Pacific Lamprey long the West Coast.
- ***Expected outcome (threats addressed):*** This study will greatly increase the information available on prey use by Pacific Lamprey in marine waters of the West Coast. This knowledge is particularly important because variation in lamprey prey abundances have been associated with variation in the number of lamprey returning to the Columbia Rive basin (Murauskas et al. 2013). Accordingly, better understanding of prey used by lamprey will help refine mechanistic processes relating between prey abundance to lamprey abundance.
- ***Identification and coordination with relevant stake holders:*** The proposed work will be coordinated with NOAA Fisheries/NWFSC, who has the fish and will provide stomachs for analysis.
- ***Feasibility and expected timeframes:*** Feasibility is extremely high because the fish have already been collected. Two labs, UAF and NOAA Fisheries/NWFSC, have the staff, equipment, and expertise to process and analyze the samples.
- ***Proponent Role and Responsibilities:*** Both the University of Alaska Fairbanks (UAF) and NOAA Fisheries/NWFSC have facilities, equipment, and expertise to conduct this work. It is not yet decided which will conduct the study.
- ***Budget and identification of potential funding source:*** The UAF has a pending North Pacific Research Board proposal to fund similar work for Arctic and Pacific Lamprey collected in Alaskan waters. The NOAA Fisheries/NWFSC receives funds from a variety of sources for genetic analyzes. This project would compliment ongoing work conducted by both organizations.

  Estimated cost to run samples is $28/sample for supplies + technician time.

  - Total Cost: $28,000

- ***Project Lead:*** **TBD (Jon Hess – CRITFC and Laurie Weitkamp –NOAA Fisheries/NWFSC co-contributors)**

IV. Status for the RMU

Not yet applicable.

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