Pacific Lamprey
2019 Regional Implementation Plan
for the
Lower Columbia/Willamette
Regional Management Unit
Lower Columbia Sub-Unit

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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-unit 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-unit include the Lower Columbia-Sandy, Lewis, Upper and Lower Cowlitz, Lower Columbia-Clatskanie, and Lower Columbia River (Figure 1).

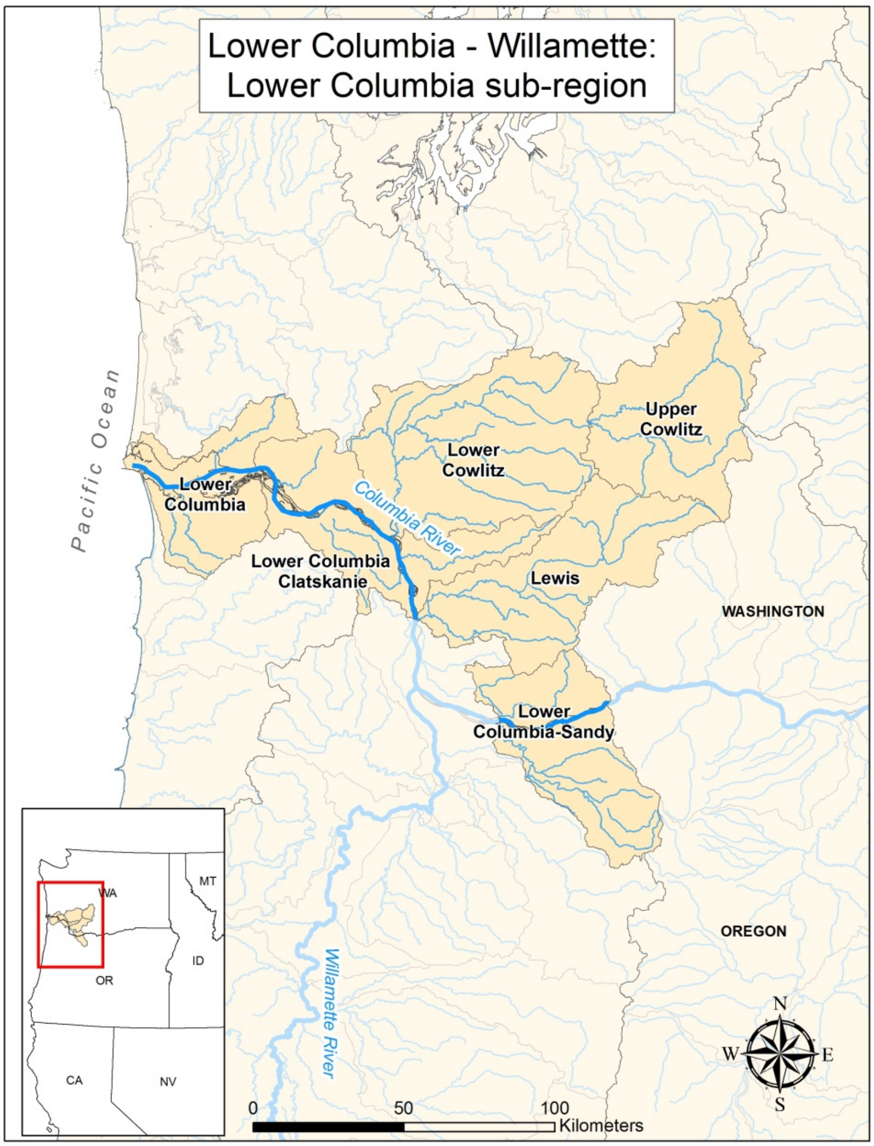

Figure 1. Map of watersheds within the Lower Columbia/Willamette RMU, Lower Columbia sub-unit.

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

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

Conservation Assessment and New Updates

Current Pacific Lamprey distribution in the Lower Columbia sub-unit is greatly reduced from historical range (Table 2). The revised Pacific Lamprey Assessment ranking of current distribution was reduced in all HUCs in 2017. The decline in these areas is a result of more accurately calculating the numeric area of occupancy (versus using a visual estimate), rather than a decline in Pacific Lamprey range (USFWS 2018). Overall, understanding of distribution has expanded considerably in many Oregon State tributaries due to increased sampling effort (e.g., smolt trapping, redd surveys, occupancy sampling). Less is known about lamprey distribution in Washington State tributaries. Existing information is largely based upon anecdotal observations, or has been collected incidentally while monitoring salmonid species. A compilation of all known larval and adult Pacific Lamprey occurrences in the Lower Columbia sub-unit are displayed in Figure 2, which is a product of the USFWS Data Clearinghouse.

Pacific Lamprey population abundance was updated in the Lower Columbia-Sandy, Lower Columbia-Clatskanie, and Lower Columbia River HUCs using new information from Oregon Department of Fish and Wildlife (ODFW) to estimate a range of abundance using available redd counts. As part of the monitoring for winter steelhead spawning populations, the Oregon Adult Salmonid Inventory and Sampling (OASIS) field crews record data on lamprey spawners and redds. These estimates are considered minimum population numbers, as the surveys are focused on steelhead, and end before the completion of Pacific Lamprey spawning (see Jacobsen et al. 2014; Jacobsen et al. 2015; Brown et al. 2017). Abundance estimates were calculated for four lower Columbia River tributaries in multiple run years: the Sandy River (2010, 2012-2016), Clatskanie River (2012-2013, 2015-2016), Youngs Bay and Big Creek (2012-2013). Average abundance of adults ranged from 2-293 fish in the Sandy Basin (avg. of avg. 97 fish), 157-782 fish in the Clatskanie River (avg. of avg. 408 fish), and 25-980 fish in Youngs Bay and Big Creek Combined (avg. of avg. 354 fish). Adult Pacific Lamprey abundance is currently unknown in the Lewis and Lower Cowlitz HUCs, and Pacific Lamprey are 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 (defined as the degree of change in population size over 3 lamprey generations or 27 years), was ranked as unknown in all HUCs of the Lower Columbia sub-unit (Table 2). 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 indicate a significant downward trend in abundance over time. Counts of adult Pacific Lamprey prior to 1970 averaged over 100,000 fish (1939-1969), while the recent 10-year average is just over 34,000 fish (FPC 2018). Historical harvest records at Willamette Falls also suggest a decline in adult Pacific Lamprey abundance. Harvest estimates have ranged from a peak of ~400,000 pounds of fish in 1946 to less than 12,000 pounds since 2001 (Ward 2001). This reduction may be attributable to reduced fishing effort, more stringent regulations, different harvest methods, or a decline in lamprey abundance (Kostow 2002). Unfortunately no long term counts of Pacific Lamprey exist in tributary or mainstem areas of the Lower Columbia sub-unit. Populations are believed to be declined (from historical levels), but adequate information does not exist to estimate the magnitude of the decline. Oregon Department of Fish and Wildlife OASIS estimates provide 2-6 years of good abundance information in select lower Columbia tributaries (i.e., Sandy, Clatskanie, Youngs Bay and Big Creek), but this data set is not long enough to infer population trends.

Table 2. Population demographic and conservation status ranks (see Appendix 1) of the 4th Field HUC watersheds located within the Lower Columbia sub-unit. 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 2011 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	S2	1000-5000	100-500	50-1000	Unknown
Lewis	17080002	S1↓	250-1000	100-500	Unknown	Unknown
Upper Cowlitz	17080004	SH	1000-5000	Zero	Zero	Unknown
Lower Cowlitz	17080005	S2	1000-5000	100-500	Unknown	Unknown
Lower Columbia-Clatskanie	17080003	S1S2↓	1000-5000	100-500	250-2500	Unknown
Lower Columbia	17080006	S2	1000-5000	100-500	250-2500	Unknown

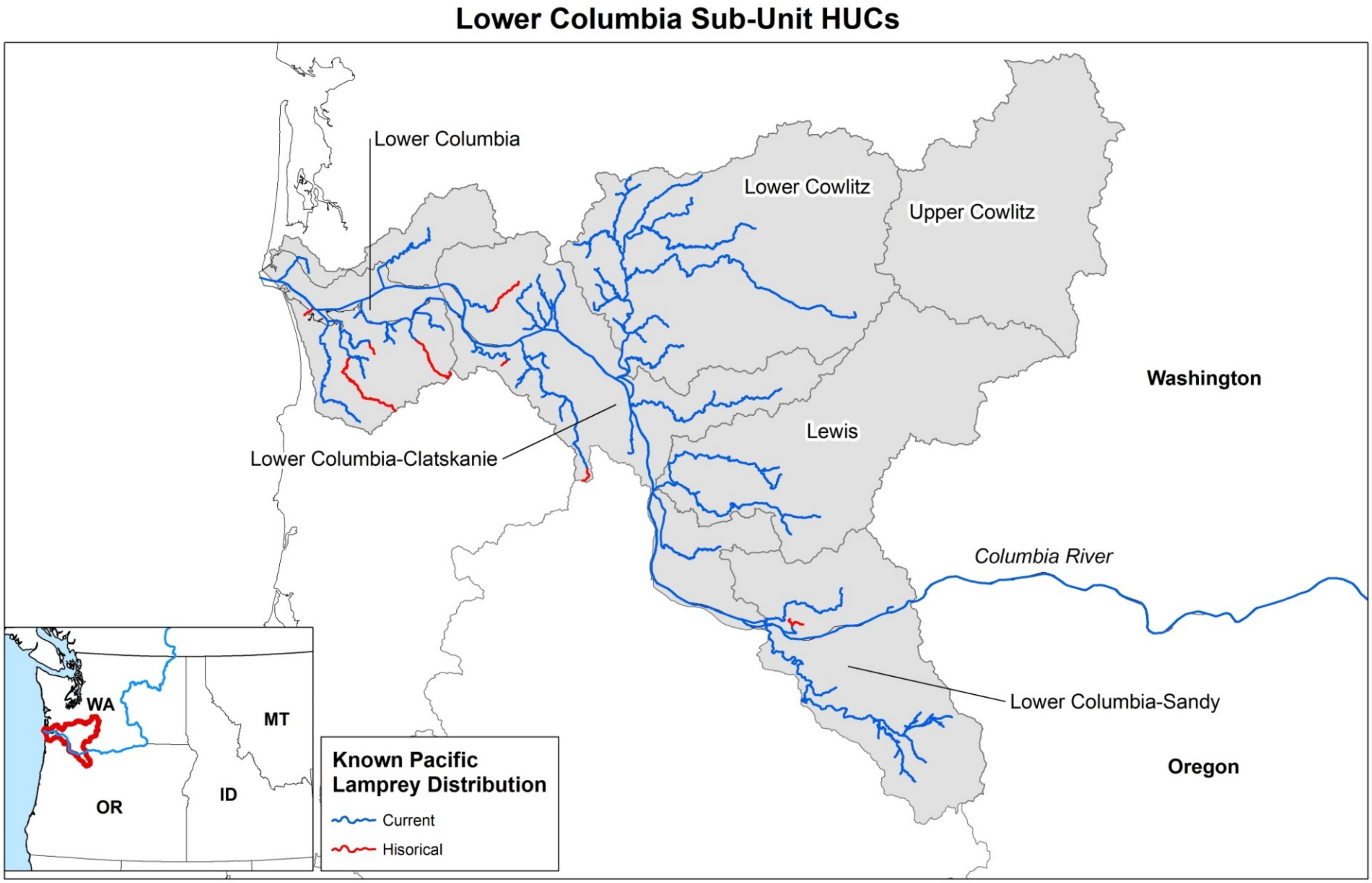

Figure 2. Current and historical known distribution for Pacific Lamprey: Lower Columbia/Willamette Regional Management Unit, Lower Columbia sub-unit (USFWS Data Clearinghouse 2017). Historical Pacific Lamprey distribution depicted in map was obtained from published literature, tribal accounts and state and federal agency records.

Distribution and Connectivity

Threats to passage were considered moderate in the Lower Columbia sub-unit (Table 3). While adult passage is not impeded by dams of the Federal Columbia River Power System (FCRPS), 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 important 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-unit 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 RMU.

Road crossing culverts are prevalent in the Lower Columbia sub-unit. 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 added features with 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). Many impassable culverts occur low in watersheds (near tributary outlets), preventing access to miles of potential habitat. An extensive effort is underway to inventory and prioritize problem culverts for removal, replacement or repair.

Tide gates are broadly distributed in tidally influenced tributaries of the Lower Columbia sub-unit. 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 are in need of maintenance. Stakeholder groups are actively working to remove or replace failing structures with fish friendly gates that remain open for a portion of incoming tide. The Oregon Watershed Enhancement Board has recently requested funding to perform a comprehensive statewide inventory of tide gates to identify structures in need of repair or replacement.

Fish hatcheries in the lower Columbia River basin often utilize barrier dams and fish ladders to divert adult salmon into the hatchery during brood collection, or to regulate fish passage above the hatchery. Many of these structures are suspected passage barriers to adult Pacific Lamprey (e.g. Cedar Creek Hatchery diversion (Sandy R.), Kalama Falls Hatchery diversion, Big Creek Hatchery diversion, North Fork Klaskanine Hatchery diversion), but the extent of the impact is unknown.

C. Threats

Summary of Major Threats

The following table summarizes the known key threats (i.e., score ≥2.50) within the Lower Columbia sub-unit tributaries as identified by RMU participants during the Risk Assessment revision meeting in May 2017. The highest priority threat in the Lower Columbia watersheds is Dewatering and Flow Management followed by, Passage, Stream and Floodplain Degradation, and Water Quality.

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

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

"*" indicates areas that were ranked higher because of the mainstem Columbia River

Current Threats

Dewatering & flow management

Dewatering and Flow Management was ranked a moderate threat in the Lower Columbia sub-unit. Low seasonal streamflow and Bonneville Dam flow regulation 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-unit 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 projected rise in human population and anticipated effects of climate change (i.e., elevated ambient temperatures, decreased surface water availability, altered flow regimes), may increase the frequency, duration and intensity of 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 (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. Lamprey larvae are especially vulnerable to stranding as they rear in fine sediments along river margins and delta regions, but impacts related to hydropeaking below Bonneville Dam are unknown (Jolley et al. 2012; Mueller et al. 2015).

Stream & floodplain degradation

Stream and Floodplain Degradation was also ranked a moderate threat. Channel confinement, channel manipulation, and floodplain development are the primary concerns in the sub-unit. 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 a pivotal 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 side channel and wetland habitat.

The Columbia River mainstem below Bonneville Dam has been straightened and confined by major railroad and transportation corridors that run parallel to the river. Much of the shoreline is armored with riprap and connection to tributaries occurs through culverts and bridges. In the Lower Columbia River and estuary, dikes and levees have disconnected the mainstem from floodplain and estuary habitat (e.g., tidal swamp, marsh, wetlands), reducing the river to a single channel. Efforts to maintain the shipping channel (e.g., jetties, pile dikes) have altered flow patterns and increased sediment accumulation that requires periodic dredging to remove. The impacts of channel maintenance dredging on larval lamprey in the Lower Columbia River have not been thoroughly documented. Dredging may displace, injure or kill burrowing larvae, disturb or destroy potential rearing habitat, or re-suspend contaminated sediments into the river (Maitland et al. 2015; Clemens et al. 2017). 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). 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), but habitat use and distribution within the estuary is still unknown.

Water quality

Elevated water temperature is the primary water quality concern in Lower Columbia tributaries. Excessive temperatures generally occur during summer months and may be attributed to increased air temperature, lack of riparian cover, reduced instream flows associated with water withdrawal, and warm irrigation water returns. The impacts of relatively 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). High water temperatures are likely a result of warmer ambient temperatures and cumulative effects of water withdrawal and land use activities in tributary and mainstem areas. Dissolved gas supersaturation resulting from spill from Bonneville Dam can exceed the EPA mandated limit of 110% saturation for several months during normal and low water years (Schneider and Barko 2006). These levels may extend throughout the entire lower Columbia River. Short-term exposure to gas 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 vulnerability of Pacific Lamprey to gas bubble disease or potential sensitivity at different life stages is unknown. Industrial discharge and surface water runoff from farms, roads and urban areas are the primary source of contaminants entering the Columbia River mainstem. Toxic contaminants such as DDE, PCBs, and heavy metals settle out and accumulate in fine sediments, reaching concentrations that may be harmful to aquatic and terrestrial organisms. Toxins and heavy metals may be a particular concern for Pacific Lamprey because direct exposure in water or sediment during larval and adult life stages can result in high concentrations of contaminants accumulating in fatty tissues that may compromise fish health and development (Nilsen et al. 2015; Clemens et al. 2017). Monitoring and restoration efforts to improve and protect water quality for fish, wildlife, and human health are ongoing in the Lower Columbia sub-unit.

Predation

Although not ranked a 'key threat', predation of adult and juvenile lamprey by native and non-native fish, birds, and marine mammals is known to occur in the Columbia River Basin (Close et al. 1995; Zorich et al. 2011; Madson et al. 2017). Pacific Lamprey encounter many of the same predators as salmonids during migration, but the severity of the threat is not well understood. Dams and other human changes to the environment can increase habitat suitability for predator species and may contribute to the decline of lamprey by delaying/slowing migration or exposing fish to increased mortality in areas where piscivorous predators may congregate (e.g. Bonneville Dam tailrace, Sand Island, etc.). In addition, temperature increases predicted with climate change models may expand the territory of warmwater predators into tributaries, putting further stress on native fish communities (Lawrence et al. 2014).

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-unit from 2012-2018.

HUC	Threat	Action Description	Type	Status
RMU	Population	Environmental DNA, spawning ground surveys, smolt trapping and occupancy sampling to better understand lamprey distribution.	Survey	Ongoing
RMU	Stream Degradation	Implementation of instream and floodplain habitat restoration activities.	Instream	Ongoing
RMU	Passage	Evaluation of adult Pacific Lamprey passage efficacy at fishways and barrier dams associated with salmon hatcheries.	Assessment	Underway
RMU	Population	Distribution surveys in mainstem and principal tributaries	Survey	Ongoing
RMU	Population	Use of eDNA to monitor effectiveness of large wood placement projects and recolonization of larval lamprey following restoration	Assessment	Proposed/ Underway
RMU	Lack of Awareness	Consideration of lamprey when planning and implementing instream habitat restoration work	Coordination	Ongoing
RMU	Passage	Map, assess and prioritize passage barriers in tributaries and evaluate available lamprey habitat upstream	Assessment	Proposed
RMU	Population	Adult/Juvenile Pacific Lamprey abundance data summary for Southwest Washington tributaries	Assessment	Underway
RMU	Population	Oregon Department of Fish and Wildlife Conservation Plan for Lampreys in Oregon	Other	Complete
Sandy	Stream Degradation	Sandy River floodplain reconnection, gravel augmentation in Bull Run River.	Instream	Complete
Sandy	Stream Degradation	Large wood augmentation, side channel reconnection in upper Sandy River.	Instream	Complete
Clatskanie	Population	Conduct adult spawning ground surveys to monitor Pacific Lamprey distribution, timing, and number of redds to develop relative abundance indexes.	Survey	Ongoing
Clatskanie	Population	Deep water sampling to document distribution and habitat use of larval lamprey in Columbia River mainstem.	Assessment	Complete

Clatskanie	Passage	Tide gate and culvert modification and removal projects to restore access to spawning and rearing habitat.	Instream	Ongoing
Lower Columbia	Passage	Evaluation of passage constraints for lamprey at Big Creek and North Fork Klaskanine Hatchery diversions	Instream	Complete
Lower Columbia	Passage	Evaluation of passage constraints for lamprey at fish hatcheries in Washington State	Instream	Underway
Lower Columbia	Population	Conduct adult spawning ground surveys to monitor Pacific Lamprey distribution, timing, and number of redds to develop relative abundance indexes.	Survey	Ongoing
Lower Columbia	Passage	Tide gate and culvert modification and removal projects to restore access to spawning and rearing habitat.	Instream	Ongoing
Lower Columbia	Population	Investigation of salinity tolerance and larval lamprey occurrence in tidally influenced estuarine stream.	Assessment	Complete

II. Selection of Priority Actions

A. Prioritization Process

Participating members of the Lower Columbia sub-unit had a conference call on May 23rd, 2019 to discuss completed and ongoing conservation actions and identify specific projects and research needed to address threats and uncertainties within the region. The following projects were submitted by RMU partners for the Lower Columbia sub-unit Regional Implementation Plan in 2019:

- Assessment of larval lamprey use in areas of salmonid habitat restoration vs non-restoration and above vs below a salmonid electronic weir
- Pilot test of an acoustic telemetry array to monitor juvenile lamprey in the lower Columbia River

B. High Priority Proposed Project Information

***Project Title:* Assessment of larval lamprey use in areas of salmonid habitat restoration vs non-restoration and above vs below a salmonid electronic weir**

Project Applicant/Organization: U.S. Fish and Wildlife Service
Contact Person: Benjamen Kennedy
Email: benjamen_kennedy@fws.gov
Phone: 360-425-6072 ext. 332

Project Type: Assessment

Lamprey RMU population: Lower Columbia Sub-Region
Watershed (5th HUC Field): Abernathy Creek Watershed (#1708000304)
NPCC Subbasin (4th HUC Field) name: Lower Columbia-Clatskanie (#17080003)
Project Location: Abernathy Creek, Washington

Total Requested funds: $19,946

Short Project Summary (200 words or less):

Threats to Pacific salmonid and lamprey populations include stream and floodplain degradation (Clemens et al. 2017). Although much habitat restoration is being implemented for salmonids, little empirical data exist on if lamprey populations also benefit (Gonzalez et al. 2017). Our first goal is to add to the knowledge gap of limiting freshwater habitat and evaluate if salmonid habitat restoration techniques are positively addressing lamprey limiting habitat.

Additionally, passage barriers are a major threat to lamprey populations (Clemens et al. 2017). This study will take place on Abernathy Creek which has been the site of an electric weir located at Abernathy Fish Technology Center. This weir is used in the collection of adult steelhead and has been in operation for 14 years from mid-November through mid-June. Our second goal is to evaluate if the weir is negatively affecting the lamprey population. Next year (November 2019 – June 2020) will be the last year of operation and the last chance to evaluate its impacts.

1. Detailed Project Description (500 words or less):

Our first objective is to determine larval lamprey presence and abundance in areas that have seen recent salmonid habitat restoration measures versus areas that have not seen treatment. Our second objective is to measure presence and abundance of larval lamprey above versus below the weir facilities.

Additionally, once lamprey abundance and habitat relationships are determined, these data can be linked with the IMW's extensive habitat monitoring data to evaluate how habitat restoration changes have influenced larval lamprey population throughout Abernathy Creek. These data can also be expanded to two similar nearby creeks that have received little (Germany Creek) or no habitat restoration work to assess if salmon habitat restoration can influence lamprey habitat use on a watershed scale.

A nested sampling design will be used to examine larval lamprey presence and abundance at two spatial scales (within and among sites; Armitage and Cannan 1998; Togersen and Close 2004). Additionally, lamprey abundance will be compared below and above Abernathy's electric weir and fish ladder adult steelhead trapping facilities (rkm 5). Eight sites along Abernathy Creek will be sampled during base flow conditions when habitat may be most limiting. Four sites will be below Abernathy Fish Technology Center and four sites will be above the Center. Of the four sites below the Center two will be in salmonid restoration areas and two will be in non-restoration areas. Of the four sites above the Center, two will be in restoration areas and two will be in non-restoration areas.

2. ***Descriptive Photographs-illustrations-Maps*:** N/A

3. ***Linkage of actions to Identified Threats in RMU (300 words or less):***
   - *What threat(s) does this project address?* **Stream and Floodplain Degradation**
   - *Project scope: Does this project address threat(s) specific to this RMU only, or does the project address the threat(s) prevalent in multiple RMUs?*
     Single RMU ☐, Multiple RMUs ☒ list additional RMUs:
   - *How does this project address key threat(s) within the HUC where the project is proposed?*

This project will address habitat threats that are important across the entire coastal distribution of lamprey. Additionally, knowledge of the passage impact of an electric weir may be used in the planning, evaluation, or cancelation of electric weirs planned in the future.

Larval lampreys depend on areas of fine sediments to live and feed. Streams and floodplains have been significantly altered by humans during the last 150 years. Great effort is currently spent restoring streams for steelhead and salmon, but benefits to lamprey populations remain uncertain. Also, this project will address the impact of an electric weir.

This project will provide much needed information on the relationship between salmonid habitat restoration and lamprey conservation by linking larval lamprey distribution data to an extensive stream habitat database from an ongoing watershed scale habitat restoration project (https://wdfw.wa.gov/publications/01398/; https://www.lcfrb.gen.wa.us/libraryimwcomplex). This knowledge on habitat use can then be used in future salmon habitat restoration planning to maximize benefits to lamprey populations. Additionally, if the electric weir is found to impact lamprey distribution, operation modifications or timing may be adjusted to benefit lamprey passage.

4. ***Species/Habitat Benefits (200 words or less):***
    - *How will the project provide meaningful measureable results to improve lamprey populations and/or their habitat conditions?*
    - *What life stage or stages will benefit from action? How?*
    - *What other species may benefit from action?*

Lamprey ammocoetes and macropthalmia will benefit most from this study as knowledge leading to better habitat restoration practices should lead to better survival and higher larval lamprey abundance. This in turn should lead to higher adult abundance.

Multiple species that feed on lampreys including, birds, seals, sea lions, etc. should benefit from increased numbers of lamprey.

5. ***Project Design / Feasibility (200 words or less):***
    - *Have the designs for the project been completed already or will they be completed before planned project implementation?* Yes ☒, No☐
    - *Are the appropriate permits (e.g., ESA consultation, Scientific Collection, fish health/transport, etc.) in place already or will they be in place before planned project implementation?* Yes ☒, No☐
    - *Can the project be implemented within the defined timeframe?* Yes ☒, No☐

Each site will be made up of two riffle-pool combinations. Each site will be divided into preferred (Type I), acceptable (Type II), and unacceptable (Type III) habitat types (Moser et al 2007; Mullett and Bergstedt 2003; Slade et al. 2003). Five 1 m^2 subsamples from each habitat type will be randomly selected for sampling.

Lamprey will be collected from each 1 m^2 subsample via lamprey specific electrofishing methods (Dunham et al. 2013). Abundance will be determined using 70% depletion estimation methods (Stone and Barndt 2005). Captured lamprey will be measured and weighed. Lamprey over 60 mm will be identified between *Entosphenus* and *Lampetra* using methods described by Goodman et al. (2009).

For each subsample location a multitude of habitat variables will be measured. These variables include water depth, organic depth, water velocity, channel unit type, substrate size, habitat type (I, II, or III), channel position (margin or mid-channel), wetted width, canopy closure, pH, rkm and water temperature.

For each larval lamprey species, presence and absence among sites and habitat variables will be evaluated using logistic regression. Larval abundance among sites and habitat variables will be evaluated using linear regression. For each type of regression, a set of candidate models in an information-theoretic approach using Akaike's information criterion will be simultaneously ranked to determine the best approximating model (Burnham and Anderson 2002).

6. ***Partner Engagement and Support (200 words or less):***
    - *What partners are supporting the project?*

Washington Department of Fish and Wildlife, Washington Department of Natural Resources, Cowlitz Tribe, Interfluve, Lower Columbia Fish Recovery Board.

- *What partners are active in implementing the project?*

Washington Department of Fish and Wildlife, Washington Department of Natural Resources, Cowlitz Tribe, Interfluve, Lower Columbia Fish Recovery Board.

- *What partners are providing matching funds or in-kind services that directly contribute to the project?*

Partners have completed over 8 km of instream and off-channel habitat restoration as well as over 32,000 m^2 of riparian area restoration. Activities have included increasing instream habitat complexity, off-channel reconnection, floodplain reconnection, fish passage, riparian planting, and bank stabilization.

7. Monitoring and Reporting (200 words or less):

- *How is completion of the project going to be documented?*
- *How will the projects' benefits to lamprey be monitored over time?*

There is currently no monitoring framework for lamprey associated with these habitat restoration projects. However, this study can add to current knowledge gaps and be used as a tool for future monitoring frameworks in this watershed as well as many others.

8. Project Budget (Including overhead):

	Items	**# Hours or Units**	**Cost per Unit ($)**	**RIP Funds Requested ($)**	**Cost Share ($)**	**Total Cost ($)**
A	***Personnel:*** USFWS Personnel	-	-	$15,817	$5,520	$21,337
	a. Fish Biologist (GS-11/8)** - (Project leader)	320 hrs	$39.15	$7,008	$5,520	$12,528
	b. BioTech (GS-5/5)** - (Field Technician)	120 hrs	$19.62	$2,354	$0	$2,354
	c. BioTech (GS-5/5)** - (Field Technician)	120 hrs	$19.62	$2,354	$0	$2,354
	** rates OPM salary table 2019 - Portland	Benefits	@ 35%	$4,101	$0	$4,101
B	***Equipment & Supplies:***	-	-	$0	$8,500	$8,500
	a.Electrofishing unit, batteries, nets			$0	$8,000	$8,000
	b.Habitat measuring gear, waders, misc			$0	$500	$500
C	***Travel:***	-	-	$0	$100	$100
	a.Gas			$0	$100	$100
D	***Other:***	-	-	-	-	-
	a.					

	b.						
E	***Administrative:***	-	-	$4,128	$0	$4,128
	USFWS indirect costs @ 26.1%			$4,128	$0	$4,128
	Total (Sum of A - E)	-	-	$19,946	$14,120	$34,066

9. Timeline of major tasks and milestones:

Workflow	*Start Date/Month*	*End Date/Month*	*Responsible Party*
Environmental compliance/permits	January 2020	June 2020	Ben Kennedy
Pre-project preparation	January 2020	June 2020	Ben Kennedy
Field surveys	July 2020	September 2020	Ben Kennedy
Data analysis	October 2020	December 2020	Ben Kennedy
Reporting	January 2021	April 2021	Ben Kennedy

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Project Title: **Pilot test of an acoustic telemetry array to monitor juvenile lamprey in the lower Columbia River**

Project Applicant/Organization: US Geological Survey
Participants: Theresa "Marty" Liedtke, Toby Kock, Noah Adams, and Scott Evans
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Project Applicant/Organization: Columbia River Inter-Tribal Fish Commission
Participants: Laurie Porter and Greg Silver
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Project Applicant/Organization: Yakama Nation Fisheries
Participants: Ralph Lampman and Tyler Beals
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Project Applicant/Organization: Confederated Tribes of the Umatilla Indian Reservation
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Project Applicant/Organization: Nez Perce Tribe
Contact Person: Todd Sween
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Project Applicant/Organization: Pacific Northwest National Laboratory
Contact Person: Daniel Deng
Email: zhiqun.deng@pnnl.gov
Phone: (509) 372-6120

Project Applicant/Organization: Mainstem Fish Research LLC.
Contact Person: Geoff McMichael
Email: geoff@mainstemfish.com
Phone: (509) 531-8065

Project Type: Assessment

Lamprey RMU population: Lower Columbia Sub-Region
Watershed (5th HUC Field): Columbia Gorge Tributary
NPCC Subbasin (4th HUC Field) name: Lower Columbia/Sandy
Project Location: Columbia River RKM 86 (near Oak Point)

Total Requested funds: $ 78,432.99

Short Project Summary (200 words or less):

The proposed pilot project will install and evaluate an array of acoustic telemetry receivers in the Lower Columbia River to monitor movements of juvenile lamprey. The goal of the project is to test and refine the approach needed for a monitoring array that will have high detection probability of juvenile lamprey implanted with the new JSATS lamprey acoustic transmitter. Acoustic monitoring arrays for salmon studies have been tested and refined over many years and commonly have high detection probabilities (95-100%). The lamprey transmitter is less powerful than transmitters used in juvenile salmon, and lamprey behavior may be very different, so evaluations of monitoring arrays are needed. The new lamprey transmitter will soon be commercially available, making acoustic telemetry evaluations of juvenile lamprey movements and survival possible. Currently, the transmitter is being tested in the field through partnerships with PNNL and this project would continue that partnership to tag and release lamprey to evaluate the monitoring array. Refining the monitoring approach for juvenile lamprey will support future studies of their behavior at Columbia River dams by guiding array design as well as adding a detection location in the lower river that can be linked with detections of tagged lamprey at the dams.

1. Detailed Project Description (500 words or less):

Objective #1: Design, install, test, and refine a monitoring array

We propose to install an array of 12 JSATS receivers at Columbia River km 86, near Oak Point (Figure 1). This site performed well for salmon studies (Harnish et al., 2012), and our proposed receiver spacing is based on our experience with the lamprey transmitter in the Yakima River (Liedtke et al., 2019). Receivers and acoustic releases for the array (12 each, see Figure 2) will be provided as part of cost-sharing and the project budget would provide expendable supplies and manpower to install and maintain the array. We plan array installation in December 2020 and array maintenance and operation through early March 2021.

Objective #2: Acquire transmitters

We will acquire 100 lamprey transmitters from PNNL through an agreement and funding from CRITFC (as part of cost-share). The agreement will be initiated immediately after funding decisions are made to ensure timely delivery of transmitters.

Objective #3: Tag and release juvenile lamprey

Juvenile lamprey will be collected, tagged, and released by CTUIR) and YNF. Our study period will capture the early part of the juvenile lamprey outmigration, when fish collection facilities on the Columbia River are not operating. Lamprey collected by CTUIR and YNF beginning in December will be the source of fish for tagging. Tagging will follow procedures in Mesa et al., 2012. Tagged fish will be transported to a location approximately 1-1.5 rkm upstream of the array and released. A release site further upstream of the array would provide more insights into lamprey behavior, but would risk fewer fish passing through the array, which is required to estimate detection probability. We plan 2-4 releases, ideally separated in time to capture different environmental conditions (flow or tidal influence) and components of the migration. Collection, tagging, and release of study fish will be conducted by CTUIR and YNF as part of cost-share for the project. USGS will provide standard operating procedures for tagging, transport and release and will be responsible for data management.

Objective #4: Coordinate with partners to expand testing opportunities

Due to timing requirements for funding agencies, our project will be nearing completion just as the lamprey outmigration is peaking. Ideally, the monitoring array would continue operating through June to maximize our ability to learn about lamprey movements in the lower Columbia River. We will seek funding from partners to continue operating the array beyond the scope of this project and to purchase additional transmitters so more tagged lamprey can be monitored. There is interest in estimating survival of juvenile lamprey from Bonneville Dam to our array, and this objective can be met with additional funding. Designing and installing an array are significantly more expensive than maintaining one, and there is growing interest in acoustic telemetry evaluations of lamprey, so we are hopeful that other funding sources will be identified to expand the monitoring duration.

Objective #5: Data analysis and reporting

Data analysis will begin immediately after data collection is complete in March 2021. Although we may secure funding to continue operating the array beyond March, we will summarize findings from the 100 tagged lamprey released for this project, and calculate detection probability for the array. A survival estimate from the point of release to the array could be generated but will not be meaningful over such a short distance. If additional funding is secured to release tagged lamprey at sites further from the array, we can generate and report survival estimates. A summary report will be completed by April 30, 2021.

2. *Descriptive Photographs-illustrations-Maps*:

Figure 1. JSATS acoustic receiver array located on the Columbia River at RKM 86, between Oak Point on the north (Washington) shore and Port Westward on the south (Oregon) shore. Yellow pins designate individual acoustic receiver locations (12) which are spaced 96 m apart and 50 m from shore.

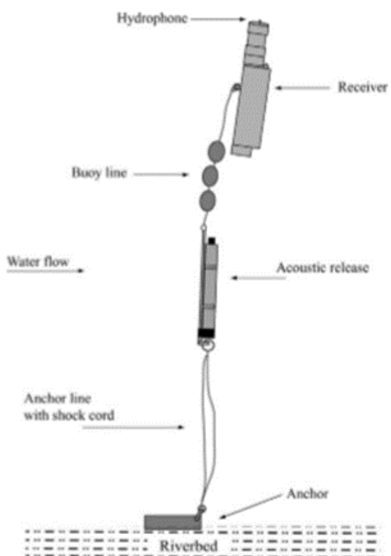

Figure 2. Depiction of the planned deployment approach for a single acoustic receiver. The

distance between the hydrophone and water surface is variable, and dependent upon the length of the anchor line.

3. Linkage of actions to Identified Threats in RMU (300 words or less):

- *What threat(s) does this project address?* **Passage**
- *Project scope: Does this project address threat(s) specific to this RMU only, or does the project address the threat(s) prevalent in multiple RMUs?*
  Single RMU ☐, Multiple RMUs ☒ list additional RMUs:

This project addresses threats and uncertainties for juvenile lamprey across all RMUs with juvenile passage barriers. Acoustic telemetry studies are needed to assess juvenile passage success, migration timing, and behavior across their range. Understanding juvenile passage behavior in all RMUs is critical to conservation of the species. This project is a pilot study to determine efficiency of an array in the lower Columbia River for detection of juvenile Pacific Lamprey and to inform future studies.

- *How does this project address key threat(s) within the HUC where project is proposed?*

This study would improve our understanding juvenile lamprey passage success in lower Columbia River tributaries as well as the lower Columbia River mainstem. Tributary passage was identified in the USFWS Lower Columbia River RIP as the highest priority threat in the lower Columbia River subunit (Wang et al. 2016). Basin-wide improvements to juvenile lamprey dam passage and survival have been identified by the USFWS, USACE and the CRITFC member tribes as high priorities and this project will provide information on the utility and efficiency of an acoustic array for detecting tagged lamprey. Additionally, we can estimate travel time and survival of juvenile lamprey using detection data from this study. This information will be beneficial for future projects that aim to understand juvenile passage routes, timing, and survival through the hydrosystem. Array configuration, receiver spacing, and transmitter configuration (i.e., ping rate) information will be shared with regional partners to inform future juvenile lamprey research and monitoring programs in the lower Columbia River and elsewhere in the system. The timing of our project could potentially overlap with USACE juvenile lamprey passage studies at mainstem dams that are also using acoustic telemetry. Having our array deployed in the lower river concurrent with the USACE studies may allow for assessments of juvenile survival rates and travel times from Bonneville Dam (or other mainstem dams) to the lower Columbia River. Securing additional funding may allow operation of the monitoring array to extend beyond the timeframe defined for this project and to purchase additional transmitters to tag and release lamprey at sites upstream of the array.

4. Species/Habitat Benefits (200 words or less):

- *How will the project provide meaningful measurable results to improve lamprey populations and/or their habitat conditions?*

This pilot project will measure the efficiency of an acoustic array to detect tagged juvenile Pacific Lamprey in the lower Columbia River environment below Bonneville Dam. Little is known of juvenile lamprey migration behavior, travel rates, etc. and this project will begin to fill those knowledge gaps so that management actions can be devised and implemented to improve lamprey populations. Project findings will also inform the design of future acoustic telemetry studies that can provide additional insights into lamprey behavior and protective and restorative actions.

- *What life stage or stages will benefit from action? How?*

Juvenile Pacific Lamprey. Passage is a threat throughout the range of Pacific Lamprey, so lessons learned from this project will benefit all RMUs. How? We will learn about lamprey movements and the efficiency of an acoustic array in the lower Columbia River to inform future research into juvenile lamprey passage, including future studies of passage/travel routes, bottlenecks and behavior in the lower Columbia River environment and throughout the system.

- *What other species may benefit from action?*

Salmonid species may benefit from refinements to acoustic monitoring arrays in the lower Columbia River.

5. ***Project Design / Feasibility (200 words or less):***
   - *Have the designs for the project been completed already or will they be completed before planned project implementation?* Yes ☒, No☐
   - *Are the appropriate permits (e.g., ESA consultation, Scientific Collection, fish health/transport, etc.) in place already or will they be in place before planned project implementation?* Yes ☒, No☐
   - *Can the project be implemented within the defined timeframe?* Yes ☒, No☐

This proposal outlines our design for the monitoring array and it will be refined through range testing with the lamprey transmitter prior to the installment of the full array. Permits needed for lamprey collection and transport are either in place or will be in place prior to the study period and will be coordinated by CTUIR and YNF. The project can be implemented within the defined timeframe as we will initiate efforts to acquire transmitters and equipment for the array as soon as funding decisions are made. Our planned deployment is six months after funds would be released, which allows ample time to acquire equipment and supplies. The largest obstacle to execution of the project is collecting juvenile lamprey for tagging since it will be early in the outmigration. We are confident that CTUIR and YNF will collect 100+ lamprey during the study period, but they may all arrive in 1-2 large groups, limiting our ability to execute 2-4 releases over a range of environmental conditions. We will manage tag and release operations adaptively, monitoring environmental conditions and the run, to best meet the study objectives.

6. ***Partner Engagement and Support (200 words or less):***
   - *What partners are supporting the project? What partners are active in implementing the project?*
   - *What partners are providing matching funds or in-kind services that directly contribute to the project?*

   The proposed project is supported by USGS, YN, CTUIR, NPT, CRITFC, Mainstem Fish Research (MFR) and PNNL. Project partners are providing matching funds or in-kind services that directly contribute to the project. USGS is providing acoustic receivers, hydrophones and other equipment for the array (see detail in project budget). CRITFC will purchase transmitters and a significant amount of new equipment required for the array. YNF and CTUIR are both contributing in-kind services to collect, tag, and release juvenile lamprey. Implementation of the project will involve cooperative efforts from all project partners. USGS will install and maintain the array, provide procedures for tagging and release, manage project data, and lead the reporting effort. MFR will assist with array design. YNF and CTUIR will lead lamprey collection, tagging and release, but all partners will assist. Project reporting will also be a cooperative effort, including all project partners.

7. Monitoring and Reporting (200 words or less):

- *How is completion of the project going to be documented?*
- *How will the projects' benefits to lamprey be monitored over time?*

Completion of the project will be documented with a summary report, submitted by April 30, 2021. We will structure and format the report to meet the requirements of the funding agency. The project will provide benefits to lamprey by beginning to fill the significant data gaps on juvenile lamprey behavior, movements, and survival. Improved understanding of juvenile lamprey can then be used to design or modify dam operations and/or structures to reduce adverse effects.

8. Project Budget (Including overhead):

- See proposed project budget table on last page.

9. Timeline of major tasks and milestones:

Workflow	***Start Date/Month***	***End Date/Month***	***Responsible Party***
Environmental compliance/permits	Feb 2020	March 2020	CTUIR, YNF
Agreement for transmitters	Jan 2020	March 2020	CRITFC, PNNL
Acquire array equipment	Jan 2020	March 2020	CRITFC
Pre-project preparation (receiver testing, site visits)	March 2020	May 2020	USGS, MFR
Array installation	Nov 2020	Dec 2020	USGS
Tag & release lamprey	Dec 2020	March 2021	All partners
Data analysis	March 2021	April 20201	USGS
Reporting	March 2021	April 2021	All partners

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Project Budget:

	Items	# Units	Cost per Unit ($)	RIP Funds Requested ($)	Cost Share ($)	Total Cost ($)
A	***Personnel:***	-	-	-	-	-
	a. USGS Electronic Technician	200	$ 57.25	$ 11,450.00		$ 11,450.00
	b. USGS Electronic Technician	100	$ 58.97	$ 5,897.00		$ 5,897.00
	c. USGS Fishery Biologist	125	$ 39.57	$ 4,946.25		$ 4,946.25
	c. USGS Project Leader	40	$ 76.07	$ 3,042.80		$ 3,042.80
	d. YNF staff				$ 10,000.00	$ 10,000.00
	e. CTUIR staff				$ 10,000.00	$ 10,000.00
B	***Equipment & Supplies:***	-	-	-	-	-
	CRITFC					
	Acoustic transmitters	100	$ 300.00		$ 30,000.00	$ 30,000.00
	Teledyne R500 acoustic release	12	$ 5,300.00		$ 63,600.00	$ 63,600.00
	Teledyne top-side unit	1	$ 7,500.00		$ 7,500.00	$ 7,500.00
	USGS					$ -
	ATS SR5000 submersible receiver	12	$ 5,000.00		$ 60,000.00	$ 60,000.00
	ATS hydrophones	12	$ 1,500.00		$ 18,000.00	$ 18,000.00
	floatation buoys and lead	12	$ 100.00		$ 1,200.00	$ 1,200.00
	Lithium-ion batteries	24	$ 300.00		$ 7,200.00	$ 7,200.00
	4 port charger for li-ion batteries	3	$ 220.00		$ 660.00	$ 660.00
	Receiver deploy, retrieve and redeploy supplies					
	steel cable lead, 1/4" dia.	900	$ 1.04	$ 936.00		$ 936.00
	shock cord	900	$ 0.57	$ 513.00		$ 513.00
	steel weights	125	$ 80.00	$ 10,000.00		$ 10,000.00
	CTUIR					
	truck, boat, and fuel				$ 5,000.00	$ 5,000.00
C	***Travel:***	-	-	-	-	-
	Field Trips for crew of 3	6	$ 267.00	$ 1,602.00		$ 1,602.00
D	***Other:***	-	-	-	-	-
	Mainstem Fish Research LLC (40 h + mileage)			$ 7,750.00		$ 7,750.00
E	***Administrative:***	-	-	-	-	-
	Overhead (70%)			$ 32,295.94		$ 32,295.94
	Total (Sum of A - E)	-	-	**$ 78,432.99**	**$ 213,160.00**	**$ 291,592.99**
				26.9%	**73.1%**	

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Clemens, B.J., R.J. Beamish, K.C. Coates, M.F. Docker, J.B. Dunham, A.E. Gray, J.E. Hess, J.C. Jolley, R.T. Lampman, B.J. McIlraith, M.L. Moser, J.G. Murauskas, D.L.G. Noakes, H.A. Schaller, C.B. Schreck, S.J. Starcevich, B. Streif, S.J. van de Wetering, J. Wade, L.A. Weitkamp, and L.A. Wyss. 2017. Conservation Challenges and Research Needs for Pacific Lamprey in the Columbia River Basin. Fisheries 42:5, 268-280.

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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.