ATTACHMENT A

Development of artificial propagation methods for production of juvenile Pacific lamprey (*Entosphenus tridentatus*) for use in research associated with Section 4.2.3 of the Rocky Reach Pacific Lamprey Management Plan

Statement of Work and Budget for

Performance Period May 1, 2018– April 30, 2019

Funds requested:

$ 41,700.70

U.S. Fish and Wildlife Service
Abernathy Fish Technology Center
Nutrition/Physiology Program
1440 Abernathy Creek Road
Longview, WA 98632
(360) 425-6072x339
ann_gannam@fws.gov

In cooperation with

Rocky Reach Fish Forum, via
Public Utility District No. 1 of Chelan County
327 North Wenatchee Avenue, PO Box 1231, Wenatchee, WA 98807-1231

Scope of Work: The US Fish and Wildlife Service (USFWS) Abernathy Fish Technology Center (AFTC) will provide to the Public Utility District No. 1 of Chelan County (Chelan PUD) data concerning husbandry and rearing requirements, and rearing success of Pacific lamprey ammocoetes (*Entosphenus tridentatus*) by investigating rearing conditions and methodology including water temperature, photoperiod and diet. In this process the USFWS will develop specific rearing techniques (from spawning to juvenile rearing) to produce a sufficient number of migration-ready juvenile Pacific lamprey large enough to be used in future evaluations supporting the Rocky Reach Pacific lamprey Management Plan.

Background: Pacific lamprey possess a highly complex life cycle, spending 2-7 years in a filter feeding larval stage (ammocoete) in freshwater, a few months as an out-migrating juvenile (macropthalmia), 1-3 years as a parasitic adult at sea, and returning to freshwater for approximately 1 year before spawning. Pacific lamprey populations have greatly declined from historical levels within the Columbia River Basin (Close et al. 2002; Moser & Close 2003; Moyle et al. 2009). The number of adult lamprey counted by the Fish Passage Center (FPC) passing Bonneville Dam has declined from 379,509 in 1969 to 38,716 in 2015 (FPC 2015). The decline in population size is attributed to various factors including delay, entrainment, and mortality during passage at hydropower facilities, rearing and spawning habitat loss, increased predation (Beamish 1980; Beamish & Northcote 1989; Matter et al. 2000; Close et al. 2002), and abundance of host species in ocean environments (Murauskas et al. 2013). Lamprey declines have raised concerns among tribal, state and federal management agencies throughout the Columbia River Basin (Close et al. 2002) and have led to recent calls for development of lamprey culture to supplement declining populations (CRITFC 2011). Although the conservation of Pacific lamprey is increasingly important given the ecological and cultural importance of the species, insufficient information is available about many basic life history characteristics thereby hampering efforts to make informed management decisions. In particular, there are many knowledge gaps in the methods for culturing Pacific lamprey for conservation and experimental studies purposes. Refined culture methods for this species are needed to create the capability to produce fish to use for mitigation, research, and translocation efforts, or to establish and maintain populations in refugia.

There are many differences between lamprey and most commonly cultured fin fish that make lamprey culture unique and challenging. The primary differences are the requirement for sediment in the culture tanks which larval lamprey burrow into, and their filter feeding behavior which requires unconventional diets and feeding methods. Culture is further complicated because the Pacific lamprey begins life as a larval fish measuring less than 1 cm in length. To date, our experiences with lamprey culture efforts at AFTC have been effective, but at times survival is poor. In the first year of work under this contract we examined the possible cause for a bottleneck in survival in first feeding prolarvae/larvae and we characterized the temporal pattern of mortality during the bottleneck period. In the second year we investigated the effects of substrate, tank water exchange and cleaning frequency on growth and survival of ammocoetes. The third year focused on rearing methods for ammocoetes ranging from 3

months to 2 years old. The research investigated the effects of water temperature, photoperiod and diet. These factors influenced growth and survival of the ammocoetes. The fourth year's studies will include the effects of feeding frequency on ammocoete growth and survival. Currently feeding twice a week is the protocol. In this feeding trial the current protocol will be compared to feeding the fish five times a week. Young of the year (YOY) and one year old fish will be used. Additionally, we will use a factorial design to test sediment depth and ammocoete density and their effects on fish growth and survival. In conjunction with this study we will run a straight density trial using the standard sediment depth. These two studies will help define the rearing parameters that allow lamprey to have optimum growth. We will also test the addition lipid to the diet to enhance the lipid portion of the ammocoetes' body composition. Some aspects of the studies proposed here were developed with our partners, NOAA Fisheries and the Yakama Nation, and we are continuing our collaborative work with them. Results from the studies proposed here will be shared with our partners.

Ultimately, the lamprey rearing research will include refining captive culture to be able to grow lamprey to size for tagging with acoustic transmitters commonly used in wild fish movement studies. Once the techniques are developed to grow lamprey to 50-150 mm, there will be a ready source of fish available for tagging and instream studies without having to mine wild populations.

The following tasks will be performed by the USFWS:

Task 1.

- Determine the optimum feeding frequency for the lamprey to achieve the best growth
    - Compare the current twice a week feeding to feeding the fish five times a week. Use YOY and one year old fish

- Determine the effects of density X sediment depth on growth and survival of BY15 ammocoetes
    - Use low, medium and high sediment depths
    - Use a low and a high stocking density

- Conduct a trial to run concurrently with the density X sediment depth using just density as a density refinement study
    - Use several levels of fish density that fall on either side of the current standard density
    - Use the same medium level of substrate used in the density X sediment depth study

- Conduct a feeding trial to assess the effects of increased levels of lipid in the diet on fish

growth and body composition

  - Use the 1) standard diet of 80% yeast/20% Otohime, 2) standard diet plus 20% fish oil emulsion, 3) standard diet plus 40% fish oil emulsion

- Continue to rear ammocoetes for long term objective of metamorphosed juvenile production

Task 2. Reporting

A final report will be disseminated to the Chelan PUD by 04/30/2019. A manuscript will also be submitted to a peer-reviewed scientific journal. Final reports will be supplied to the public upon request.

Expected Products:

- Deliverables:
  - Status summary of Year 4 lamprey culture operations that will include the following:
    - Results from the feeding frequency trial, YOY and one year olds
    - Results from the sediment/density experiment
    - Results from an experiment investigating density alone
    - Results from the diet/lipid study
    - Detailed information on the progress of the 2015, 2016 and 2017 brood year lamprey that are being reared for long term grow-out to macropthalmia

Timeline

  - Obtain prolarvae lamprey from Prosser Hatchery end of June
  - Test the effects of feeding frequency on YOY and one year old fish. Conduct each feeding trial for two months. Run concurrently.
  - Test the effects of density X sediment depth using BY15 ammocoetes. Conduct trial for three months.
  - Test the effects of density using a standard sediment depth using BY15 fish. Conduct trial for three months, run concurrently with the density X sediment depth trial.
  - Run feeding trial testing the effects of increased lipid in the diet on growth and body composition. Conduct the trial for two months.
  - Maintain ammocoetes for grow out to macropthalmia until the fish reach metamorphosis.

Data Management Plan

All finalized data will be stored in the Nutrition Projects database on the AFTC's network drive. The final report/publication will be stored in an Endnote database on the AFTC's network drive.

Literature Cited

Beamish, R. J. 1980. Adult biology of the river lamprey (*Lampetra ayresi*) and the Pacific lamprey (*Lampetra tridentata*) from the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 37:1906-1923.

Beamish, R. J., and T. G. Northcote. 1989. Extinction of a population of anadromous parasitic lamprey *Lampetra tridentata* upstream of an impassable dam. Canadian Journal of Fisheries and Aquatic Sciences 46:420-425.

Close, D. A., M. Fitzpatrick, and H. Li. 2002. The ecological and cultural importance of a species at risk of extinction, Pacific lamprey. Fisheries 27:19-25.

CRITFC (Columbia River Inter-Tribal Fish Commission). 2011. Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin. CRITFC, Portland, OR. Pp 183.

Matter, A. L., J. J. Vella, and L. C. Stuehrenberg 2000. Migration passage patterns of Pacific lamprey at Bonneville Dam, 1996-1998. In Biotelemetry 15 (ed. by J. H. Eiler, D. J. Alcorn and M. R. Neuman), pp. 278-285. International Society on Biotelemetry, Wageningen, The Netherlands.

Moser, M., and D. Close. 2003. Assessing Pacific lamprey status in the Columbia River Basin, Project No. 1994-02600, 10 electronic pages, (BPA Report DOE/BP-00005455-5).

Moyle, P. B., L. B. Brown, S. D. Chase, and R. M. Quinones. 2009. Status and conservation of lampreys in California. In *Biology, management, and conservation of lampreys in North America* (ed. by L. R. Brown, S. D. Chase, M. G. Mesa, R. J. Beamish and P. B. Moyle), pp. 279-293. American Fisheries Society, Symposium 72, Bethesda, Maryland.

Murauskas, J.G., A.M. Orlov, and K.A. Siwicke. 2013. Relationships between the Abundance of Pacific Lamprey in the Columbia River and Their Common Hosts in the Marine Environment. *Transactions of the American Fisheries Society*. 142:143-155.

FPC (Fish Passage Center). 2015. http://www.fpc.org/lamprey Fish Passage Center 847 NE 19th Ave., Suite 250, Portland, OR.

Chelan PUD lamprey Trials 2018-2019					
Direct Costs:		*Salaries:*			
		Staff	Hours		
		GS-13/9	*80*	*$56.25*	*$ 4,500.00*
		GS-11/9	*20*	*$39.47*	*$ 789.20*
		GS-11/2	*100*	*$31.16*	*$ 3,116.00*
		GS-9/5	*300*	*$29.18*	*$ 8,754.00*
		GS-5/2	*200*	*$17.56*	*$ 3,512.00*
			Benefits (35%)		$ 7,234.92
		Salaries and Benefits Total:			***$ 27,906.12***
		Supplies:			
		Supplies (feeds, consumables for analyses)			$ 1,000.00
		Replacement tanks, sand, screening material, airstones			$ 2,000.00
		Supplies Subtotal:			***$ 3,000.00***
		Direct Costs Total:			***$ 30,906.12***
		Nutrition O&M (7%)			$ 2,163.43
		Indirect cost (26.1%)			$ 8,631.15
		Total indirect cost			***$ 10,794.58***
Total Funds for Project					**$ 41,700.70**