OWEB Final Report: Grant 217-2051

Tenmile Lakes Basin Partnership

June 2018

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Acknowledgements

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Technical Assistance

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Executive Summary

Pacific Lamprey are native to the Tenmile Watershed and culturally important to the local Native American Tribes. Likewise, Salmon and Steelhead have both an economic and cultural significance to the local citizens and Tribes. Pacific Lamprey were historically harvested by the people of the Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI), but it was unknown if Pacific Lamprey were still present in the Tenmile Watershed. A fish trap was built on Eel Lake by the Oregon Department of Fish and Wildlife (ODFW) in 1989 for the purpose of fish capture and rearing. The trap is effective in capturing Salmon and Steelhead but may act as a barrier to the passage of Pacific Lamprey.

This monitoring effort was designed to assess the presence/absence of Pacific Lamprey in the Tenmile Watershed, identify migration timing, potential lamprey passage barriers and rearing/spawning habitats, and collect and organize data from Eel Lake Trap on native Coho, Cutthroat, and native/hatchery Steelhead returns and trends.

Lamprey larvae (ammocoete) monitoring was conducted in the summer of 2017 using electro-shockers. Shocking occurred on 3 tributaries of Tenmile Lakes (Big Creek, Johnson Creek, and Shutter Creek), and 3 creeks within the Eel Lake basin (Eel Creek, Clear Creek, and Winters Arm Creek).

Two species of lamprey were identified, Western Brook (*Lampetra richardsoni*) and Pacific (*Entosphenus tridentatus*). Western Brook were found in all sampled Tenmile Lakes Basin streams, but only in the streams above Eel Lake Trap in the Eel Lake Basin. No Western Brook were identified in Eel Creek below the Trap. Pacific Lamprey were found in Johnson Creek and Big Creek in the Tenmile Lakes Basin, and in Eel Creek in the Eel Lake Basin. No Pacific Lamprey were identified above the Eel Lake Trap, suggesting that it may act as a complete passage barrier to that species. In addition, over 200 adult Pacific Lamprey were salvaged from an ODOT culvert enhancement project on Eel Creek near Hwy 101. Pacific Lamprey larvae were identified upstream of this project, but it is likely that it was a partial barrier. Two other ODOT culverts were identified as potential partial lamprey barriers on Eel Cr.

Spawning areas for Pacific and Western Brook Lamprey are similar to spawning areas for salmon. Upper reaches of all the Tenmile Lake tributaries have appropriate spawning gravel. Lower stream areas are often high in sediment which is conducive to rearing lamprey larvae. This was confirmed in Johnson creek with high numbers of Pacific Lamprey larvae found at the mouth as it enters South Tenmile Lake. Farther upstream in the Johnson Creek system, larvae were abundant, but much smaller with many being too small to identify (<65mm). Western Brook larvae were found, but no Pacific Lamprey larvae were identified, perhaps amongst those unidentified specimens. Western Brook ammocoetes were also found at the lower site on Johnson Creek, and in Big Creek and Shutter Creek.

Pacific Lamprey migration into the watershed is difficult to determine due to the elusive nature of the species and their life cycle trait of migrating in from the ocean in the spring of one year, then holding over until the next spring before spawning. When specimens are captured, it is difficult to determine whether it is a fresh migrant or last year's holdover. Even if it can be determined which year it is from, it is still difficult to know how long it has been in the system before it was captured. In Phase 2 of this project, we will capture Pacific Lamprey either in traps near the mouth of Eel Cr, or at the lower culverts. This should give us a better sense of migration timing.

Native Coho salmon counts at Eel Lake Trap were down significantly from the recorded high at the Trap of 441 in 2012, with only 66 native Coho returning in 2018 (the winter of 2017-2018). The previous 2 years were also low with 2016 and 2017 showing returns of only 53 and 118 respectively. The Coho numbers for most of the Oregon Coast also showed low returns.

Hatchery Winter Steelhead counts were 502 for 2018. This compares to a record high of 828 in 2007, 595 in 2016, and 226 in 2017. Returning native Steelhead only numbered 10 for the 2018 season. The average return for Native Steelhead is 24. In 2018, 60 Steelhead were spawned including 2 native males, but no native females. 252 hatchery Steelhead were recycled into Saunders Lake, and 148 into Butterfield Lake. ODFW allocated 25,000 smolts for the Tenmile Watershed, which were acclimated and then released in April 2018.

Background and Historical Context

Tenmile Watershed

The Tenmile Watershed is located on the Southern Oregon Coast near the city of Lakeside. Comprised of approximately 100 square miles and usually less than 12 air-miles from headwaters to the ocean. There are 12 lakes within the watershed including North and South Tenmile Lakes and Eel Lake. Big Creek is a major tributary of N Tenmile Lake along with Blacks, Wilkins, and Murphy Creeks. The main tributaries of South Tenmile Lake include Johnson, Benson, Adams, and Shutter Creeks. Eel Lake is located just northwest of N Tenmile Lake and is fed by 3 main tributaries: Clear Creek, Winters Arm Creek, and Marsh Creek. Eel Lake drains at the southern end through 3-mile-long Eel Creek, which joins with the outflow of Tenmile Lakes, in Tenmile Creek, for another short 3 mile passage to the ocean. Eel Lake is the source water lake for the City of Lakeside.

Pacific Lamprey Background and Life History

Pacific Lamprey are native to the Tenmile Watershed and were historically harvested by the people of the Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). Culturally important as a first-food and for ceremonial and medicinal purposes, declines in lamprey populations have threatened those historic bonds between the tribes and lamprey as elder-knowledge fades, and younger generations lose touch with the role that Pacific Lamprey play in their traditions. Local knowledge of historic harvest locations and methods, cleaning, preservation, and preparation for food, medicine and ceremonial purposes are all imperiled due to the decline in Pacific Lamprey populations. TLBP is currently working with CTCLUSI to develop a 30-year Pacific Lamprey conservation management plan, and the work conducted in this grant, and the other proposed phases of this monitoring project, will build the knowledge base necessary to assist in the recovery of Pacific Lamprey within the Tenmile Lakes Watershed.

Lamprey related nomenclature is varied in relationship to their stages of development. Dr. Ben Clemens (ODFW Statewide Lamprey Coordinator) recommends the following three stages of post-hatch terminology be used for lampreys:

- <u>Larvae</u>: Immature, non-sex determinant, filter-feeding larvae without eyes
- <u>Juveniles</u>: Individuals with eyes and sucker mouths with sharp teeth designed for parasitizing various fishes (and sometimes whales) in the Pacific Ocean. Juveniles may also be individuals that have recently transformed from a formerly eyeless, filter feeding existence in freshwater streams in preparation for parasitic feeding in the ocean.
- <u>Adults:</u> Non-feeding, upstream-migrating lamprey in various stages of sexual maturation

In general, the term *Ammocoete* is frequently used in place of *larvae*, and *Macrophthalmia* is the used for *juveniles*. It should be pointed out that the lamprey are considered <u>Juveniles</u> for their entire ocean life phase and only termed <u>Adult</u>, when the lamprey enter freshwater to begin their upstream migration and spawning behavior.

Pacific Lamprey are an anadromous species and play an important role in the local ecosystem by bringing ocean nutrients into the fresh water system, and by providing a high-calorie food source for marine and land mammals, and avian predators and scavengers. In addition, they are a high value food source for rearing juvenile salmon and other native species during the lamprey's egg and larval stages.

Pacific Lamprey spawn in gravel areas, creating redds similar to Salmon and Steelhead, although they tend to be smaller and rounder. Eggs are lightly buried into the gravel where they hatch into prolarvae which remain in the redd for up to 15 days. After this initial period, the eyelash-sized larvae float downstream until they locate a suitable Type 1 rearing area, consisting of fine sediments, sand and detritus. Lamprey larvae live in fresh water for 3 to 9+ years, filter feeding on algae and other detritus material, before transforming into the eyed, 130-180mm, juvenile stage and out-migrating to the ocean.

Positive field identification of lamprey larvae is challenging. Western Brook Lamprey and Pacific Lamprey are very difficult to distinguish in young larvae below 65mm. In our data collection efforts, we marked all larvae below 65mm as “unknown.”

Juvenile Pacific Lamprey are parasitic while in their ocean phase, feeding on Pollock, Hake, Salmon, Herring, Cod and other marine fish. They are also prey to some species of fish and marine mammals, such as sea lions and killer whales.

After spending 2 to 3 years in the marine environment, and growing to 50-90cm (20-36 inches), they return to freshwater in late winter to spring to begin their adult life stage while migrating upstream and spawning. Unlike salmon, they don’t appear to home in on their natal streams, although there is some evidence that they may return to a general geographical region. They stop feeding during their freshwater migration and generally have a holdover period of approximately 12-18 months before spawning the following spring.

Lamprey travel mostly at night or during periods of high stream turbidity. Anthropogenic barriers such as dams, culverts, weirs, and tide gates can create passage barriers if they are not built to accommodate the lamprey’s method of travel using their suction mouths. Pacific Lamprey are not strong swimmers and rely on their suction mouth attachments to secure their place in the water. If a barrier has a ninety-degree corner, the lamprey may get washed back downstream if its oral disc cannot secure a hold as it tries to negotiate the corner. This is particularly true in areas with high velocity flows. Pacific Lamprey do not jump but can climb vertical surfaces depending on the substrate characteristics and flow.

Eel Creek Salmon Background

Salmon and Steelhead also have both an economic and cultural significance to the local citizens and tribes. Salmon are considered to be one of the most sacred animals by the Coos, Lower Umpqua and Siuslaw Indian Tribes. There are numerous stories and myths around the care and preparation of salmon, and the bad luck or death that can come from mistreatment of them. Per tradition, after the first salmon is caught in the river, all fishing stops and the leading Shaman of the village would divide it among the most respected and honored people in the village first. The heart and cheeks being the most desired parts. Ceremonies would take place, sometimes for several days, and fishing would resume once all the respects and rituals were observed. This tradition allows for many of the salmon to travel far upstream to the spawning grounds unhindered by the hundreds, or thousands of people that would be fishing for them. In effect, allowing for sustainable harvests for generations and generations. Salmon is smoke cured and dried by the tons, for the winter months and for trade.

The Eel Lake Trap (Trap) was built on the outlet of Eel Lake by ODFW in 1989 as a means to enhance Coho runs in the Eel Lake basin. Later the hatchery Coho production was discontinued and a hatchery Steelhead fishery was created on Tenmile Creek. The Trap is effective in capturing Salmon and Steelhead but may act as a barrier to the passage of Pacific Lamprey. There are also small native Steelhead and Cutthroat runs through the Trap.

The original broodstock for the hatchery program came from Steelhead caught in the Alsea and Coos Rivers, with a few coming from Tenmile Lakes. Broodstock for the current Steelhead program is obtained from STEP spawning efforts on returning fish at the Trap. One of every six native Steelhead females are spawned along with select native males. These are in addition to hatchery Steelhead of various sizes that are also spawned, usually in mid-February. Spawned native females are released downstream into Eel Creek while the partially spawned native males and unspawned native females are released into Eel Lake. Approximately 40,000 eggs were collected in the 2018 season, hatched in the Bandon Hatchery, and reared at the Cole Rivers facility for a return of ~25,000 smolts to the Tenmile Cr/Eel Cr acclimation sites in 2019.

ODFW decided in 2014 not to allow hatchery Steelhead to pass the Trap. Concerns with hatchery fish interfering with both native Steelhead and Coho spawning prompted the new protocols. Hatchery Steelhead are either dispatched or recycled into either Saunders or Butterfield Lake. Native Steelhead, Cutthroat and Coho are all released into Eel Lake and allowed to proceed to Winters Arm Creek and Marsh Creek spawning areas. Habitat improvement projects have occurred in Winters Arm Creek in the form of gravel augmentation and large woody debris (LWD) improvements. Spawning surveys have shown both Coho and Winter Steelhead redds in the augmented areas. (See Photo 1 below)

Photo 1-Winter Arm Cr Gravel Augmentation & LWD

Native Coho Salmon captured in Eel Lake Trap are counted, identified as male or female, and immediately released into Eel Lake. This provides a nearly 100% count of the native Coho run within this basin and provides data on this important endangered species.

The Trap also acts as an acclimation site for Steelhead smolts. This is in addition to 2 sites farther downstream near Tenmile Creek.

Project Results and Discussions

Pacific Lamprey Presence/Absence within Tenmile Watershed

Adult Lamprey

It was unknown if Pacific Lamprey were still present in the Tenmile Watershed. According to Trap records, no Pacific Lamprey have ever been seen in the Trap in the nearly 30 years that it has been in operation. It was unknown if the absence was due to the lack of Pacific Lamprey in the system, or their inability to negotiate the fish ladder at the Trap. Anecdotal evidence from local ranchers and fishermen indicated that they had been seen in Eel creek and used as fishing bait or seen in the Tenmile Lakes basin as they passed through the ditched channels of the ag-lands. These reports were dated by 20 or more years. Likewise, the people of the CTCLUSI are thought to have used Eel Creek for catching Pacific Lamprey, but the historical memories are unclear.

ODFW has conducted spawning surveys on Johnson and Benson Creeks in the Tenmile Lakes basin. They were designed to count Steelhead redds, but data was also taken on lamprey redds, both Western Brook and Pacific Lamprey. A spawning survey specifically designed for Pacific Lamprey might have continued beyond the termination date of the Steelhead surveys, but their spawning times overlap, so some lamprey data was collected.

As the ODFW table below shows, Pacific Lamprey redds were found in 2006, 2007, 2012, and 2013. The only live Pacific Lamprey was seen on 4/17/2013, but 14 redds were counted on 5/1/2013. Western Brook Lamprey were found in relative abundance that same year with 114 live lamprey and 74 redds counted on 5/1/2013.

Table 1- ODFW Lamprey Spawning Data

Tenmile Lake (Lamprey Data)

Steelhead Season Spawning Ground Survey Daily Count Data (tblSTWData).

Reach ID	Survey Name	Miles	Survey Year	Date	Live Fish Act. Cut	Lm	Pacific Lamprey Live	Pacific Lamprey Dea	Pacific Lamprey Redds	Brook Lamprey Live	Brook Lamprey Redds
22359.00	Benson Cr	1.22	2006	04/26/06	15		0	0	1	0	0
22359.00	Benson Cr	1.22	2006	05/10/06			0	0	1	0	0
22359.00	Benson Cr	1.22	2007	04/10/07			0	0	1	0	0
22359.00	Benson Cr	1.22	2007	04/24/07			0	0	1	0	0
22359.00	Benson Cr	1.22	2007	05/15/07	14		0	0	1	0	0
22357.70	Johnson Cr	0.92	2012	05/15/12		16	0	0	13	6	20
22357.70	Johnson Cr	0.92	2012	05/23/12			0	0	4	0	0
22359.00	Benson Cr	1.22	2013	03/05/13			0	0	1	0	0
22357.70	Johnson Cr	0.92	2013	04/03/13			0	0	1	0	0
22359.00	Benson Cr	1.22	2013	04/03/13	14		0	0	2	0	0
22357.70	Johnson Cr	0.92	2013	04/17/13		16	0	0	1	1	1
22359.00	Benson Cr	1.22	2013	04/17/13		16	1	0	1	0	0
22357.70	Johnson Cr	0.92	2013	05/01/13		16	0	0	14	114	74
22359.00	Benson Cr	1.22	2013	05/01/13			0	0	4	0	0

Due to its lack of gravel spawning grounds, no ODFW spawning surveys have been conducted on Eel Creek. The first real proof that Eel Creek may have a current population of Pacific Lamprey came on 8/10/2017. ODOT was working on a culvert passage project on Eel Creek under Hwy 101. Part of the project involved de-watering the culvert. When the water dropped around the riprap of the jump pool, 217 adult Pacific Lamprey were salvaged from that area.

Photo 2-Pacific Lamprey Salvage at HWY 101 Culvert (EC SC#3) Photos courtesy of ODOT

This culvert was improved to provide Pacific Lamprey passage by notching the concrete barrier on the north side exit and installing lamprey ramp passages through the interior baffles of the culvert. On 10/5/2017 an adult Pacific Lamprey was found in the Eel Lake Trap for the first time. It is likely that the Hwy 101 culvert was a partial barrier to lamprey passage and by making the passage improvements it is allowing more Pacific Lamprey to migrate up Eel Creek to the Eel Lake Trap.

One Pacific Lamprey was discovered partially crushed under some culvert construction material. This specimen was taken and preserved in 95% denatured alcohol. It measured 48cm (~18.75inches) long and had a girth of 96mm anterior to the anterior dorsal fin.

Lamprey larvae (ammocoetes)

Background

Western Brook lamprey ammocoetes are seen frequently when ditches are cleaned or other activities that move bottom sediments of the Tenmile Lake tributaries. With the difficulties of properly identifying Western vs Pacific lamprey it is also possible that some of those ammocoetes were Pacific Lamprey that were misidentified as Western Brook Lamprey.

TLBP also conducted lamprey larvae surveys on Eel Creek and 3 other creeks in the Tenmile Lakes basin. To acquire the proper training and sampling protocols, TLBP formed the Tenmile Lamprey Advisory Group in the summer of 2017. This group consisted of: Dr. Ben Clemens (ODFW Statewide Lamprey Coordinator), Gary Vonderohe (ODFW Assistant District Fish Biologist), John Schaefer (CTCLUSI Biologist), and Richard Litts (TLBP Monitoring Coordinator). This group met four times over the course of the summer to do field surveys, and multiple times through email and teleconferences. In addition, Gary Vonderohe, Mike Mader, and Richard Litts surveyed Winters Arm Creek for lamprey larvae.

Sampling methods

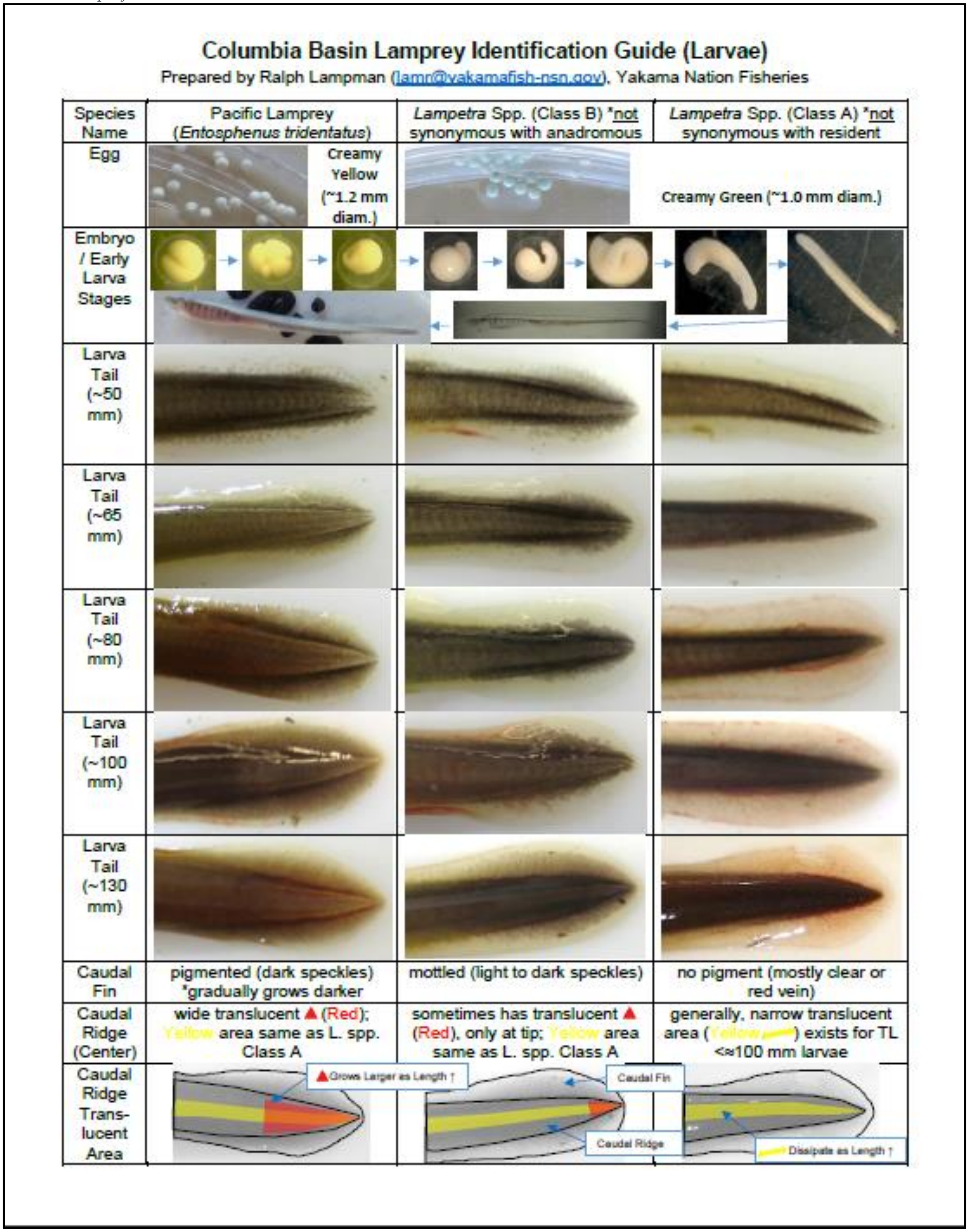
We followed the rapid biological assessment protocol outlined by Reid and Goodman (2015), wherein shocking occurred for no more than 30 minutes per site. Shocking protocols were followed using either the Smith-Root LR-24, 550V, 1Hz, Std Pulse; or the ETS AbP2, 250V Slow=25% duty cycle (3 on: 1 off), Fast=30 Pulses/sec. We generally had 3-4 netters (including the shocker). Our main goal was to detect the presence/absence of larvae; our secondary goal was to ascertain the relative abundance, if possible, using catch per unit effort (CPUE) as a proxy (Schultz et al. 2014). In this way, we expressed CPUE as #larvae/(M^2*Sec).

In an attempt to standardize shocking times and areas to enable comparisons of CPUE across habitats, we used a stopwatch to estimate the time of shocking (to the nearest second), and a tape measure to estimate the area (to the nearest M^2). The total area shocked varied widely from 5.9M^2 to over 50M^2. Type 1 habitat was chosen for our shocking efforts, consisting of fine sediments, sand and detritus.

Following ODFW protocols, shocked ammocoetes were netted and placed in a bucket of stream water. After shocking efforts were completed, the ammocoetes were moved a few at a time to a bucket of water containing MS-222 to anesthetize them. Soon after the ammocoetes stopped moving, the specimens were measured to the nearest millimeter using a fish board mounted with a small ruler. They were then identified using a handheld magnifying glass as needed. We used the expertise of Dr. Ben Clemens and the guide shown below, prepared by Ralph Lampman of the Yakama Nation Fisheries, to identify larvae 65mm and larger. Those that were below 65mm were listed as Unidentified. After measuring and identification, the ammocoetes were placed in an aerated bucket of water to recover before being return to the area of capture.

A total of 14 voucher specimens were taken, including at least 1 at almost every site, to confirm our identification accuracy (quality assurance), and to identify some specimens that were under 65mm and thus labeled as "unknown." These were taken in areas where identification was crucial, such as above the Eel Lake Trap, in Winters Arm Creek, where visual observations showed only Brook Lamprey and it was important to know if any of the small larvae might be Pacific Lamprey. The specimens were preserved in 95% Ethanol, labeled, and stored in the freezer. Thirteen of the voucher specimens were later sent to the ODFW genetics lab for DNA analysis and positive identification. The lab results are shown in the *Lamprey larvae (ammocoetes) survey results* section below.

Table 2- Lamprey Larvae ID Guide



Columbia Basin Lamprey Identification Guide (Larvae)

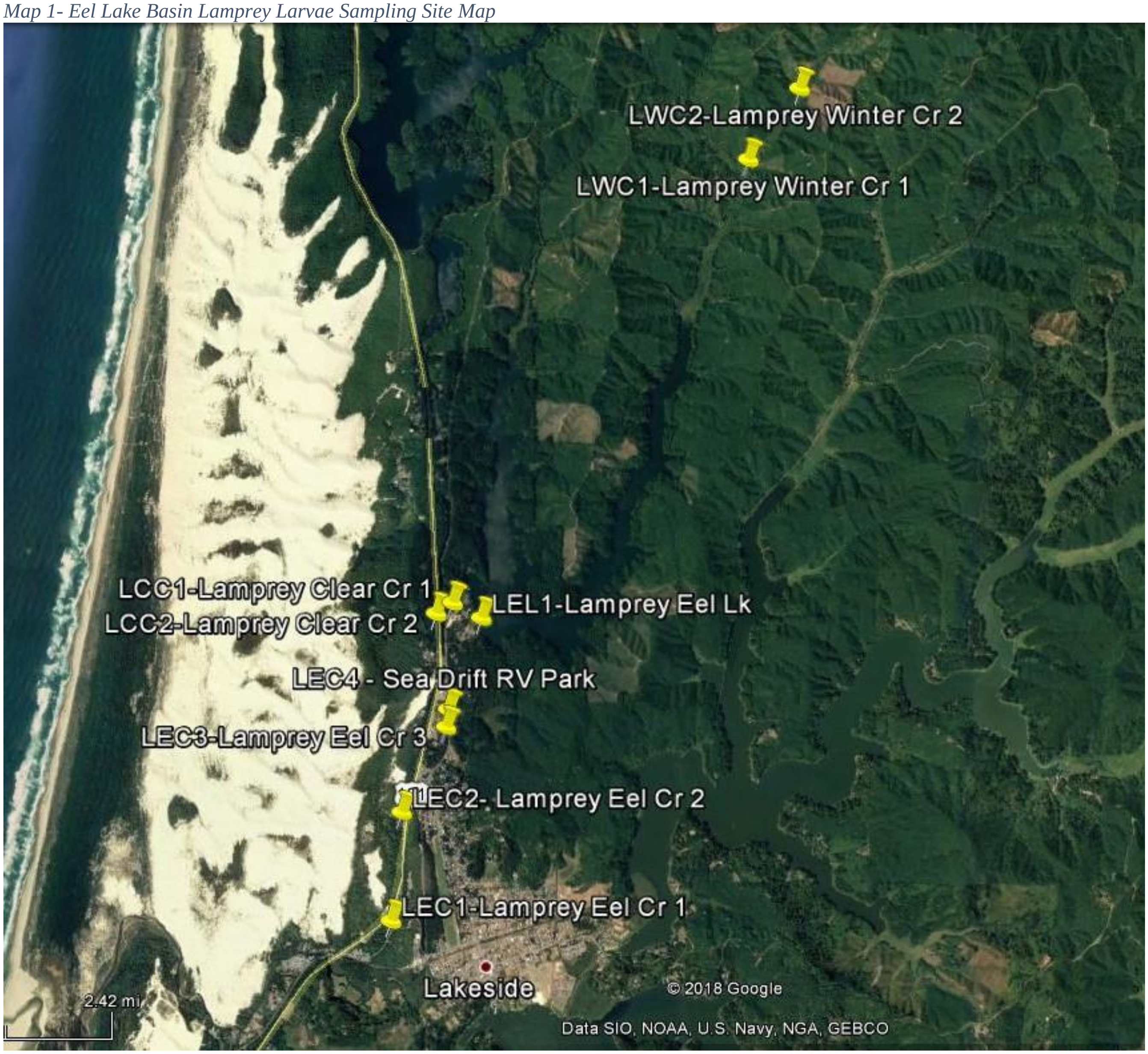
Prepared by Ralph Lampman (lamr@yakamafish-nsn.gov), Yakama Nation Fisheries

Species Name	Pacific Lamprey (*Entosphenus tridentatus*)	*Lampetra* Spp. (Class B) *not synonymous with anadromous	*Lampetra* Spp. (Class A) *not synonymous with resident
Egg	Creamy Yellow (~1.2 mm diam.)		Creamy Green (~1.0 mm diam.)
Embryo / Early Larva Stages			
Larva Tail (~50 mm)			
Larva Tail (~65 mm)			
Larva Tail (~80 mm)			
Larva Tail (~100 mm)			
Larva Tail (~130 mm)			
Caudal Fin	pigmented (dark speckles) *gradually grows darker	mottled (light to dark speckles)	no pigment (mostly clear or red vein)
Caudal Ridge (Center)	wide translucent ▲ (Red); Yellow area same as L. spp. Class A	sometimes has translucent ▲ (Red), only at tip; Yellow area same as L. spp. Class A	generally, narrow translucent area (Yellow) exists for TL <≈100 mm larvae
Caudal Ridge Trans-lucent Area			

Site Selection

Eel Lake Basin Sites

Map 1- Eel Lake Basin Lamprey Larvae Sampling Site Map



Site selection on Eel creek was based on their relation to possible passage barriers. Lamprey Eel Creek #1 (LEC1) was below the Hwy 101 culvert (SC#E3) discussed above. LEC2 was just below Eel Cr Campground Bridge (SC#E5) and also below Hwy 101 box culvert (SC#E6). LEC3 was above SC#E6 and ~50ft below SC #E7 Bridge. The final site was chosen above SC#E7 to verify that Pacific Lamprey larvae were above the SC#E6 culvert, which is likely a partial lamprey barrier. A map of the barrier locations can be found in the Passage Barrier Assessment portion of this report. The Eel Lake Basin lamprey larvae sampling site map is shown above, and photos of several sampling sights are shown below.

Photo 3-LEC1 - Eel Creek Below HWY 101 Culvert (SC#E3)

Photo 4- LEC2 - Just below Eel Cr Campground Bridge (ED SC#5)

Photo 5- LEC3 - Just below EC SC#7

Photo 6- LEC4- Possible Spawning Gravel

Approximately 200ft above Eel Lake Trap, we sampled in a sandy beach area on the shore of Eel Lake (LEL1). The next site was in Clear Creek. A dunal stream that enters Eel Lake about a quarter mile up the western shore from the Trap. We sampled both above and below the Clear Creek Hwy 101 culvert (LCC2 and LCC1 respectively.) We also sampled in Winters Arm Creek, a tributary feeding the eastern arm of Eel Lake. The mouth of Winters Arm Creek is located approximately 2.5 miles from the Trap. Sampling site LWC1 is approximately 0.9 miles above the lake at the confluence of the main stem and the north fork. LWC2 is farther upstream by 0.5 miles. The spawning gravel enhancement projects mentioned previously are located above these two sites, one on the North Fork and one on the main stem. (Photos of all sites are shown below)

Photo 7- Sampling Site LEL1 – Eel Lake

Photo 8- Sampling site LCC1 –Clear Creek

Photo 9- Winters Arm Creek Valley with Sampling locations shown. (LWC1-left and LWC2-right)

Photo 10- Sampling Site LWC1 –Winters Arm Creek (Looking South)

Photo 11- Sampling Site LWC1 –Winters Arm Creek (Looking North)

Photo 12- Sampling Site LWC2 –Winters Arm Creek (Looking South)

Tenmile Lakes Basin Sites

Site selection in the Tenmile Lakes Basin was determined by stream sub-basin, accessibility, and distance from the lakes. The largest tributary of North Tenmile Lake is Big Creek. We chose 2 sampling sites, LBC1 which is located 1.7 river miles above the lake where North Lake Rd crosses Big Creek, and LBC2 located 1.25 mile farther upstream and next to a recently completed livestock exclusion fencing project. Ammocoetes have been observed in this area before, but it was unclear whether they were Pacific or Western Brook Lamprey. Coho spawning habitat is located ~ 2 miles upstream from LBC2, which is likely Pacific Lamprey spawning habitat also.

Photo 13- Sampling Site LBC1 – Big Creek Near N. Lake Rd Bridge

Photo 14- Sampling Site LBC1 – Big Creek in Ag-land area

South Tenmile Lake's largest tributary is Johnson Creek. Site LJC0 is located on a sand bar on the NE bank of Johnson Cr as it enters Tenmile Lake. LJC1 is on an active cattle ranch, 1 mile upstream from LJC0. The third site on Johnson Creek (LJC2) is upstream another 2.6 miles, ~150ft below the confluence of Hatchery Creek. It is also on an active cattle ranch, but within a fenced exclusion zone. Spawning surveys have shown redds from both Pacific Lamprey and Western Brook Lamprey on Johnson Creek. These sites are located approximately 2 miles upstream from LJC2.

Photo 15- Sampling Site LJC0 –Mouth of Johnson Cr at S. Tenmile Lake

Photo 16- Sampling Site LJC1 – Johnson Creek Below Fritz Bridge

Photo 17- Sampling Site LJC2 – Johnson Creek below Hatchery Cr Confluence

Photo 18- Sampling Site LTA – South Tenmile Lake (Templeton Arm)

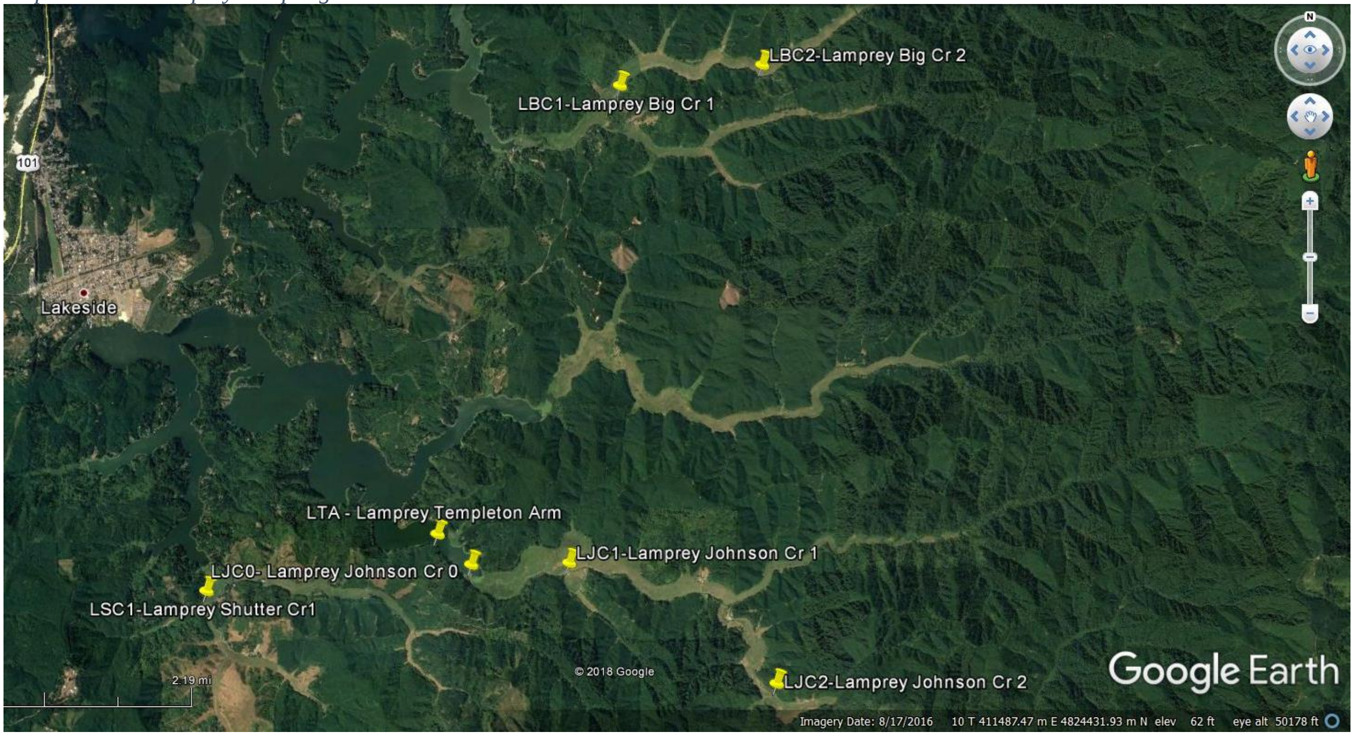
We sampled one site on the south shore of South Tenmile Lake in Templeton Arm (LTA). It is located ~1800ft west of site LJC0 on Johnson Creek. The shoreline consisted of rocks and sediment, probably classified as Type 2. No obvious current, but wave action from boats was heavy.

Photo 19- Sampling Site LSC1 – Shutter Creek at County Bridge

LSC1 is located on Shutter Creek, another tributary of South Tenmile Lake. Samples were taken just upstream from the bridge crossing at Shutters Landing Rd. Shutter Creek is the location of historical anecdotal Pacific Lamprey sightings.

Tenmile Lakes Basin lamprey larvae sampling sites are shown below.

Map 2- Larval Lamprey Sampling Sites Within the Tenmile Lakes Basin



Lamprey larvae (ammocoetes) survey results

Eel Lake Basin

Eel Creek cuts through a sand dune, so the stream substrate is composed of sand, sediments and woody debris/organics. No obvious spawning grounds were identified. The only rocky areas found were small and localized, with the exception of the rip-rap areas around stream crossings. One area at LEC4 had a small area of sandstone type rocks in a round, slight depression. There was speculation that it could have been an old lamprey redd. Phase 2 of this project proposes to conduct lamprey spawning observations on Eel Creek. This could be assisted by the use of the radio telemetry tags also proposed in that phase.

The source water for Eel Creek is Eel Lake. Previous TLBP monitoring on Eel Lake has shown summer temperatures are often in the low to mid 70's (low 20's Celsius) and the water cools as it proceeds downstream in Eel creek. The table below show the results of a TLBP continuous temperature study done on Eel Creek in 2014. The site was about 200ft upstream from LEC2 and showed no 7-day average maximum temperatures exceeding the 18°C threshold established for Coho rearing.

Table 3- Eel Creek Continuous Temperature Data 2014

			Seasonal Maximum		Seasonal Minimum		Seasonal Maximum	
Site Name	**Start Date**	**End Date**	**Date**	**Temp °C**	**Date**	**Temp °C**	**Date**	**ΔT °C**
EC1	7/22/2014	9/30/2014	7/27/2014	16.2	9/14/2014	11.6	7/27/2014	2.2

Days Exceeding Temperature Thresholds (Max 7-Day Avg Temps)					
7-Day Avg Max Temp>13°C	**% of Total Days >13°C**	**7-Day Avg Max Temp>18°C**	**% of Total Days >18°C**	**7-Day Avg Max Temp>21 °C**	**% of Total Days >21°C**
65	100%	0	0%	0	0%

In addition, we did a baseline sampling on 9/14/2017 for standard field parameter in Eel Creek and gathered elevation data from Google Earth. Both charts are shown below. As expected, the temperature drops sharply as it leaves Eel Lake (SC#E9 is at the Trap with a reading of 20.5°C) to SC#E7 (the bridge above sampling site LEC3) where the temperature was 14.8°C. It then becomes more constant at ~13.5°C. pH ranges between 6.35s.u. and 6.83s.u., with the exception of Eel Lake at 7.24s.u.

Dissolved oxygen ranged upward of 7.0mg/L with the exception of the SC#E6 to SC#E7 area. As can be seen with the elevation chart, this area very low grade and thus very slow-moving water. The sampling area (LEC3) also had a layer of brownish red scum on the creek bottom. It is likely a bacterial growth that may be lowering oxygen levels and perhaps indicative of less desirable habitat of lamprey larvae. Specific conductivity, and turbidity can also be seen on the chart below.

Chart 1- Eel Creek Baseline Data

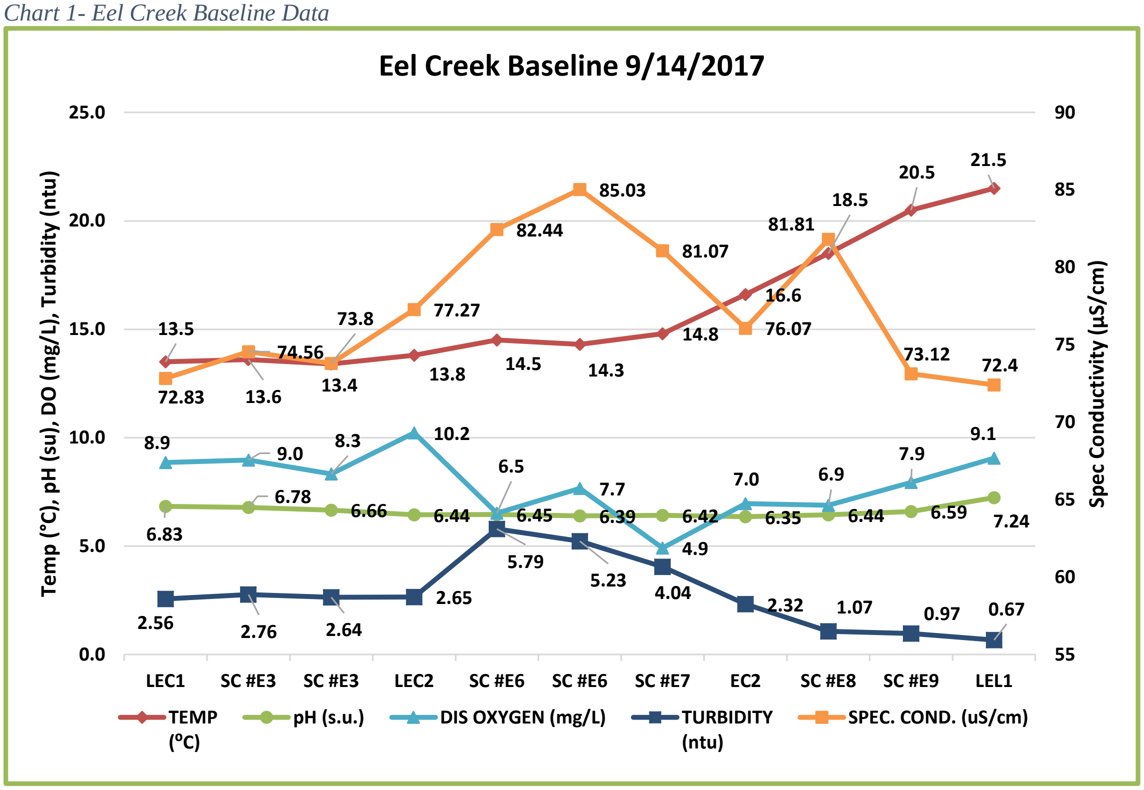
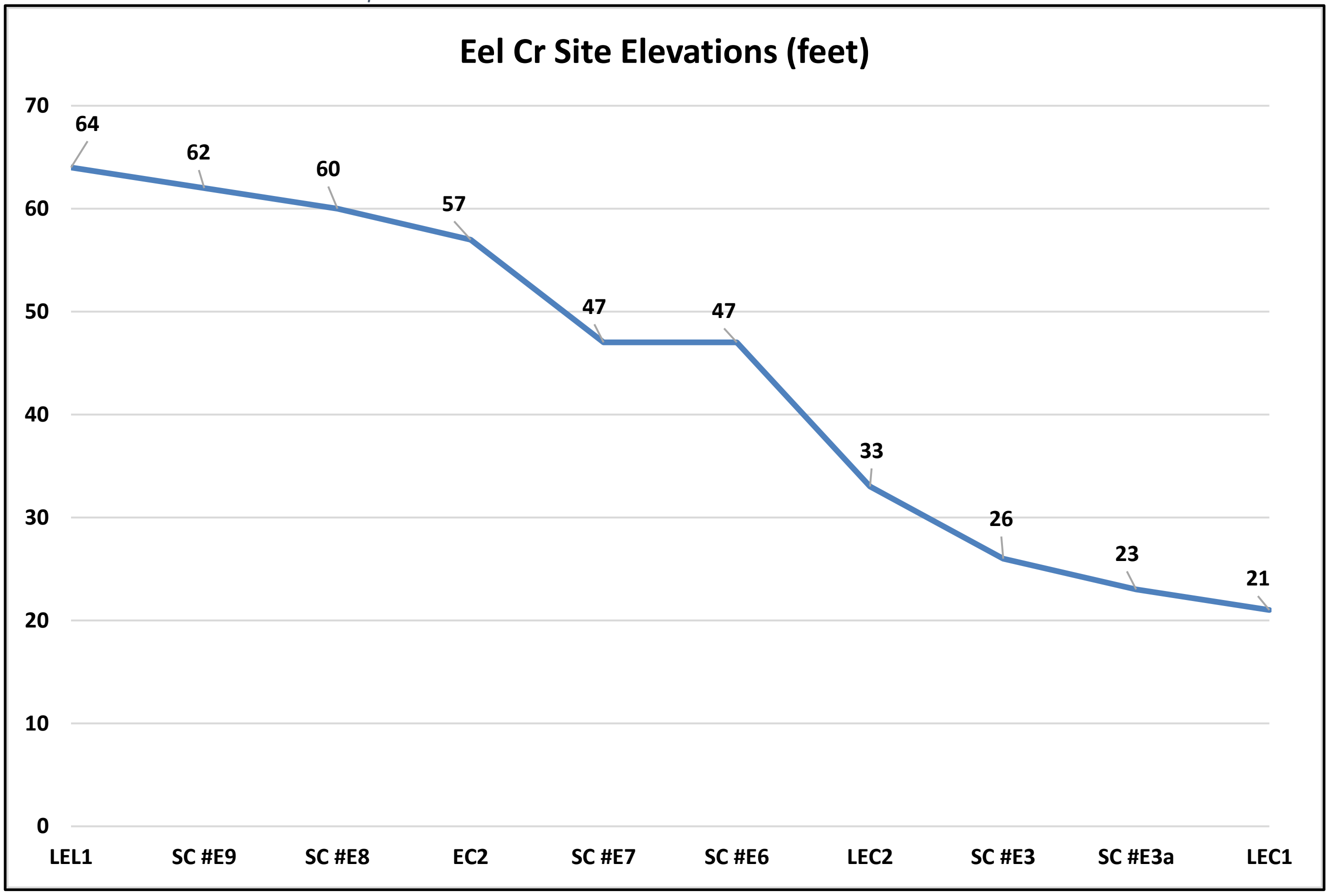


Chart 2- Eel Creek Site Elevation Profile



Eel Lake Basin 2017 larvae surveys were conducted at various locations on 8/15, 8/16, 8/22, 8/25, and 9/25. Data is shown in the table below. Eel Creek data showed Pacific Lamprey larvae were found at all sites in Eel Creek, but no Western Brook ammocoetes were identified. There were unidentified larvae at each of the 4 Eel Creek sites, so Western Brook larvae could be amongst those unknown specimens, but of those "unknowns" chosen for genetic testing all were identified as *Entosphenus tridentatus* (Pacific Lamprey). Genetic test results also validated our visual larvae idetifications with 100% accuracy. See genetic test results below. Larvae totals LEC1-LEC4 are 14, 14, 13, and 9 respectively.

Table 4- Lamprey Larvae Sampling Data from Eel Lake Basin (continued on next page)

Site	Date	Water temperature (°C)	Site Description	Number of Pacific Lamprey	Number of Western Brook Lamprey	Number of Unidentified Lamprey	Eel Cr Totals including UNKN in Pacific Totals	Area shocked (M^2)	Total Shocking Time (seconds)
LEC1	8/15/2017	14.4	Eel Cr - Across from Cemetary	11	0	3	14	32.6	898
LEC2	8/15/2017	14.4	Eel Cr - Below Campround Bridge SC #5	4	0	4	8	51	1014
LEC3	9/25/2017	ukn	Eel Cr - Above SC #E6 Hwy 101 Culvert and ~50ft below SC #E7	4	0	9	13	27.1	2210
LEC4	9/25/2017	17.2	Eel Cr- Just south of Sea Drift RV Park. Acessed through empty lot next to Space E15. Then ~150ft downstream.	6	0	3	9	33.5	1712
LEL1	8/15/2017	23.3	Eel Lake Swimming area just above trap	0	0	0		14	480
LCC1	8/15/2017	20.0	Clear Cr - Across from main Tugman parking area	0	0	0		25	449
LCC2	8/25/2017	18.3	Clear Cr - West side of Hwy 101, approximately 0.18 miles from junction of Hwy 101 and Wildwood Dr on East side of road	0	0	0		50.4	178
LWC1	8/16/2017	14.4	Confluence of Main Winter Cr Arm and North Fork	0	8	4		30	1542
LWC2	8/16/2017	13.3	Half mile upstream from Site LWC1	0	4	0		23.6	601

Site	Pacific Lamprey CPUE (Lamprey/(M2* Sec))	Unknown CPUE (Lamprey/(M2* Sec))	Pacific Lamprey including unknown CPUE (Lamprey/(M2* Sec))	Western Brook Lamprey CPUE (Lamprey/(M2* Sec))	Average size (mm)
LEC1	375.7	102.5	478.2	0.0	72.8
LEC2	77.3	77.3	154.7	0.0	59.6
LEC3	66.8	150.3	217.1	0.0	44.1
LEC4	104.6	52.3	156.9	0.0	66.3
LEL1	0.0	0.0	0.0	0.0	N/A
LCC1	0.0	0.0	0.0	0.0	N/A
LCC2	0.0	0.0	0.0	0.0	N/A
LWC1	0.0	86.5	0.0	172.9	58.3
LWC2	0.0	0.0	0.0	282.0	58.8

*See comments on page 30 about CPUE interpretation

Chart 3- Lamprey Larvae Counts - Eel Lake Basin

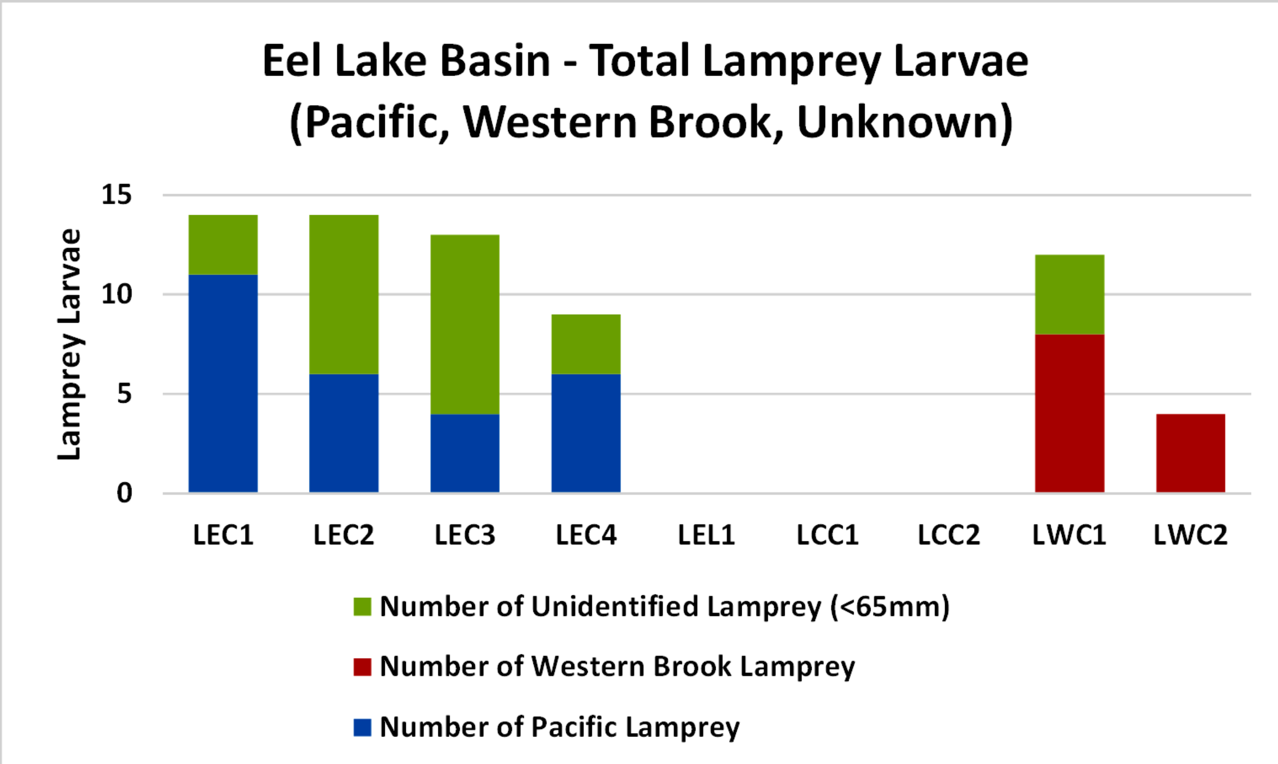
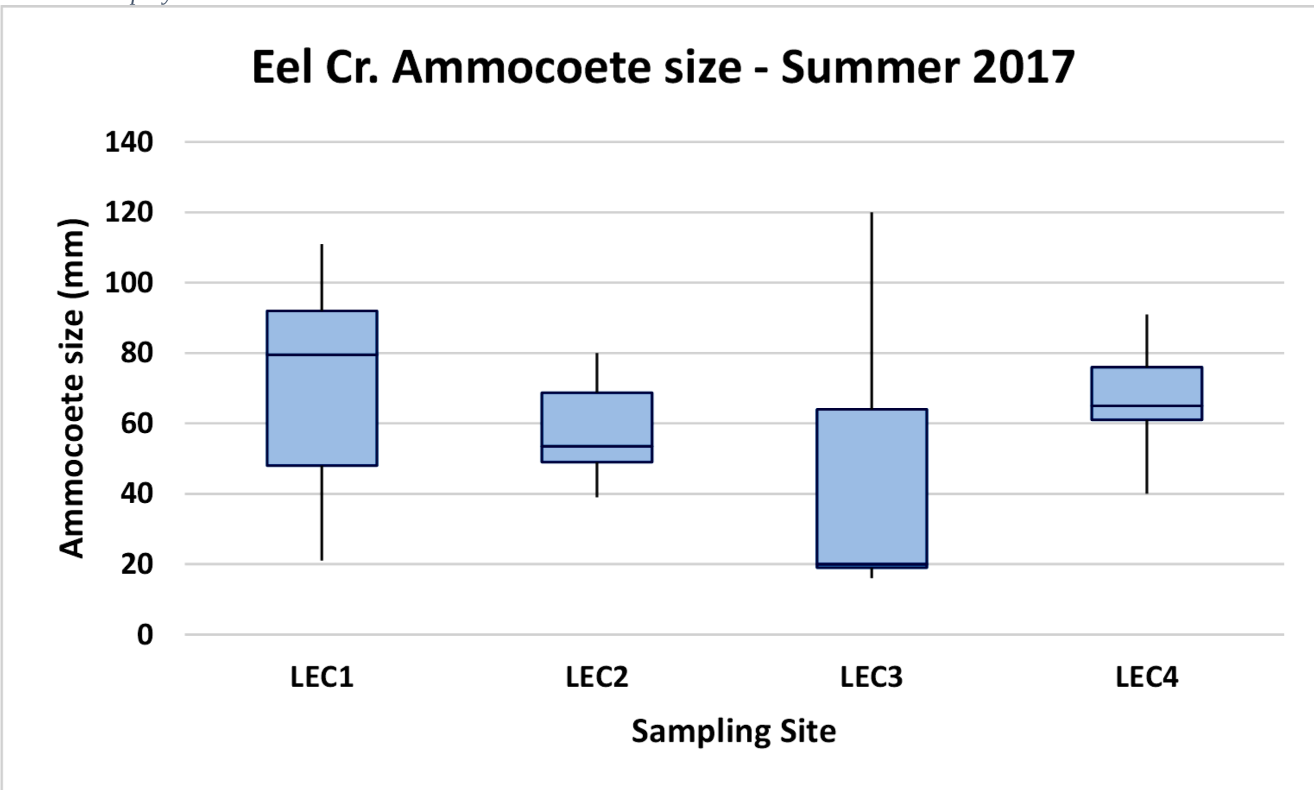


Table 5- Genetic ID Results - Entire Tenmile Watershed

Location	Site ID	Date	Length (mm)	Field ID	Genetic ID	Confirmation
Big Cr at Bridge	LBC1	8/25/2017	43	Unkn	BL	
Big Cr	LBC2	8/25/2017	98	PL	PL	Yes
Eel Cr Cemetary	LEC1	8/15/2017	63	Unkn	PL	
Eel Cr Cemetary	LEC1	8/15/2017	43	Unkn	PL	
Eel Cr Campground Bridge	LEC2	8/15/2017	68	PL?	PL	yes
Eel Cr below Campbell Br	LEC3	9/25/2017	120	PL-Eyed	PL	yes
SeaDrift	LEC4	9/25/2017	91	PL	PL	yes
Johnson Mouth	LJC0	9/25/2017	75	BL	BL	yes
Johnson Cr	LJC1	8/22/2017	87	PL	PL	yes
Winter Arm Cr #1	LWC1	8/16/2017	81	BL	BL	yes
Winter Arm Cr #1	LWC1	8/16/2017	44	Unkn	BL	
Winter Arm Cr #2	LWC2	8/16/2017	74	BL	BL	yes
Winter Arm Cr #2	LWC2	8/16/2017	41	Unkn	BL	
			BL= Brook Lamprey PL=Pacific Lamprey			

Lamprey larvae sizes at LEC1 ranged from 21mm to an eyed-Pacific Lamprey juvenile at 111mm, with an average of 72.8mm, and a median of 79.5mm. The Box and Whisker plot below shows the size distribution throughout Eel Creek. Note that this is the size chart of all lamprey larvae in the sampling area and includes those too small to identify. At these 4 sites, the only lamprey that were identified were Pacific Lamprey (including the results from the genetic tests on several "unknown" specimens), so it is likely that these are all Pacific Lamprey larvae.

Chart 4- Lamprey Larvae Size Box Plot - Eel Creek Sites



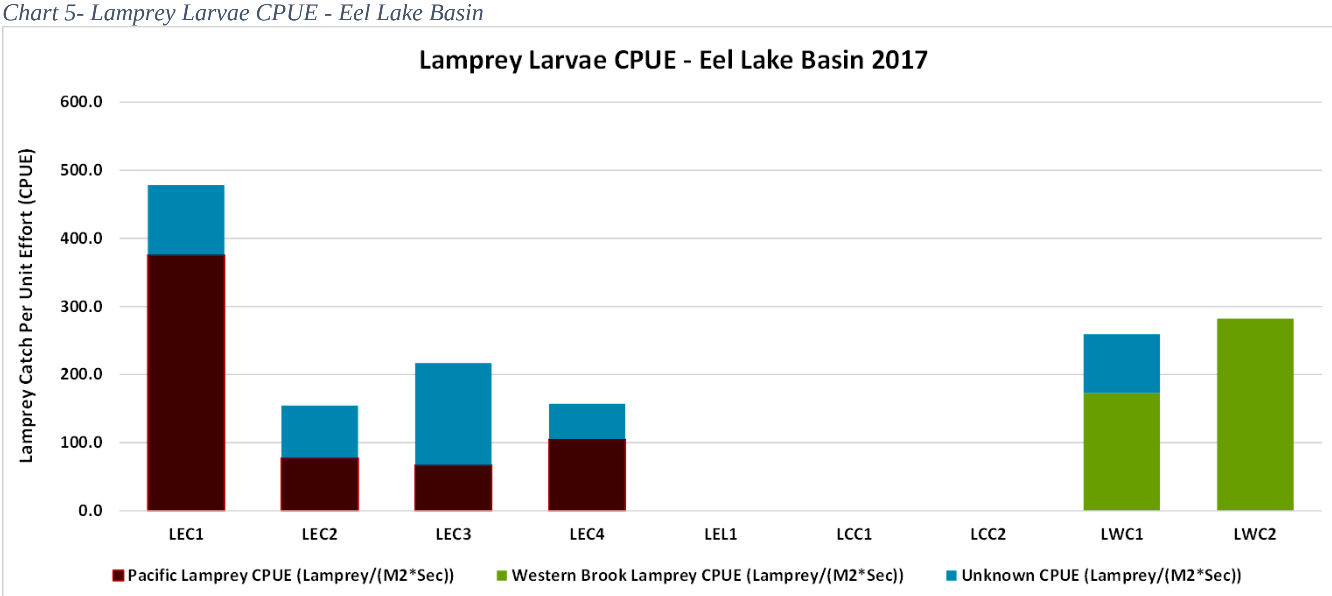
The median larvae size for LEC1 is skewed upward, indicating that the upper 50% are concentrated between 80mm–111mm, whereas the bottom 50% are spread out over a larger range (21mm – 80mm). LEC3 is skewed in the opposite direction with the bottom 50% all between 16mm-21mm, whereas the top 50% is spread out between 21mm-120mm). A similar trend is shown in LEC2 and LEC4, but they both appear to be more concentrated in the middle sizes.

Although not enough sampling sites or replicate data to do a valid trend analysis, the concentration of larger larvae at the downstream sites and smaller larvae upstream is consistent with what we might expect as ammocoetes drift downstream over the estimated 5-9+ years of rearing. The high concentration of small ammocoetes at LEC3 might indicate a close proximity to a spawning area. There is a bridge 50-100ft above LEC3, so the rip-rap and rock near the bridge may indicate a spawning site.

Catch per Unit Effort (CPUE) is shown in the chart below. CPUE is an attempt to calculate relative abundance from one site to another. Although the number of lamprey caught at each of the 4 sites is similar, there is wide variation in the amount of time spent shocking and the area covered. CPUE tries to take those variations into account by calculating the number of lamprey per square meter * shocking time in seconds: (CPUE=(#larvae/(M^2*Seconds)*1,000,000)). The result is multiplied by one million just to make the numbers more readable. Because shocking efforts varied across habitats, based on the subjective effort of finding and capturing what was thought to be a sufficient number of larvae (including shocking times and areas shocked), we now question whether our method for using CPUE has limited use for comparing relative abundance. A more rigorous approach might be to decide beforehand the exact time and area of survey effort to be uniformly applied across all habitats. The CPUE chart is included but should be interpreted with caution. Reliance on the raw data including the number of lamprey, area, shocking time, and number of netters might be more useful for future analysis.

The data collected in our monitoring effort might best be looked at in broader terms of general distribution patterns, presence/absence within a given basin, and as baseline data to compare populations over time as habitat and passage improvements are implemented.

Chart 5- Lamprey Larvae CPUE - Eel Lake Basin



We sampled LEC3 twice. The first shocking event only reveled 1 unidentified larvae after 682 seconds of shocking time. Because it was important to know if Pacific Lamprey had the ability to go above the Hwy 101 culvert located below this site (SC#E6), another shocking event was scheduled about 1 month later, and site LEC4 was added, which is located another ~600ft upstream. This second sampling event covered more area at LEC3 and time was increased to 2210 seconds (almost 37 minutes - which was 7 minutes over our stated maximum time). This shocking event produced a total of 13 larvae, 4 of which were identified as Pacific Lamprey, including a 120mm eyed juvenile. Pacific Lamprey larvae were also collected at LEC4, thus confirming at least partial Pacific Lamprey passage past SC#E6.

To determine if Pacific Lamprey are able to pass Eel Lake Trap, we surveyed at LEL1 on the shore of Eel Lake. No lamprey were found in this area. We also sampled Clear Creek both above and below Hwy 101 culvert. Again, no lamprey were found. Clear Creek goes dry on low-water years, so this may not provide stabile rearing habitat.

As described above, Winters Arm Creek is at the northern tip of the eastern arm of Eel Lake. It is known by ODFW as a spawning ground for both Steelhead and Coho salmon. Sampling results from the 2 sites LWC1 and LWC2 showed the presence of Western Brook Lamprey, but no Pacific Lamprey were identified, either visually or from the unknowns that were genetically sampled.

Eel Lake Basin Summary

Our original monitoring questions were:

1. Are Pacific Lamprey present in Eel Creek/Eel Lake?
   Our lamprey larvae surveys confirm that Pacific Lamprey larvae are present throughout the Eel Creek system. In addition, the dewatering of the Hwy 101 culvert (SC#E3) also confirms that adult Pacific Lamprey are actively using the stream. It also indicated that no Western Brook Lamprey are present in Eel Creek. They were found in almost every other stream throughout the entire Tenmile watershed. Future

efforts to understand this anomaly might shed light on habitat preferences, competition between species, water quality preferences, or other factors that might indicate habitat or spawning differences between the two species. It is also possible that we simply didn't find them during this survey but will in the future. No Pacific Lamprey were identified above the Eel Lake Trap. No lamprey were seen of either species in Eel Lake or Clear Creek. Western Brook Lamprey were shown to inhabit Winters Arm Creek, but no Pacific Lamprey were found. This indicates that a) The Trap is a total passage barrier to Pacific Lamprey, b) Pacific Lamprey prefer the Eel Creek habitat and don't chose to spawn in the Eel Lake tributaries, or c) The lake itself is acting as a barrier to migration. Since Pacific Lamprey are able to navigate through Tenmile Lakes, and are thus found in those tributaries, this might indicate that the Trap is the mitigating factor in this system.

2. What is the period of spawning migration for Pacific Lamprey?

   There is currently not enough information to make an accurate assessment. The adult Pacific Lamprey found at the Hwy 101 culvert were salvaged on 8/12/2017. Assessing their sexual maturity by using the inter-dorsal fin gap, indicates that they are sexually immature and thus likely to have migrated in during the current season, but this method of sexual determination is not fully reliable.

   In addition, spawning surveys from the Tenmile Lakes basin in 2006, 2007, 2012, and 2013, show Pacific Lamprey redds appearing as early as March 5th, with most recorded in April and May (surveys end in May so it is unclear if more would have been recorded if the surveys had continued.) In the Columbia system Pacific Lamprey migrations appear to be later (July – Nov), while Willamette River basin is April through September. Migration into the Tenmile Watershed might coincide closer to this latter time frame, but more information is needed. In these very small coastal watersheds, where distance from ocean to spawning habitat is only 10 miles, migration, holdover, and spawning behaviors may vary from the larger systems. Phase 2 of this project will capture adult Pacific Lamprey, tag and track them over the course of a year. This will allow us to gather more baseline information such as migration timing and patterns, holdover areas, and spawning habitat.

3. What is the number, age, and size of Pacific Lamprey entering Eel Lake?

   The Eel Lake Trap appears to be a complete barrier to the passage of Pacific Lamprey into Eel Lake. We found no evidence that Pacific Lamprey enter Eel Lake or inhabit any areas within the upper basin. The proposed installation of a lamprey ramp at Eel Lake Trap in the summer of 2018 may open up this habitat for the first time in over 30 years. Phase 2 of this project will evaluate the effectiveness of the ramp and track lamprey migration through Eel Lake and its tributaries.

4. Is there suitable habitat within the Eel Lake subbasin?

   The data shows that Pacific Lamprey larvae are finding suitable rearing habitat throughout the Eel Creek system. The dunal stream; comprised of sand, detritus, and organic matter; may be nearly perfect Type 1 rearing habitat. The water quality also appears to be high, with low temperatures and medium-high dissolved oxygen content. Eel Lake and ground water provide a consistent water flow throughout the summer months, even in dry years. The high water temperatures flowing in from Eel Lake; large amounts of invasive macrophyte, *Egeria densa;* and the hard-clay streambed substrate may affect rearing areas very close to the Trap, but the majority of the stream appears to be ideal larvae habitat.

   The existence of larvae in Eel Creek implies that adults are finding acceptable holdover areas (if they do holdover) and suitable spawning habitat somewhere within the stream. From our observations, it is unclear where the spawning habitat is in Eel Creek, but phase 2 of this project will help us to identify that habitat through radio telemetry tracking. Both holdover regions and spawning habitat may be occurring in the rip-rap areas around stream crossing, but if historic accounts of large Pacific Lamprey runs are true, the lamprey must either have adapted to the Eel Creek substrate for their spawning needs, or spawned in the tributaries above Eel Creek that are still used by Coho and Steelhead and presumably suited to Pacific Lamprey use as well. Clear Creek is known to dry up on very low water years, so it may act as spawning habitat, but be limited for rearing.

Tenmile Lakes Basin

Phase 3 of this monitoring project involves expanding the distribution surveys for Pacific Lamprey into the other basins of the Tenmile Lakes Watershed. To allow for better planning in this future monitoring effort, we sampled 3 tributaries of Tenmile Lakes as described in the site selection area above.

Big Creek was sampled at LBC1 and LBC2. All larvae were identified as Western Brook Lamprey at LBC1, but 2 Pacific Lamprey were found at LBC2. One was sent to the ODFW genetics lab for testing and was confirmed to be a Pacific Lamprey. LBC2 also had a relatively large number of Western Brook Lamprey. LBC1 did seem to have larger sizes as shown in the box and whisker plot. We caught more larvae at LBC2, but the time and area were larger, so the CPUE was higher at LBC1.

Shutter Creek on South Tenmile Lake did not show any Pacific Lamprey, but we did find a relatively small number of Western Brook Lamprey (3). The sizes were relatively small with 5 of 8 being labeled as unknown. We only sampled a small area next to the road, so the CPUE was higher due to our small sampling area and time. As stated above, use these CPUE figures with caution.

Johnson Creek had Pacific lamprey larvae present at LJC0 and LJC1. None were identified at the upstream site, LJC2, but as the charts above show, the sizes were relatively small at that site, and the majority were classified as Unknown. It was apparent that the sizes were considerably larger at the lower stream site, especially LJC0 where most were in the 90-110mm range.

LJC0 is at the mouth of Johnson Creek as it enters South Tenmile Lake in Templeton Arm. For Pacific Lamprey larvae, this was one of the most abundant sites. Many were found along the edge of the creek, between the weedline and the bank. We adapted our sampling technique to deploy the netters in the weeds and capture the larvae as they dove for the weedline after emerging from the sediment.

LTA was a quick sampling done on the bank of the lake, and no lamprey were found. We are interested in how Pacific Lamprey are utilizing the lakes within the watershed, and coastal lakes in general. As noted in the site selection section above, this area was rockier than other sampling sites. We shocked for only a couple of minutes. The wave action from boats, probably made this site less than ideal larvae habitat. More lake sampling will be proposed in Phase 3, including sampling on the bottom of the lake where sediment habitat might be more favorable.

Table 6- Lamprey Larvae Sampling Data from Tenmile Lakes Basin

Site	Date	Water temperature (°C)	Site Description	Number of Pacific Lamprey	Number of Western Brook Lamprey	Number of Unidentified Lamprey	Area shocked (m^2)	Total Shocking Time (seconds)
LSC1	8/22/2017	16.7	Shutter Creek at the Bridge near Coots Rd turn off	0	3	5	8.8	446
LJC0	9/25/2017	17.8	NE bank of Johnson Cr as it enters Tenmile Lake on sand bar	14	4	0	12.4	688
LJC1	8/22/2017	19.4	Johnson Cr below Fritz Field bridge	1	1	0	23.3	785
LJC2	8/22/2017	20.6	Johnson Cr bridge below Hatchery Cr confluence	0	6	22	46.8	1200
LBC1	8/25/2017	15.6	Big Cr both sides of County Bridge at river mile 1.72	0	13	4	14	783
LBC2	8/25/2017	17.2	0.3 miles upstream from corral fence. South side of field. 1.25 miles from LBC1	2	15	8	40	1200
LTA	9/25/2017	20.6	Templeton Arm of S Tenmile Lake. SW side of arm near point	0	0	0	5.94	139

Site	Total Shocking Time (seconds)	Pacific Lamprey CPUE (Lamprey/(M^2*Sec))	Western Brook Lamprey CPUE (Lamprey/(M^2*Sec))	Unknown Lamprey CPUE (Lamprey/(M^2*Sec))	Average size (mm)
LSC1	446	0.0	764.4	1274.0	40.6
LJC0	688	1641.0	468.9	0.0	99.2
LJC1	785	54.7	54.7	0.0	98.0
LJC2	1200	0.0	106.8	391.7	44.6
LBC1	783	0.0	1185.9	364.9	80.1
LBC2	1200	41.7	312.5	166.7	66.4
LTA	139	0.0	0.0	0.0	N/A

Chart 6- Lamprey Larvae Counts - Tenmile Basin

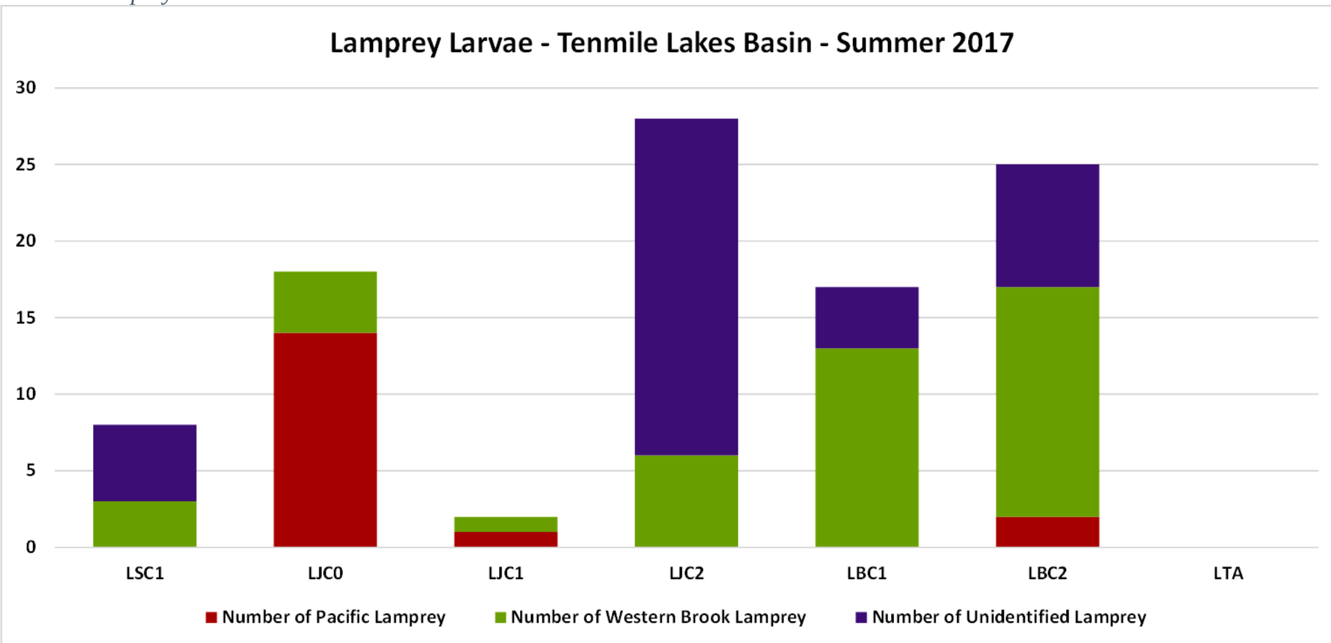


Chart 7- Lamprey Larvae Size Box Plot - Tenmile Basin

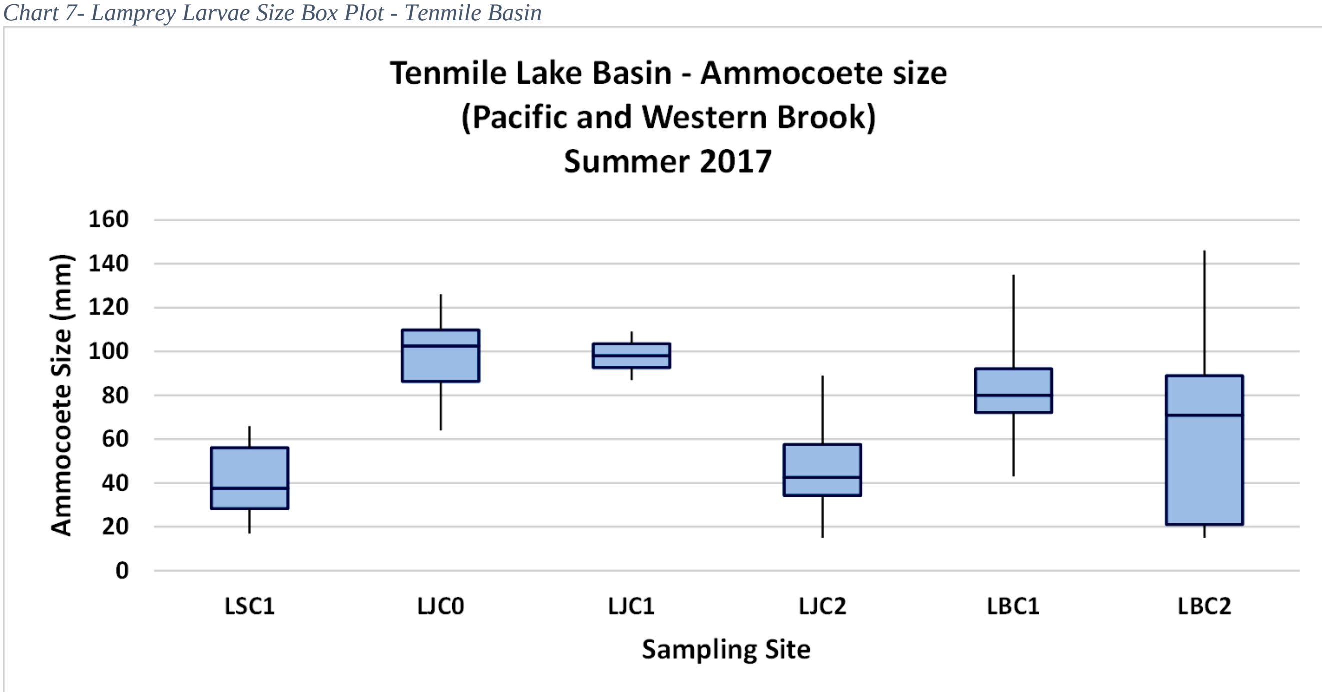
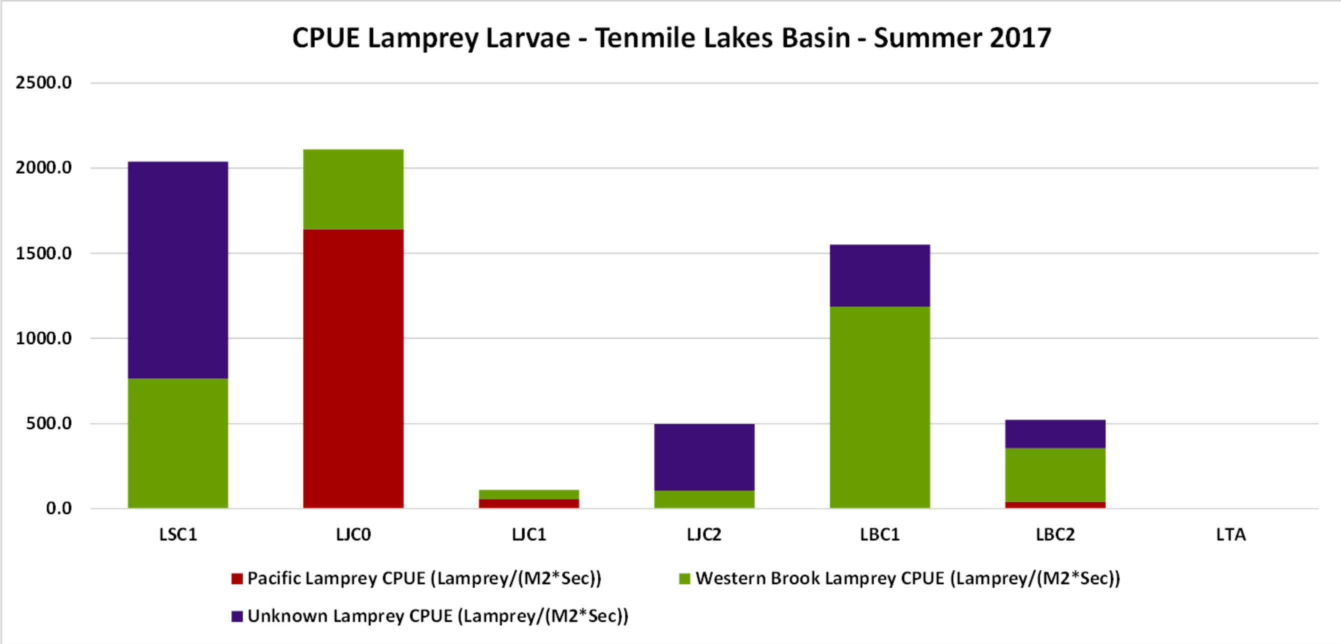


Chart 8- Lamprey Larvae CPUE - Tenmile Basin



Tenmile Lakes Basin Summary

Although not a comprehensive sampling of the relatively large basin, it was enough to confirm the presence of Pacific Lamprey within the two largest tributaries, one on each lake. The apparent abundance at the Johnson Creek mouth sampling site (LJC0), show that Pacific Lamprey larvae might use the areas adjacent to the lake for rearing purposes, and that sampling at the mouth of the tributaries might be a productive strategy for determining presence/absence within the stream subbasins.

Western Brook Lamprey were present at all sites within the basin and seemed to be more prevalent than Pacific Lamprey in the higher reaches.

These findings support the ODFW spawning surveys that found lamprey redds from both Pacific and Western Brook lamprey in Johnson Creek. Pacific Lamprey redds were also found in Benson Creek which was not sampled for this effort.

Phase 2 of this lamprey monitoring project, scheduled to start in June of 2018, will include radio telemetry of Pacific Lamprey tagged in Eel Creek. The results of this data may also affect the timing of Phase 3 and lead to a more focused monitoring of lamprey movements or habitats that are not yet known, and an expansion of radio tagging efforts to other areas of the watershed. We are also working in concert with the ODFW State Lamprey Coordinator to help answer questions on a broader scale, especially with Pacific Lamprey populations of the Oregon Coastal region. This can include more information on genetics of the lamprey in this area, habitats that are unique to this region such as coastal lakes and dunal systems (as compared to the more studied Columbia system) and determining appropriate sampling protocols to expand the monitoring of lamprey in this region.

Phase 3 of this monitoring project proposes to expand distribution and habitat surveys to all major tributaries of both Tenmile Lakes including spawning surveys in Johnson and Big Creeks, evaluate passage barriers on the streams, determine possible effects of agricultural land use on lamprey habitat, and sample lake bottom sediments and baseline field parameters, such as dissolved oxygen and temperature, to determine habitat suitability for rearing larvae. Predation, both avian and fish, might also be an important component to evaluate.

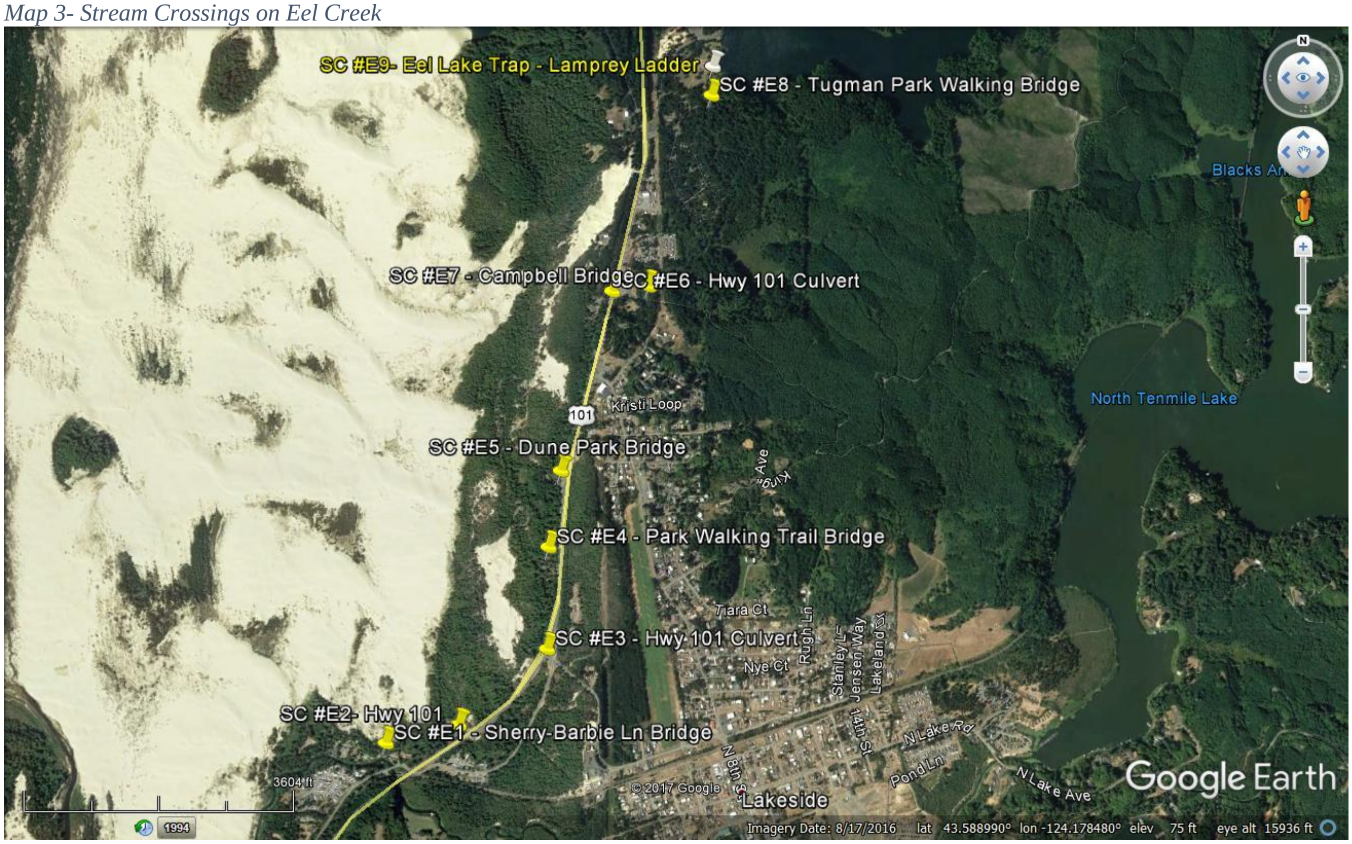
Surveys of other lakes and streams within the watershed would also be important to a full understanding of the lamprey distribution and habitat use. This could extend the scope of phase 3 or lead to an additional phase.

Future monitoring should also include evaluation of de-watering sites in larvae rearing areas which can strand larvae, killing those that cannot find their way back to appropriate habitat. This can occur in agricultural areas when irrigation canals are drained or channels are ditched to remove excess sediment. It can also occur in reservoirs where water levels can change quickly and dramatically and even during stream restoration efforts. Larvae salvage operations during these events could be useful in saving multiple generations of ammocoetes.

Passage Barriers to Pacific Lamprey on Eel Creek

Anthropogenic passage barriers were surveyed from the mouth of Eel Creek to its source at the outflow of Eel Lake. Stream crossings were labeled starting with SC #E1 and ending at the Eel Lake Trap (labeled SC #E9). The map below shows all 9 crossings.

Map 3- Stream Crossings on Eel Creek



The goals for our barrier monitoring efforts were to identify all stream crossings, and visually assess each crossing as a potential barrier or clear passage.

The nine stream crossings included 5 bridges, and 3 concrete box culverts under Hwy 101, and the Eel Lake concrete weir and trap. Each stream crossing was visually evaluated and photographed. The site index and barrier evaluation are listed in the table below.

Because stream barrier assessment criteria for Pacific Lamprey are still being developed, it is currently difficult to definitively state whether a particular barrier is a total or partial barrier. In the table below, we use the term *Possible* and *Probable* for our visual evaluations. Since subsequent monitoring for Pacific Lamprey larvae determined that larvae are found above all culverts, it must be concluded that none of the barriers, except the Eel Lake Trap, are total passage barriers. They could, however, be partial barriers, limiting the number of Pacific Lamprey that are able to successfully pass and reach spawning grounds.

An informative review of passage barrier criteria can be found in *Evaluation of Barriers to Pacific Lamprey Migration in the Eel River Basin,* (Stillwater Sciences 2014). They looked at 4 criteria:

- Swimming performance in relation to water depth and velocity
- Ability to attach to or climb different types of substrates and structures of various types, sizes, and shapes
- Leaping ability in relation to crossing structures
- Potential effects of migration timing, fish size and maturation stage, and water temperature on swimming ability and passage success.

This study also estimated that most migration occurs between January and July. This would suggest that lamprey may have a variety of depths and flow conditions, so some barriers may be passible during some periods but not others, seasonal barriers.

Photos and summary information from each site are shown below. The original data forms are included with this report.

Table 7-Eel Cr Stream Crossing Site Index

Site No.	Lat/Long	Rd. Name	Ownership	Owner	Crossing Type	Lamprey Barrier
SC#E1	**43.577014 -124.193496**	**Sherry Barbie Ln**	**Private**	**Unknown**	**Railcar Bridge**	**No**
SC#E2	**43.577691 -124.189779**	**Hwy 101**	**Public**	**ODOT**	**Concrete Culvert**	**Possible**
SC#E3	**43.580470 -124.185292**	**Hwy 101**	**Public**	**ODOT**	**Concrete baffle Culvert**	**Probable changed to No after enhancements**
SC#E4	**43.584239 -124.185243**	**Park Walking Trail**	**Public**	**USFS**	**Wooden Walking Bridge**	**No**
SC#E5	**43.587076 -124.184633**	**Park Entrance Rd**	**Public**	**USFS**	**Bridge**	**No**
SC#E6	**43.593817 -124.182013**	**Hwy 101**	**Public**	**ODOT**	**Concrete baffle Culvert**	**Probable**
SC#E7	**43.594012 -124.180119**	**Private Dr.**	**Private**	**Campbell**	**Bridge**	**No**
SC#E8	**43.601276 -124.176860**	**Park Walking Trail**	**Public**	**OSP**	**Wooden walking Bridge**	**No**
SC#E9	**43.602398 -124.176783**	**Eel Lake Trap**	**Public**	**ODFW**	**Concrete weir**	**Yes**

SC #E1

Located just above the confluence of Eel Creek and Tenmile Creek. It is privately owned. As with all the bridges surveyed, there is no barrier to fish or lamprey passage.

Photo 20- SC#E1-Bridge deck

Photo 21- SC#E1-Under bridge

SC #E2

SC #E2 is a 13ft X 8ft X 80ft concrete box culvert under Hwy 101. It is divided in half vertically, flat bottomed with no flow baffles on either side. There are large rocks at the outflow that may provide good habitat for adult lamprey to hide and good attachment points for culvert approach.

At low flows (August) there is ~ 2 inches of water flowing through the culvert, with a ~6 inch perch from the bottom slab of the culvert to the water surface level of the pool. Pacific Lamprey have a difficult time negotiating 90 degree angles, so this is likely to be at least a partial barrier in the summer or other low-water times. The lack of baffles may allow unobstructed Pacific Lamprey in-migration passage through the culvert, but conversely, winter high velocity flows could have a negative impact due to the lack of baffles. It seems likely that if high flows make it difficult to traverse the culvert, then lamprey could wait for flows that are less intense, but still high enough to allow passage over the lip of the culvert.

Future monitoring efforts could collect data on flow rates within the culvert to determine the need for lamprey friendly baffles, and work with ODOT to make appropriate modifications to the downstream lip of the culvert to ensure Pacific Lamprey passage. Consideration to available attachment points upstream from the culverts could also ensure that the transition from culvert to streambed is completed successfully after egress.

Photo 22- SC #E2 Inlet

Photo 23- SC #E2 Outlet – Summer flow

Photo 24- SC #E2 Outlet – Winter flow (2-26-2018)

SC #E3

SC#E3 is a 16ft wide X 6ft tall X 80ft long, vertically divided, concrete box culvert under Hwy101 near the south entrance to Lakeside. It was modified originally with interior baffles to slow water flow for salmonid passage. The baffles consist of concrete barriers that extend across the entire width of the culvert on the north side. These baffles appeared to work well to allow salmon migration through the culvert during high water, but the 90 degree angles they created were likely at least a partial barrier to Pacific Lamprey. They also created a large perched waterfall on the north side, as can be seen in the outlet photos below.

In August of 2017, ODOT implemented a passage barrier enhancement project that modified the culvert baffles by notching them in the middle, then pouring a concrete ramp for the lamprey to use. In addition, the jump pool and roughen chute below the outlet was modified to raise the height of the pool level above the lip of the culvert. (See photos below).

During the dewatering process of the jump pool, over 200 adult Pacific Lamprey were salvaged from the large rocks at the base of the pool and moved downstream. As noted above, this was the first real confirmation that adult Pacific Lamprey were using Eel Creek. It is unknown if the lamprey were using the rocks because they couldn't get past the culvert, or if they found the large rip-rap in this area a convenient hiding place and were using it as a holdover area.

After completion of the ODOT enhancement project, this culvert is likely to no longer be a passage barrier. No flow measurements have been taken, so future monitoring could verify that the 2.7m/s estimated flow limited is not exceeded. In addition, the Phase 2 radio telemetry data should give us information on how Pacific Lamprey are using the rocks and culvert, and if it appears to still be a migration barrier.

Photo 25- SC #E3 –Inlet with ODOT's temporary flow restrictor. 8-8-2017

Photo 26- SC #E3 –Outlet with large perch on right side – Before modification 8-8-2017

Photo 27- SC #E3 – Hwy 101 culvert before modification. 8-8-2017

Photo 28- SC#E3 – ODOT salvaging over 200 Pacific Lamprey. 8-10-2017

Photo 29- SC #E3 – ODOT modifying baffles for lamprey passage. Water diversion pipe on left. 8-11-2017

Photo 30- SC#E3 – Outlet baffle modified to allow lamprey passage. 8-15-2017

Photo 31- SC#E3 – Concrete ramps poured for lamprey passage on interior baffles. 8-15-2017

Photo 32- SC #E3 – ODOT project completed. 8-24-2017. Jump pool surface level above culvert lip

Photo 33- SC#E3 – Modified roughened chute below culvert jump pool. 10-11-2017

SC #E4

This walking bridge is located in the John Dellenback Dunes Trailhead, just off Hwy 101. It poses no passage barrier issues.

Photo 34- SC #E4 – Walking Bridge

SC #E5

This vehicle bridge is located at the entrance of Eel Creek Campground, just off Hwy 101, and near larvae sampling site LEC2. There is no stream impediment caused by the bridge. It is not a passage barrier.

Photo 35- SC #E5 – Bridge at Eel Creek Campground Entrance

SC #E6

SC #E6 is a concrete box culvert under Hwy 101 near Tree Acres store. It measures 12ft wide X 8ft tall X 80ft long and is divided in half by a vertical wall. The south side is blocked during low flow forcing flow to the north. The north side has interior baffles that extend the width of the culvert but are notched lower for about two feet on alternating sides. These baffles are likely a partial lamprey barrier, although they may be able to use the culvert walls to navigate around them. The floor is relatively smooth concrete which should act well for Pacific Lamprey attachment. The outlet is perched above the jump pool by 12 – 18 inches at low water and is slightly undercut below the lip of the culvert. This is also a likely partial lamprey passage barrier especially at low water levels. ODFW and TLBP have both informed ODOT of these potential passage issues.

Photo 36- SC #E6 – Inlet showing small baffle on north side. Shown with August water level

Photo 37- SC#E6 – Interior baffle

Photo 38- SC#E6 – Perched Outlet 9-14-2017

SC #E7

SC #E7 is a small, private, vehicle bridge over Eel Creek. It poses no passage barrier issues to lamprey.

Photo 39- SC#E7 – Private Bridge

Photo 40- SC#E7 – Under bridge

SC #E8

SC#E8 is a foot bridge located within Tugman State Park. It is not a lamprey passage barrier.

Photo 41- SC#E8 – Foot bridge in Tugman State Park

SC #E9

Stream crossing SC#E9 is the Eel Lake Trap and weir. It was installed in 1989 and only 1 Pacific Lamprey has ever been recorded in the Trap. As mentioned above, it was found in 2017 after the Hwy101 culvert at SC#E3 was modified. The square corners of the weir, fish trap and ladder likely make this a total passage barrier to Pacific Lamprey. ODFW, CTCLUSI and TLBP have worked together to propose and design a lamprey ramp that is scheduled to be installed in the summer of 2018. Phase 2 of this project will monitor the effectiveness of this passage enhancement.

Photo 42- SC #E9- Eel Lake Trap and weir - summer low water

Photo 43- SC#E9 – Winter water level. Future lamprey ramp location

Photo 44- Entrance to fish trap. Note 90-degree corners on all ladder steps

Photo 45- Trap and weir at SCE#9

Photo 46- Eel Lake Weir 12-20-2017

Eel Creek Passage Barrier Summary

The following table summarizes the passage barrier issues identified on Eel Creek and the proposed enhancements.

Table 8- Eel Cr. Passage Barrier Evaluation Summary

Site ID	Description	Problem	Proposed Enhancement
SC#E1	Private vehicle bridge	None- unobstructed passage	None required
SC#E2	Concrete box Culvert – Hwy101	Perched culvert	Raise jump pool or modify culvert entrance. Evaluate flow velocity within culvert. Consult with ODOT
SC#E3	Concrete box Culvert – Hwy101	Perched culvert and baffles	ODOT enhancement completed. Evaluate flow velocity within culvert. Inform ODOT of continuing monitoring results
SC#E4	Walking bridge	None- unobstructed passage	None required
SC#E5	Large bridge	None- unobstructed passage	None required
SC#E6	Concrete box Culvert – Hwy101	Perched culvert and baffles	Raise jump pool or modify culvert entrance, modify baffles, and evaluate flow velocity within culvert. Consult ODOT
SC#E7	Private vehicle bridge	None- unobstructed passage	None required
SC#E8	Walking bridge	None- unobstructed passage	None required
SC#E9	Eel Lake Trap and weir	Complete barrier – designed for salmon not lamprey	Install lamprey ramp as proposed by ODFW, CTCLUSI, and TLBP. Follow up with effectiveness monitoring and modify as needed.

We still don't fully understand Pacific Lamprey migration behavior within the basin. Since they possibly spend up to 18 months in freshwater before spawning, it is unclear if they migrate quickly to the spawning ground area, then holdover, or more likely, find suitable holdover habitat then proceed to the spawning grounds later. This could imply that barriers that are passible in the winter, but not the spring, may partially block migration. Lamprey may choose to not pass a barrier because suitable holding habitat exists below the barrier, yet not be able to pass the barrier when they are ready to proceed upstream for spawning. It may, therefore, be advisable to have all barriers passable at all times of the year, but especially January – July when migration movements may most likely occur.

In addition, there may be an ocean maturing life history for some Pacific Lamprey (Clemens, etal 2013) which spawn shortly after entering freshwater and, therefore, need no holding areas, but direct access to spawning grounds.

Phase 2 of this project will use radio telemetry to track adult Pacific Lamprey. This data will help to give us a better understanding of how the lamprey use Eel Creek and when they arrive at, and subsequently pass (or not pass) the known barrier locations.

It would also be informative to conduct stream flow measurements within each of the suspected barriers to determine the likelihood of culvert flow velocity being an impediment to upstream migration. Modification of the culvert entrance edges to provide a sloped entry would also be recommended, along with ensuring that suitable attachment substrate is available both below the culvert entrance and above the culvert egress to allow lamprey to stage their approach and successfully exit upstream, especially during higher flow velocities. The sandy bottom substrate of dunal creeks may make placement of strategic attachment points more critical than in other systems.

Using this information, along with the barrier evaluations from this project and the criteria listed below, it is recommended to continue working with ODOT to evaluate the culverts and implement passage enhancements as directed by the data.

The following Table from *Evaluation of Barriers to Pacific Lamprey Migration in the Eel River Basin,* (Stillwater Sciences 2014), lists critical factors that can be used to do extensive evaluations of the suspected barriers listed above, or other barriers identified in the *Tenmile Lakes Basin 30-Year Pacific Lamprey Conservation Management Plan.*

Passage barrier enhancement is a critical step in the long-term recovery process of the Tenmile Watershed Pacific Lamprey. We will continue to work with our partners to understand the life history of our local Pacific Lamprey populations and make the necessary enhancements to meet our conservation plan goals.

Table 9- Summary of Passage Barrier Factors (Stillwater Sciences 2014)

Passage criteria	Explanation/value	Source	Key uncertainties	FishXing application
Swimming performance				
Critical swimming speed (*U*crit)	At sites lacking attachment points for resting, assume PL can pass when water velocities <0.86 m/s.	Mean critical swimming speed of sexually immature adult PL at 15°C = 0.86 m/s (Mesa et al. 2003).	- Value may underestimate PL swimming performance during passage through road crossings. - Length of time (and distance) critical swimming speed can be sustained.	Applied as "Prolonged speed" parameter = 0.86 m/s.
Burst swimming speed (*U*max)	At sites with suitable attachment points for resting, assume PL can pass using burst-and-attach behavior when water velocities <2.7 m/s.	Velocities of 2.5–3.0 m/s impeded sexually immature adult PL passage through weir, despite availability of attachment points (Keefer et al. 2010).	- Time to exhaustion at burst swimming speed. - Ability to burst-and-attach on corrugated culvert surfaces.	Applied as "Burst speed" parameter (when Prolonged speed exceeded).
Time to exhaustion using burst-and-attach swimming behavior	If suitable attachment points available, assume PL can engage in burst-and-attach swimming for 20 minutes before exhaustion.	Conservative estimate.	- Time to exhaustion using burst-and-attach swimming behavior. - Factors affecting exhaustion.	Applied at sites with suitable attachment points.
Time to exhaustion at burst speed	If suitable attachment points *not* available, assume time to exhaustion at burst speed is 10 s.	Default value in FishXing model; extrapolated from studies on other fish species.	Time to exhaustion at burst swimming speed.	Applied at sites without attachment points.
Minimum water depth	Assume minimum water depth for successful passage ≥3 cm (0.1 ft).	Conservative value based on evidence that PL can ascend inclined ramps with 3cm depth (Moser et al. 2011).	- Behavioral avoidance of shallow water. - Relationship between depth and distance PL can pass. - Effects of depth on swimming speed.	Used to parameterize minimum water depth.

Attachment, leaping, and climbing capabilities				
Attachment substrate material	PL can attach to a wide range of non-porous artificial and natural materials. Damaged or rusted out bottoms may preclude attachment.	Adams and Reinhardt 2008; Reinhardt et al. 2008; Moser and Mesa 2009; Moser et al. 2011.	Variation in energetic demand between different attachment surfaces and relationship to exhaustion time.	Used to help determine which swim speed and exhaustion criteria are applied.
Attachment substrate shape and configuration	PL can attach to a wide range of substrate shapes. Discontinuities in surface (e.g., deep slots or grates) and 90° corners at baffles, weirs, or fish ladders lowing may impede or block passage.	Adams and Reinhardt 2008; Reinhardt et al. 2008; Kemp et al. 2009; Moser and Mesa 2009; Moser et al. 2011.	- Ability to attach to culvert corrugations with different shapes and configurations. - Ability to attach to and use burst-and-attach behavior on non-uniform substrate surfaces such as corrugations. - Effects of attachment shape on swimming performances.	Used to help determine which swim speed and exhaustion criteria are applied.
Attachment substrate size	- Assume PL can attach to substrates with minimum surface length and width ≥ diameter of oral disc. - Assume *all* PL can attach to corrugations with diagonal surface dimensions >4.6 cm (1.8 in) and *most* can attach to most smaller corrugation sizes by contorting their oral discs.	Based on reported oral disc diameters and common culvert corrugation sizes.	- Effects of various size culvert corrugations on attachment, burst swimming speed, and exhaustion time. - Smaller corrugation sizes may reduce velocities that can be passed using burst-and-attach swimming.	Used to determine whether burst-and-attach swimming behavior is possible and thus which exhaustion criteria is applied.
Climbing ability	PL can climb most wetted vertical or steeply sloped surfaces (assuming attachment criteria are met); however, they have difficulty passing vertical features ending in abrupt right angles.	Reinhardt et al. (2008), Kemp et al. (2009), Keefer et al. (2011), Zhu et al. (2011).	Ability to attach to and climb slightly perched culvert outlets or concrete outlet aprons with right angle steps.	Not applied, but used to assist with interpretation of results at some sites.
Leaping ability	PL cannot leap. Crossing outlets perched above downstream water surface elevation are assumed impassable at that flow.	Conservative assumption based on Moser and Mesa (2009) and professional judgment.	Ability to swim up or attach to and climb slightly perched culverts.	Used to parameterize “Max Leap Speed”.

Coho and Steelhead Data - Eel Lake Trap

Our goals and objectives for this monitoring task were to collect and analyze trend data for Coho, Steelhead, and Cutthroat Trout at the Eel Lake Trap. We will answer the following questions:

- What are the number and type of native fish species entering Eel Lake?
    - What are the number of these species entering Eel Lake since 2002?
- What are the hatchery Steelhead return rates?
    - What are the return rates of marked recycled hatchery Steelhead?
- Are any non-native fish species present in Eel Lake transiting Eel Creek?

TLBP is working with ODFW and STEP volunteers to collect trend data for Coho Salmon, Steelhead, and Sea-run Cutthroat Trout at the Eel Lake Trap. This is the same location discussed earlier for the installation of the lamprey ramp in 2018. This data is important to the ODFW for integration into its statewide Coho return rates, and for the hatchery Steelhead program on Tenmile Creek. The Trap is run once per week unless excessive number of fish are collected, then extra days are added. Gary Vonderohe is the lead ODFW biologist for this program.

TLBP staff collects the data personally, whenever possible. Two backup volunteers were trained for data collection during the 2017-2018 season. In the past, collected data was often difficult to interpret, so data gaps occurred in 2004 and 2008, and other years we were only able to interpret total run numbers, so TLBP and ODFW have made an effort to create appropriate data forms and carefully record data, including entering data into the Excel spreadsheets quickly.

What are the number and type of native fish species entering Eel Lake? What are the number of these species entering Eel Lake since 2002?

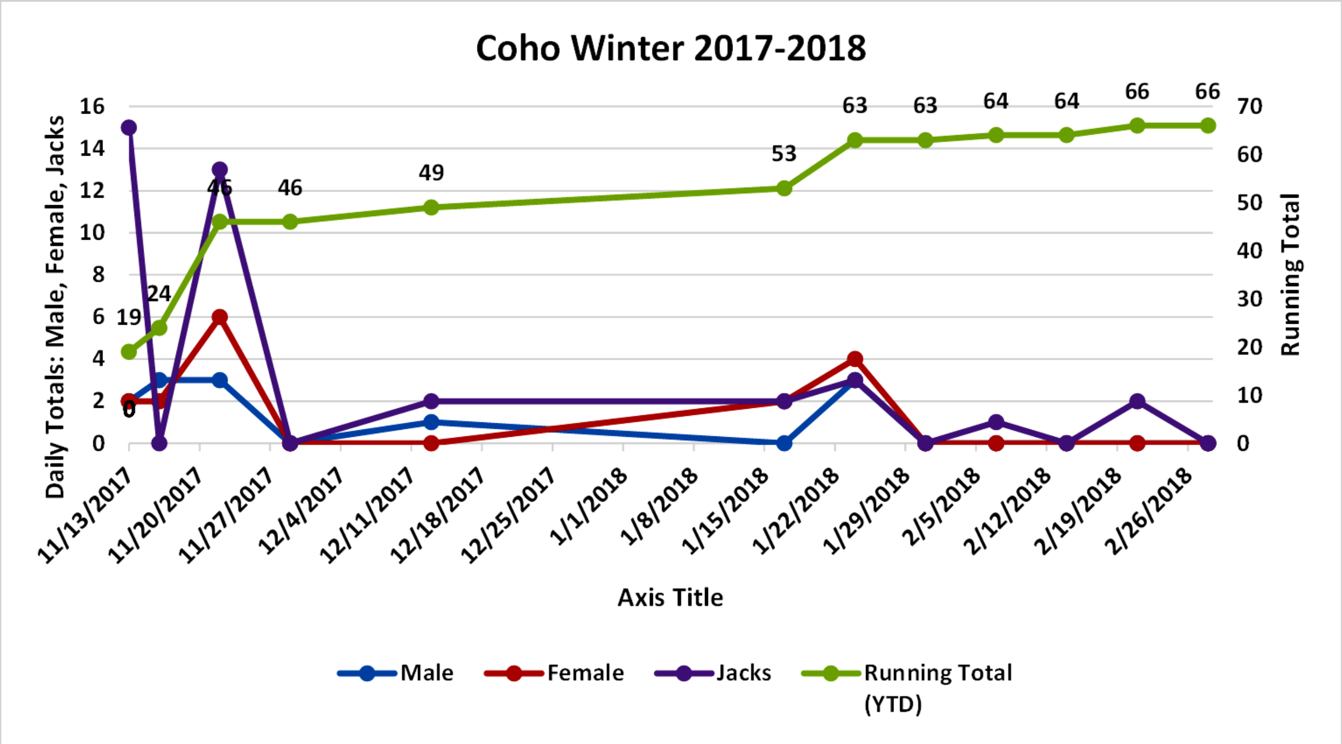
Native Coho

Native Coho return to the Eel Lake basin to spawn in the streams above Eel Lake. The Eel Lake Trap provides the means for counting nearly 100% of this native run. During flooding events, some salmon have been seen to jump over the weir and into Eel Lake. This can introduce an error into the final count for any given year, but the numbers are likely small and similar from year to year.

All native fish (as determined by the presence of an adipose fin) are counted, the sex is noted, and they are immediately released into Eel Lake. Any hatchery Coho that stray into the system are dispatched.

The Winter 2017-2018 Native Coho Data is shown below:

Chart 9- Native Coho 2017-2018 Data

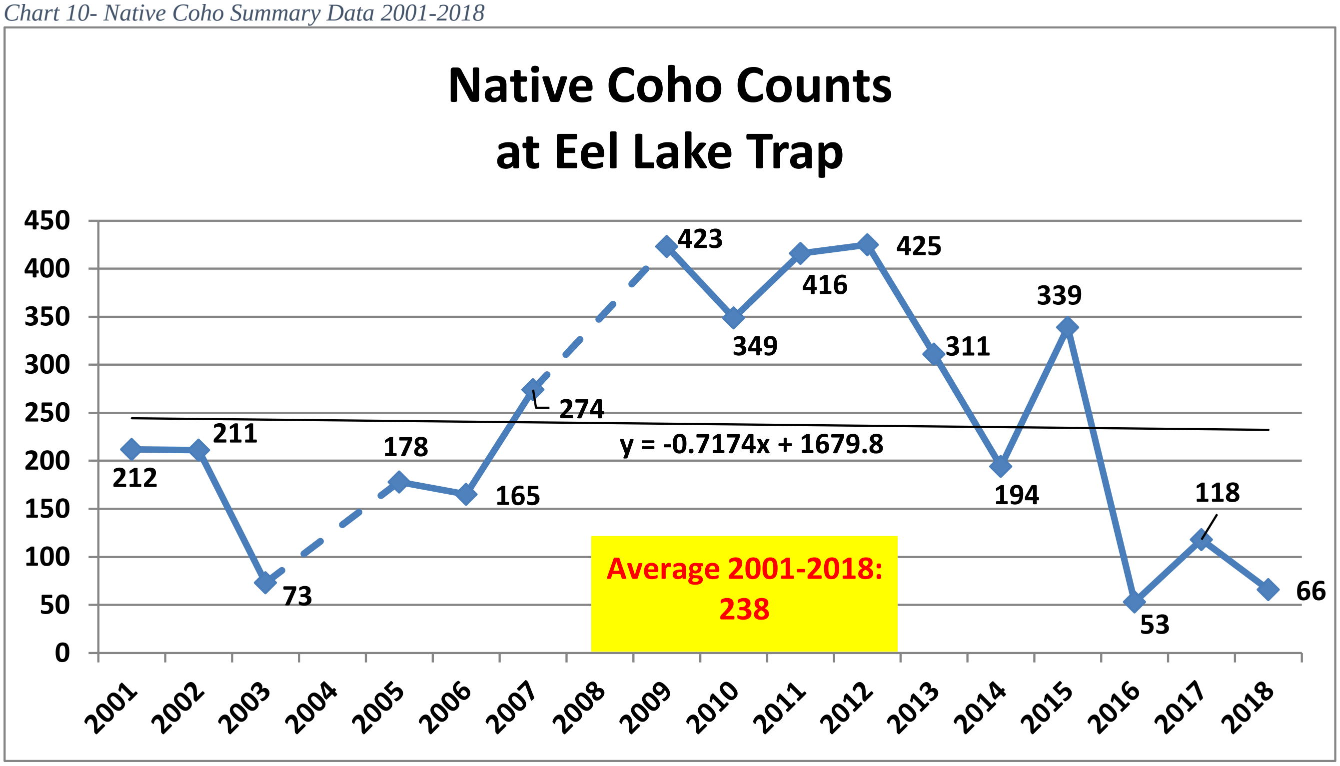


The Eel Lake Trap was converted from the summertime fish ladder configuration to the capture/holding pen design on October 5th, 2017. An adult Pacific Lamprey was found in the Trap during setup and released into Eel Lake. Probably the first Pacific Lamprey in Eel Lake in over 25 years. The first Coho appeared in the Trap on 11/13/2017. That day we had 2 each of adult Coho males and females, and 15 jacks. The 2018 Native Coho run was the second lowest run total since 2001, with only 66 counted for the season. That included 12 males, 16 females, and 38 jacks. As those numbers show, 58% of the run was comprised of small Coho jacks; the largest % on record (See photo below). In addition, the run also included 4 hatchery Coho strays that were dispatched.

Photo 47- Coho Jack – Eel Lake Trap

The 2001-2017 average total run at Eel Lake was 261, so this year was down ~75%. The last 3 years have shown poor Coho runs throughout the Oregon Coast. The lowest 4 run totals for the 2001-2018 period include 3 from the last 3 years, with 2016 being the lowest at 53, 2017 is the 4th lowest at 118, and 2018 comes in second. Only 2003 can be included in this group with a total of 95. A trend line shows a negative slope of -2.5, indicating a slight downward trend, mainly due to the last 3 years. The new, 2001-2018 average has dropped to 238. (Note that we use the later year as the label for multi-year charts: data for the winter 2017-2018 season is listed as 2018. Also note that we were unable to locate data from 2004 and 2008, as mentioned above.)

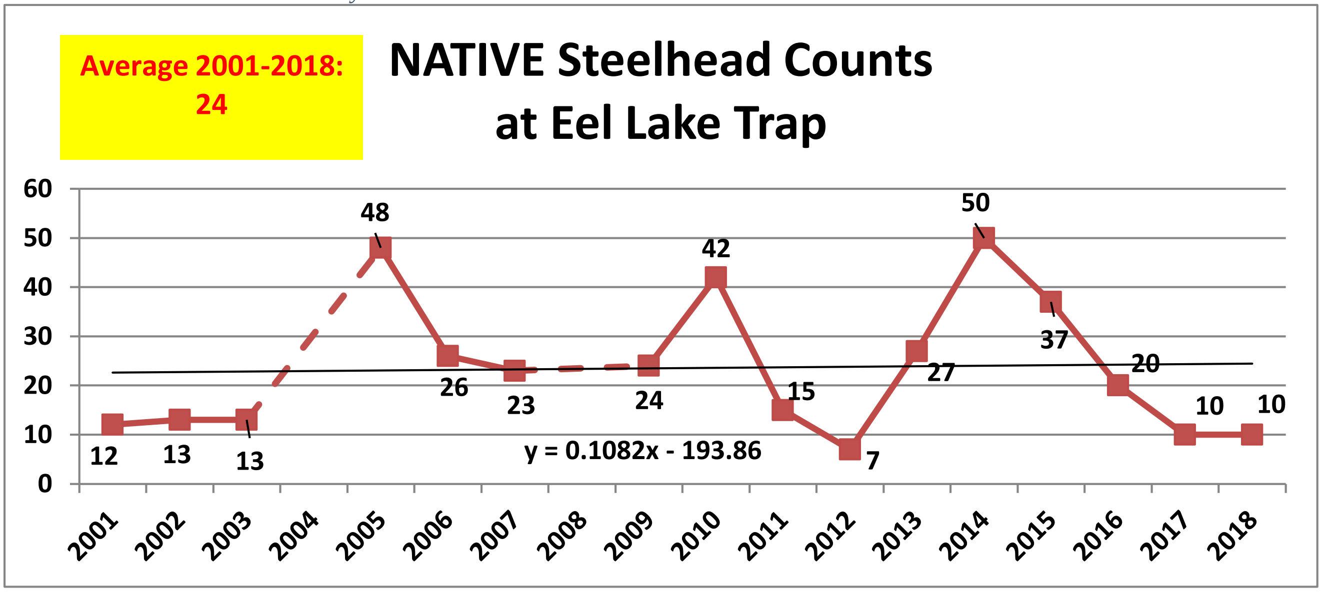
Chart 10- Native Coho Summary Data 2001-2018



Native Steelhead

There is a very small native Steelhead run into the Eel Lake Basin. The 2001-2018 average is 23. The total for the 2017-2018 season was 10; including 4 males and 6 females. These fish are released into Eel Lake to permit spawning in the upper tributaries. ODFW allows gamete collection from 1 out of every 6 females. We reached the needed 6 female total, but unfortunately the 6th one came in after the trap spawning event was complete, so there was no native Steelhead egg collection. Two males were partially spawned and then released into the lake to allow further spawning in the wild.

Chart 11- Native Steelhead Summary Data 2001-2018

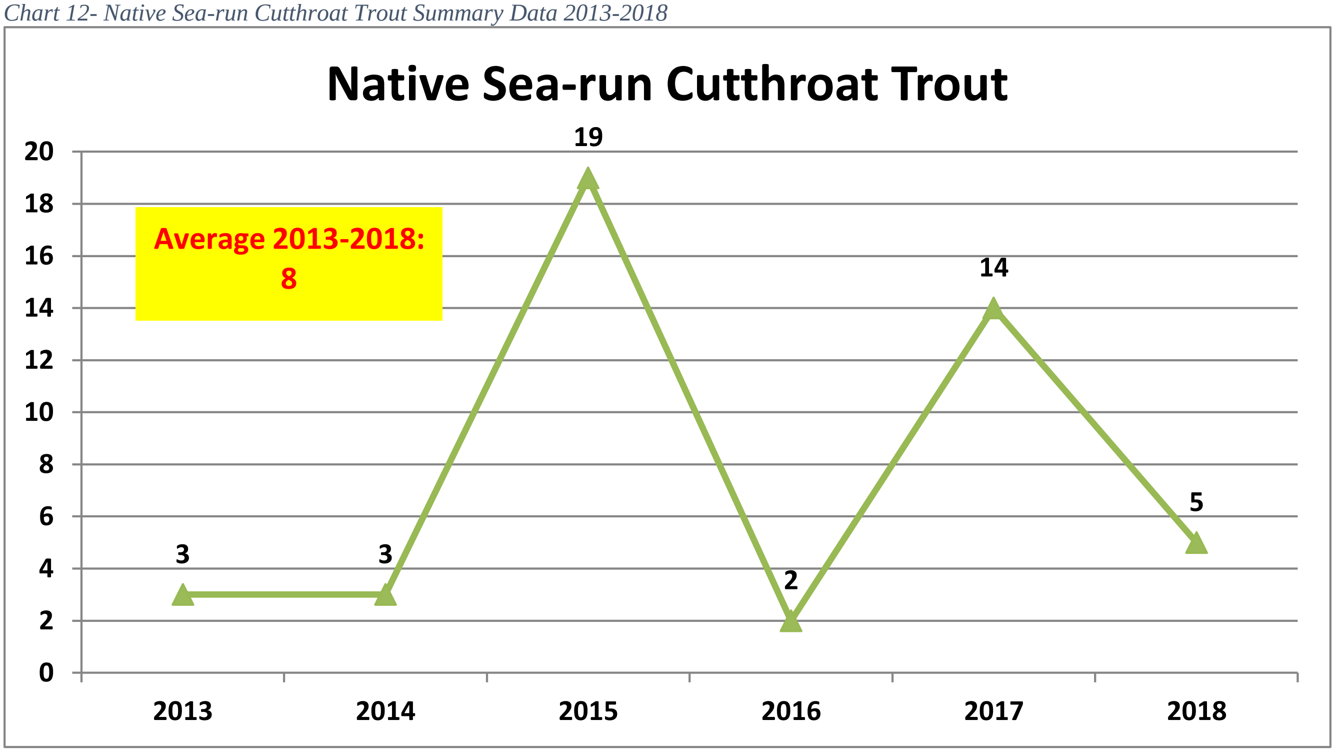


Native Cutthroat

The Eel Lake Basin also has a small run of Native Sea-run Cutthroat Trout. Even smaller than the Native Steelhead run, the average per year is 8. In the 2017-2018 season the total was 5. Cutthroat Trout are frequently caught in Tenmile Creek when fishermen are fishing for Steelhead, but many must migrate to the Tenmile Lakes Basin instead of Eel Creek.

As the chart shows below, we have less data on Cutthroat, only going back to 2013. The runs appear to be consistently small, but highly variable with yearly totals ranging from 2 to 19.

Chart 12- Native Sea-run Cutthroat Trout Summary Data 2013-2018



What are the hatchery Steelhead return rates? What are the return rates of marked recycled hatchery Steelhead?

Hatchery Steelhead

Hatchery Steelhead Returns and Trends

Hatchery Steelhead production is the main focus of the Eel Lake Trap program. Not intended to supplement the native runs, it is organized by ODFW to provide a Steelhead fishery on Tenmile Creek. The run for the 2017-2018 season began on January 17th, with 11 fish making it to the Trap. The peak capture days were 1/31/2018 with 92, 2/28/2018 with 83, and 3/7/2018 with 81.

The total 2018 run was 23% higher than average, with a total of 502 Hatchery Steelhead returning to the Trap, and the 2001-2018 Average being 409. It consisted of 173 males, 320 females, and 9 jacks. The charts below show the return for 2018 and the 2001-2018 totals for Steelhead. The Trendline for the 18 year period has a +16X slope indicating an upward trend in Hatchery Steelhead returns over that period.

Chart 13- Hatchery Steelhead Winter 2018

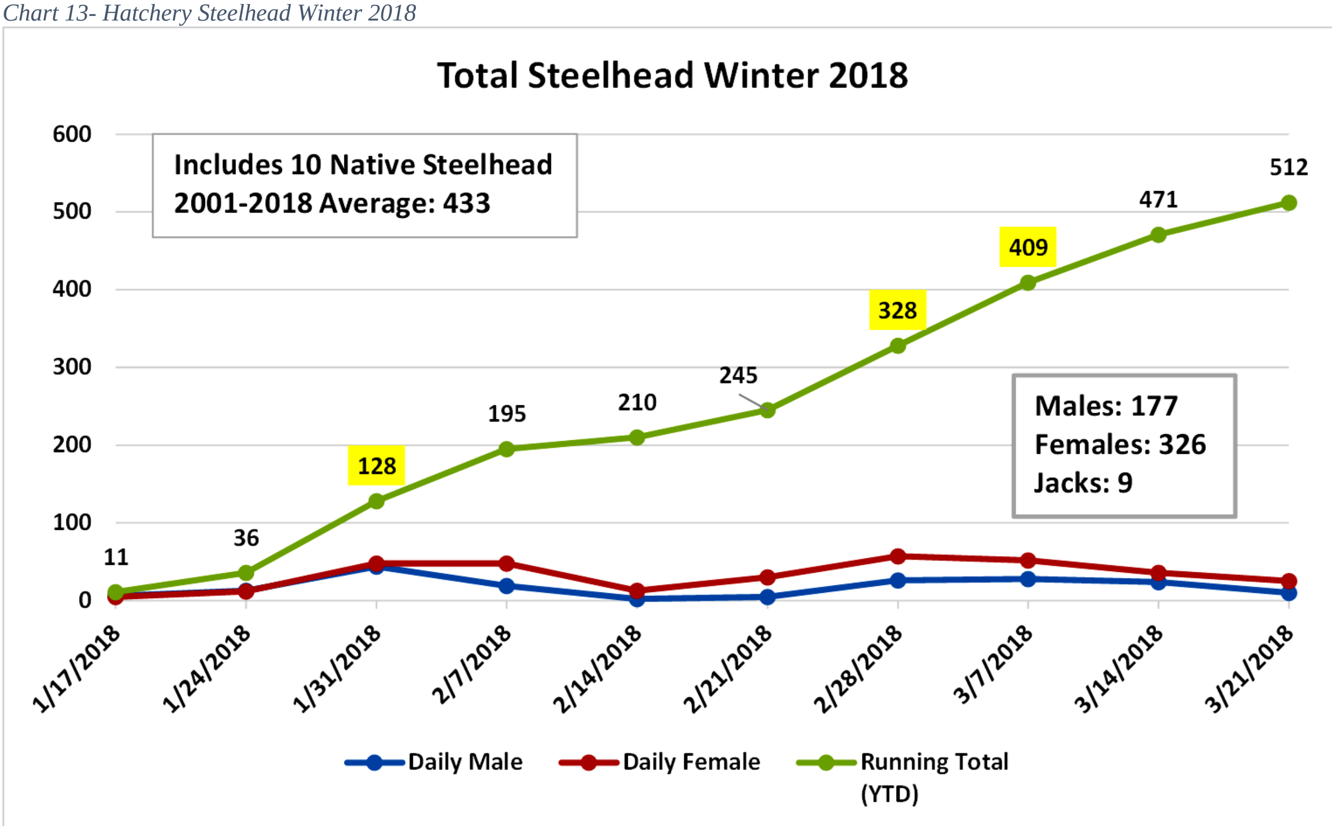
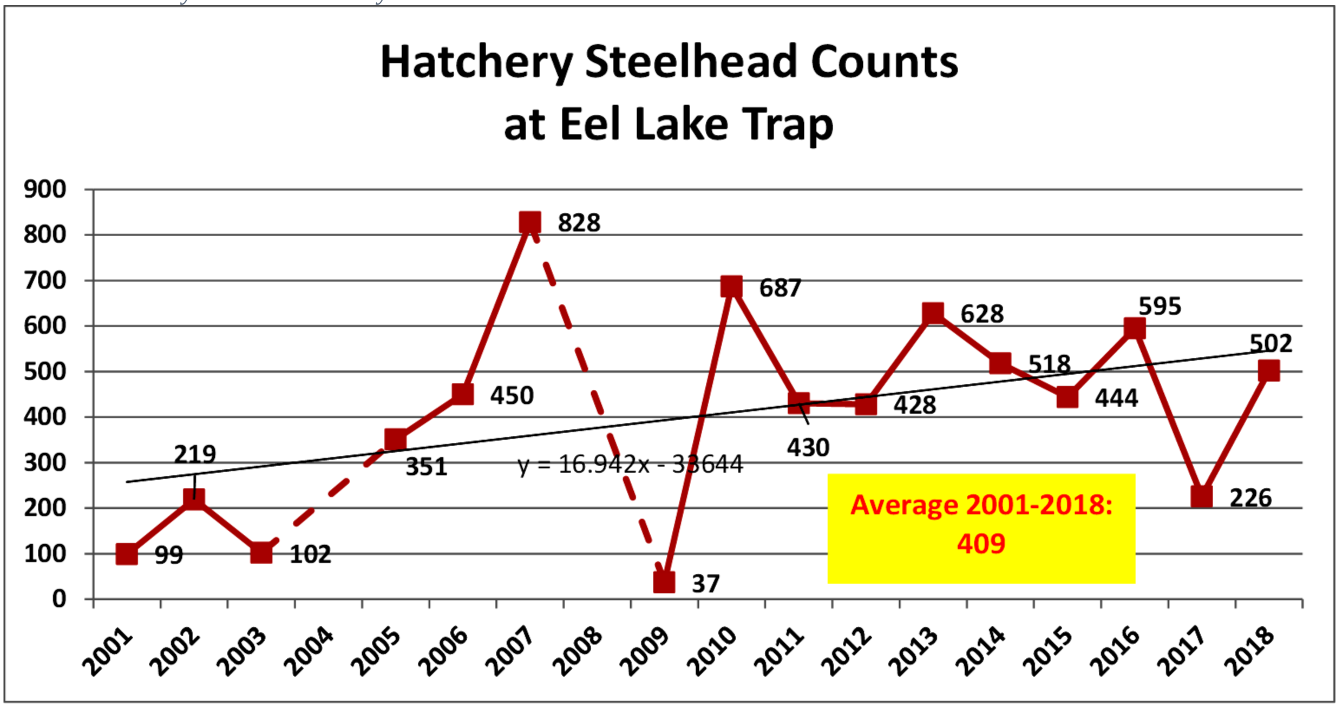


Chart 14- Hatchery Steelhead Summary Data 2001-2018 with Trend Line



When comparing the number of Steelhead smolts released to the number of adults returning, we look only at the Trap acclimation site since that is the only place we count adult returns. For the period 2008 to 2018 we see an average return of 5.9%. (This estimate could be low - see note below table). The return counts are for 2 years past the smolt release year. There is a slight negative correlation (-0.11) between the number of smolts released and the number of adults that return. This may indicate that other factors such as ocean conditions, food supply, predation, fishing, disease, etc have a larger impact on adult return numbers than the number of smolts released.

Table 10-Eel Lake Trap - Smolts Released and Adult Returns

Eel Lake Trap – Hatchery Steelhead				
Year smolts released	**# smolts released**	**Year adults returned (2 years later)**	**Adult Return***	
2008	7045	2010	687	9.8%
2009	7950	2011	430	5.4%
2010	10440	2012	428	4.1%
2011	8004	2013	628	7.8%
2012	10800	2014	518	4.8%
2013	7503	2015	444	5.9%
2014	9000	2016	595	6.6%
2015	8010	2017	226	2.8%
2016	9000	2018	502	5.6%

* Before 2015, once the egg take goal was met a part of the weir was opened up for adult steelhead to go directly into Eel Lake without being counted. These fish could have made up ¼ to ½ the run.

Hatchery Steelhead Recycling Program

ODFW instituted a Steelhead recycling program in 2015. Staff and volunteers used an operculum punch to mark recycled Steelhead from the Trap. After fish were taken from the Trap and counted, they were placed in a large aerated tank and driven to Tenmile Creek at Spinreel Park, usually in groups of 30-40 steelhead.

Photo 48- Steelhead Recycling Tank

The number of recycled fished that returned to the trap was tracked to see how many of those Steelhead came back and how many did not return, either due to: death, being caught by fishermen, migrating back out to the ocean, or straying into other streams in the Tenmile watershed. In 2015, 257 Hatchery Steelhead were recycled back to Tenmile Creek and 113 of those were recaptured at the Trap. The following year, 156 Steelhead were recycled to Tenmile Creek and 71 were recaptured at the Trap. In both cases, less than half were recaptured, leading to the conclusion that many of the fish may be straying into the Tenmile Lakes Basin. ODFW wishes to preserve the spawning grounds in Tenmile Watershed for native fish only, so the decision was made to no longer recycle Steelhead directly into Tenmile Creek.

In 2017 and 2018, Steelhead were recycled to nearby Saunders and Butterfield Lakes to give fishermen one last chance to catch them. Neither of these lakes have appropriate spawning areas or viable access to migration routes to other spawning grounds. The recycled steelhead are limited to 400 total per year; 250 to Saunders Lake, and 150 to Butterfield Lake. If more than 400 Steelhead return to the Trap, then the extras are dispatched and their carcasses are taken to nearby streams for nutrient enrichment. Since only 220 fish were recycled in 2017, no fish were dispatched. In 2018, 400 steelhead were recycled and 102 dispatched, 18 of which were smoked by STEP volunteers and donated to the Lakeside Sr. Center.

Photo 49- Recycling Steelhead to Butterfield Lake

Hatchery Steelhead Spawning

Spawning occurred on February 7th and 21st, 2018. A total of 60 Steelhead were spawned, including 2 native males, 29 hatchery males, and 29 hatchery females. Gametes were taken to the Bandon Hatchery where they were raised to the eyed-egg stage, then transported to the Cole Rivers Hatchery to complete their development to the smolt stage in a little over 1 year.

Outreach and education are important components for both TLBP and ODFW. We encourage visitors to visit the Trap and help net Steelhead from the holding pen and learn about the spawning process. Children and adults alike enjoy handling the Steelhead and getting their photo taken. Participating helps to connect people to our fish and the environmental concerns in protecting them.

TLBP analyzed and updated the Trap data throughout the season and presented it to the Watershed Council, Tenmile Lakes Association, and the STEP group at their monthly meetings. Information was also shared with ODFW staff as needed to make decisions about trap operation, and to summarize final results for their records. TLBP's lamprey efforts were also shared at these meeting and on our website. For many people it was their first exposure to Pacific Lamprey and why they might be necessary in our ecosystem.

Photo 50- Spawning Hatchery Steelhead at Eel Lake Trap

Photo 51- Kids Volunteering to help with Steelhead at Eel Lake Trap

Smolt Acclimation

Steelhead smolts are returned to the Tenmile Watershed in April of the year following the spawning event at the Trap. The eggs are carefully tracked, so the smolts that are returned are known to be from the eggs originally taken at Eel Lake Trap. STEP maintains 3 acclimation sites to acclimate the smolts to this area, so they will return as adults and create the fishery.

Eel Lake Trap Acclimation Sites

Eel Lake Trap is one acclimation site. The interior of the Trap is rearranged from a trap/holding pen to a large open pool. A net covers the area to deter predators. The smolts are transported via ODFW truck from Cole Rivers Hatchery, maintaining appropriate temperature and oxygen levels during the long trip. Transporting smolts can impose a high level of stress resulting in varying amounts of mortality. The fish are fed and acclimated for 2-3 weeks, then the trap is simply opened and the smolts allowed to flow out into Eel Creek and swim to the ocean by way of Tenmile Creek. A table at the end of this section shows the number of smolts delivered at each acclimation site and the approximate number of mortalities resulting from transport.

Photo 52- Changing Trap over to acclimation site

Photo 53- Eel Lake Trap Acclimation Site 3-27-2018

Dell's Creek Acclimation Site

The second acclimation site is at Dell's Creek, at the confluence with Tenmile Creek. It is located ~0.6 miles downstream from the confluence of Eel Creek and Tenmile Creek. A large screen is temporarily set up to trap the fish in the small tributary until acclimation is complete. As with other sites, fish are fed for 2-3 weeks, then released into Tenmile Creek. Most of the smolts swam upstream and were not visible after the first few days. Water levels and sedimentation are both challenges at this site making it ideal that the fish disperse throughout the small creek.

Photo 54- Dell's Cr Acclimation Site (right) next to Tenmile Cr (left) 3-27-2018

Photo 55- Dell's Cr Acclimation Site

Saunders Creek Acclimation Site

The third acclimation site is located in Saunders Creek just above the confluence with Tenmile Creek. It is located approximately ¼ mile downstream from the second acclimation site. A large CMP Culvert is temporarily blocked using a large screen. The smolts are released above the screen and allowed to go up stream to feed and avoid predation. Hand feeding is done in the pool above the culvert but is not heavily used after the first few days.

Photo 56- Saunders Cr Acclimation Site Screen Barrier

Photo 57- Saunders Cr Acclimation Site 3-26-2018

The table below shows the approximate number of smolts released at each acclimation site

Table 11- Acclimation Sites and Smolt Counts

Acclimation Site Name	Number of Smolts released & mortalities
Eel Lake Trap	13,620 -1,500 mortalities
Dell's Creek	2,400 -50 mortalities
Saunders Creek	12,000 -1,200 mortalities

After acclimation is finished at the Trap, it is converted over to a fish ladder. It is left in this configuration throughout the spring and summer until it is once again changed back to the trap/holding pen in October.

Photo 58- Eel Lake Trap Conversion to Fish Ladder

Eel Lake Trap Summary

Eel Lake has a small population of both native Steelhead and native Sea-run Cutthroat Trout. Although consistently observed over the years that the Trap has been in operation, the numbers are reliably small and don't appear to be trending up.

The native Coho run has varied dramatically over the years, with a high of 441 in 2012, a low of 53 in 2016, and a 2018 total of 66. The overall trend is slightly downward, although that has been heavily influenced by the last 3 years. No spawning efforts are conducted with this run; fish are counted and released into Eel Lake. The Coho numbers for the last few years for most of the Oregon Coast also showed low returns, so low counts are likely caused by ocean conditions or other parameters outside of our local environment. There has been spawning gravel augmentation done in Winter Arm Creek above Eel Lake; this will reduce a limiting factor for this native Coho run.

Hatchery Winter Steelhead counts were 502 for 2018. This compares to 595 in 2016, and 226 in 2017. Wild Steelhead only numbered 10 for the 2018 season. The average return for Native Steelhead is 24.

In 2018, ODFW transported ~25,270 smolts for the Tenmile Watershed. Approximately 12,120 were acclimated at the Eel Lake Trap, ~2,350 were acclimated at Dell's Creek near Tenmile Creek, and ~10,800 at Saunders Creek above the culvert. The 2018 Steelhead fishing season on Tenmile Creek was the best in the last 3 or 4 years, but not as good as some years in the past.

Recycling hatchery steelhead for the benefit of increasing the fishing success on Tenmile Creek, was determined to not be viable. Too many hatchery fish were possibly straying and not returning to the Trap. In 2017, the recycling spot on Tenmile Creek was abandoned, and all 400 recycled fish were relocated to either Saunders Lake or Butterfield Lake. This practice continued in 2018.

Non-native Species

Are any of the non-native fish species present in Eel Lake transiting Eel Creek, to other locations?

The table below shows the results from our observations throughout Eel Creek. The only place where non-native species were observed was in the pool below SC#E2. Bluegill were seen swimming amongst the rip-rap boulders in a small pool below the culvert. It is possible that the Bluegill could have come down from Eel Lake, or up from Tenmile Lake via Tenmile Creek. No non-native species have been observed in the Eel Lake Trap, but non-native species could float down the fish ladder, or go over the weir without a likelihood of being seen. It was also reported in spring of 2018 that Bluegill were being caught at the confluence of Eel Creek and Tenmile Creek.

Table 12- Eel Creek Invasive Species Observations

Site ID	Site Description	Invasive Species Present?
SC#E1	Sherry Barbie Ln Bridge	None Observed by TLBP staff, but Bluegill reportedly caught by fishermen just below bridge in Tenmile Creek
SC#E2	Hwy 101 Culvert #1 – near Eel Creek Mobile Home Park	Bluegill present in pool below culvert
LEC1	Larvae Sampling Site Near Lakeside Cemetery	None Observed
SC#E3	Hwy 101 Culvert at South Lakeside Entrance	None Observed

SC#E4	Park Walking Bridge at John Dellenback Dunes Trail	None Observed
LEC2	Larvae Sampling Site below SC#E5	None Observed
SC#E5	Eel Creek Campground at entrance bridge	None Observed
SC#E6	Hwy 101 Culvert #3 near Tree Acres store	None Observed
LEC3	Larvae Sampling below SC#E7	None Observed
SC#E7	Private Vehicle Bridge – logging road near Tree Acres	None Observed
LEC4	Larvae Sampling Site near Sea Drift RV Park	None Observed
SC#E8	Tugman Park walking trail bridge	None Observed
SC#E9	Eel Lake Trap	None Observed

Since non-native Bluegill were observed in Eel Creek, below HWY 101 culvert SC#E2, it is apparent that non-native fish can infect other systems with the watershed, once they have established a viable population. This is also true with plant species, as we see the rapid spread of Parrot Feather (*Myriophyllum aquaticum*) and *Egeria densa* into Tenmile Creek from Tenmile Lake. *Egeria densa* is also heavily infesting the upper areas of Eel Creek. This should be monitored, as it could cause issues with both Salmon and Lamprey larvae if the infestation spreads throughout Eel Creek. Heavy invasive aquatic plant biomass in Tenmile Creek has led to wide diel swings in both dissolved oxygen and pH. TLBP 2013 monitoring of Tenmile Cr showed DO levels as low as 1.2mg/L and as high as 15.2mg/L within the same day and would likely be a limiting factor for lamprey larvae rearing or adult holdover.

Lessons Learned

Lamprey Monitoring

1. Shockers should be set to Lamprey settings. Smith-Root uses dual channel, one for promoting the lamprey larvae to leave the sand, and the second to stun them so capture is easier. The following link from the equipment manufacturer describes the appropriate settings for each: http://www.smith-root.com/support/kb/setting-up-a-backpack-electrofisher-to-capture-larval-lamprey/
2. Lamprey larvae shocking is most useful to establish presence/absence of the species, but not as useful for abundance.
3. It would be useful to develop a good way to analyze relative abundance data for lamprey larvae so comparisons could be made between longitudinal stream sites, different streams and watersheds, and over time. We tried using CPUE, but found too many field variables and issues with the mathematical equation to feel that it was a reliable indicator. It will be important to be able to monitor recovery as we implement the *Tenmile Lakes Basin 30-Year Pacific Lamprey Conservation Management Plan*, and the ability to calculate relative abundance at know sites would be a critical tool.
    a. One factor that could help with site comparisons might be to standardize the area to be surveyed and the time allowed for completion of that area. For instance, measure out 100 square feet of Type 1 habitat, and sample that area within 15 mins for every site.
    b. Number of netters could also be standardized, but individual netting skills still leaves this somewhat subjective. A minimum of 2 netters (in addition to the shocker) would be ideal, 3 netters is more reliable, but if trying to standardize, it might be difficult to always gather 4 people for every survey. Using a shocker with a pig-tail cathode allows the shocker operator to also net.
    c. Shocking time should be calculated by the actual shocking time recorded on the shocker. It is difficult using a stopwatch because there are so many interruptions: netters looking for larvae in

their nets or transporting them to buckets, surveyors repositioning upstream and getting ready to shock again, waiting for sediments to settle so visibility will be better, etc.
    d. Lamprey sampling protocols and analysis should be standardized by ODFW, NOAA, USFWS, or other government agency.
4. The shocker is relatively heavy. If hiking into steep terrain, a person capable of safely carrying the load up the hills is required. With buckets, measuring boards, and other necessary equipment, plus the need for the appropriate number of netters, a minimum of 3 people is recommended for hiking into remote sites.
5. Lamprey larvae identification is difficult and should always require training.
    a. Larvae below 65mm should be listed as “unknown”, or “unidentified”.
    b. Voucher specimens should be taken and genetically analyzed to act as identification quality control, or to make identification of very small larvae when presence/absence in an area is critical. Our partnership with ODFW made this possible.
    c. A good quality magnification lens and identification chart are useful in the field.
    d. MS222 can be used for anesthetizing the larvae, which must be motionless to measure properly.
6. Larvae nets need to be very small mesh, especially when larvae are in the 65mm or below category. Aquarium nets have a good mesh, but the handles are too flimsy; they bend when diving the net into the sediment to dig out an escaping larva. Reinforcing the net handle with wood or something sturdy is helpful.
7. Polarized sunglasses are valuable to be able to see larvae when netting.
8. Always wear chest waders. Even though larvae sampling is always done in shallow water, getting to the sampling sites can be through deep pools.
9. The Lamprey Conference in Portland was very informative. Money should always be included in the proposed grant budget to allow for continuing education and data presentation opportunities such as conferences. This is especially true with lamprey work since there are so many data gaps in our knowledge.
10. Partnering with CTCLUSI and ODFW (both locally and at the state level) has driven this monitoring effort to the next level. Ben Clemens, Gary Vonderohe, and John Schaefer have all added greatly to the outcome of this project and to the planning of the next phases. The collaboration between Tribes, ODFW and Watershed Councils are a very valuable way to make progress on lamprey recovery statewide.

Salmon Monitoring

1. It is critical to have proper data collection forms and someone trained to use them. The name of the data collector should be on the form.
2. Data should be entered quickly after collection in case there are questions that arise, especially when data is collected by a volunteer.
3. The Eel Lake Trap is a good outreach tool for both education and conservation. Effort should be placed on engaging both adults and children in the Trap processes. Working with Reedsport schools to bring science classes to the Trap during the Steelhead season would be a worthwhile effort as a future Eel-Tenmile STEP goal.
4. A viewing system should be figured out for the Trap. It is very difficult to see into the Trap since the new security grating was installed. A camera, or lights could be installed to help with outreach to the general public by enabling viewing of the fish in the Trap. Something similar would also be useful for the Lamprey Ramp being installed at the Trap.
5. Coho should be handled as little as possible. Hatchery Steelhead are a better education tool since they can be handled more.

Future Monitoring Needs

1. Implement conservation action recommendations from the *Tenmile Lakes Basin 30-Year Pacific Lamprey Conservation Management Plan*
2. Work with CTCLUSI to reach their goal of being able to sustainably harvest Pacific Lamprey for Tribal purposes within the Tenmile Watershed
3. Work with ODFW's statewide lamprey recovery efforts
4. Fund Phases 2 and 3 of this monitoring effort
5. Specifically, we recommend the following actions:
    a. Determine Pacific Lamprey distribution throughout the Tenmile Watershed
    b. Understand Pacific Lamprey migration timing in the Tenmile Watershed – Both in and out migrations
    c. Locate Pacific Lamprey holdover areas and habitat type used for this purpose
    d. Understand how dunal stream habitat is used by lamprey for spawning and rearing
    e. Locate spawning grounds both above and below Eel Lake Trap and in the Tenmile Lakes Basin
    f. Conduct spawning surveys to estimate Pacific Lamprey populations
    g. Track use of both Eel and Tenmile Lakes for migration and rearing
    h. Monitor stream/lake temperatures in relation to Pacific Lamprey activities
    i. Track larvae numbers and distribution over time to monitor effectiveness of conservation plan actions
    j. Monitor lamprey barriers and effectiveness of barrier enhancements including the lamprey ramp at the Trap
    k. Create a genetic record of our lamprey for future use
    l. Monitor effects of agricultural land use practices on lamprey rearing habitat
    m. Determine impact of non-native fish species predation on lamprey larvae and juveniles