Mapping the Distributions of Pacific and Western Brook Lampreys Along the Oregon South Coast using eDNA and Community Science: 2021 Report.

Shon Schooler[1], Jenni Schmitt[1], Deborah Rudd[1], Becky Flitcroft[2], and Ian Rodger[1]

[1]South Slough National Estuarine Research Reserve, Charleston, Oregon

[2]USDA-USFS, Corvallis, Oregon

Dean Yurica and Karla Cottom sampling water for lamprey DNA.

Objective: To collect data on the presence of two lamprey species in Oregon South Coast streams to better understand what habitats these lampreys prefer, create baseline data to assess future changes in distribution, and inform management actions for restoration activities.

Introduction:

Two lamprey species coexist in streams along the Oregon South Coast: Pacific lamprey (*Entosphenus tridentatus*) and western brook lamprey (*Lampetra richardsonii*). Pacific lamprey are anadromous; they transform from in-stream filter-feeding larval fish to parasitic adults, spending part of their life cycle in the ocean. Adult Pacific lamprey return to streams to spawn. Western brook lamprey are not anadromous; they stay in streams for their entire lives as filter feeders. Both species require streams with deep pockets of sediment and flowing water because they bury themselves in sediment during the day and extend their bodies into the water column during the night to feed. They feed by filtering organic material from the water. Both species also require areas with pebbles or sand for spawning.

Lampreys are ecologically and culturally important species. They are one of the most ancient lineages of animal and have existed in roughly their current form for more than 340 million years, evolving long before dinosaurs existed. Anadromous lampreys, like the Pacific Lamprey, bring nutrients from the ocean into the upland forests when they spawn, which makes the forests more productive. Oregon is a hotspot for lamprey species, hosting 10 of the 38 lamprey species worldwide. In addition, lampreys have been used as food by native tribes since time immemorial. Finally, five of Oregon's lamprey species are listed by the state as Sensitive Species, due to threats to their habitat and populations. These Sensitive Species include Pacific and western brook lampreys.

Understanding where lampreys are present is important for natural resource management. However, lampreys are difficult to observe under normal circumstance because they are nocturnal and buried in stream sediments. In addition, young Pacific and western brook lampreys (<6cm length) are difficult to tell apart. A common method to study lamprey is to use electro-fishing equipment to tease them out of the sediment, capture them, and record number, species, and size. However, this method requires specialized equipment and a team of staff with technical lamprey identification experience. It also requires disturbing stream habitats and capturing and releasing lampreys.

This project sought to test a new method that involves using environmental DNA (eDNA) to detect the presence or absence of Pacific and western brook lampreys in Oregon South Coast steams. This technique may allow researchers to detect barriers to lamprey migration (by sampling above and below a culvert, tide-gate, or dam) and inform work to enhance passage. Additionally, this type of testing can be used to determine if lamprey are present before conducting road construction or maintenance or stream restoration projects. Finally, researchers can use this information to predict good lamprey habitat and protect and restore habitat to increase lamprey abundance. In addition to testing eDNA methods, researchers also collected baseline data to assess future changes in distribution and inform management actions for restoration activities.

Methods:

We tested a new method to map lamprey distributions that uses eDNA in the water column to identify lamprey species. This method requires passing five liters of water through a small fiber filter using a battery-powered pump (Carim et al., 2016; Figure 1). The filter is then removed and dried and sent to a laboratory for analysis. The laboratory uses a technique called quantitative polymerase chain reaction (qPCR) to look for the presence of DNA from the species selected for identification.

Figure 1. Equipment used to collect eDNA samples.

Results:

In 2021, we sampled 44 locations in streams along the southern Oregon coast for these two lamprey species. Pacific lamprey were detected at 32 sites (73%) and western brook lamprey (as Lampetra spp.)

at 20 sites (45%). At least one of the lamprey species were present at 37 sites (84%). Both species were detected at 15 sites (34%) (Figure 2). The results indicate that both lamprey species are prevalent in streams on the Oregon South Coast and their habitats overlap about one third of the time.

We also sampled eight lake environments in 2021 to test whether sampling lakes is a viable method to sample the streams in the watershed above the lake. Of the eight lakes sampled only one registered positive for Lampetra spp. and one for Pacific lamprey. We know some of these lakes that registered no DNA had watersheds above with lamprey present. This leads us to suggest that sampling lakes is not a good method to determine lamprey presence in the watershed above. There may be several issues reducing the accuracy of testing. First, lakes can be thermally stratified (lake water forms layers which don't mix due to different temperatures with warm water at the top and cool water at the bottom), which affects where DNA is present in the water column (Littlefair et al., 2021). The cool water flowing into the lake from the stream goes to the lake bottom and since we generally sample for lamprey at the surface there is low probability of detecting lampreys from the watershed above in these samples. Second, particles with DNA attached drop out of the water column to the sediment (Eichmiller et al., 2014) as flows decrease, such as when a stream enters a lake. Third, DNA degrades faster under conditions of higher temperature, UV radiation (sunlight), and acidity (Balasingham et al., 2017), such as conditions commonly found in freshwater lakes. Therefore, sampling lakes has higher chance to get negative results even when lamprey are present (what scientists call a false negative, or type 2 error).

We also found lamprey DNA in several small streams where lamprey were not expected to be present. This indicates lamprey may be present in small coastal streams.

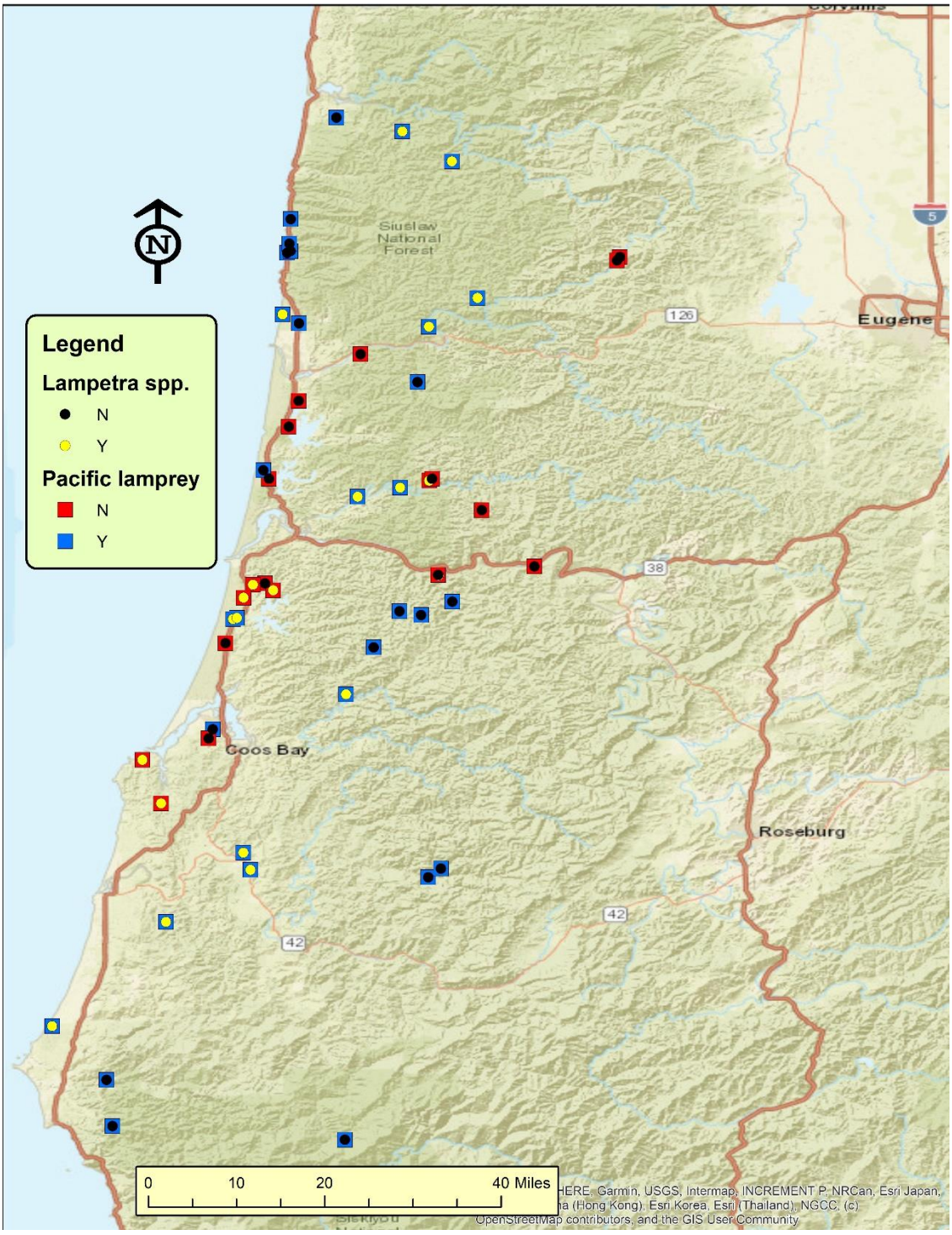

Figure 2. Results from 52 sites sampled for lamprey DNA in 2021. Note that symbols are stacked, each site was analyzed for Pacific (square symbols) and Western brook lampreys (aka Lampetra species) (round symbols).

Conclusions:

In 2021 we learned that sampling lakes is not an accurate method to detect lamprey in the watershed above the lake. We also found lamprey in smaller streams than we expected. In 2022 and 2023 we plan sample up to 100 additional sites. As sample size increases, we expect we will be able to better predict lamprey habitat. After collecting information from more sites in 2022 and 2023 we plan to examine correlations between lamprey species presence and selected landscape metrics to determine habitat suitability and then use these results to compare habitats between the two species and predict lamprey presence at sites not yet sampled.

Acknowledgements:

Thanks to our community scientists: Randy Smith, Jan Hodder, Mike Graybill, Kira Smith, Wes Burton, Pete and Zoli Baki, Dean Yurica, Ruth Bell, John Schaefer, Janet Niesser, Richard Litts, Joanna Lyle, Terry Smith, Heidi Anderson, Mike Mueller, Karla Cottom, Jon Blalock, the 2021 SSNERR Magister Camp class, and Tommy Sheridan and his 2021 OIMB Fish Biology class. The USDA U.S. Forest Service provided funding for this project: 19-CS-11261953-076, administered by the Friends of South Slough Reserve, Inc.

References:

Balasingham, KD, Walter, RP, Heath, DD. 2017. Residual eDNA detection sensitivity assessed by quantitative real-time PCR in a river ecosystem. Molecular Ecology, 17:523-532.

Carim, KJ, McKelvey, KS, Young, MK, Wilcox, TM, Schwartz, MK. 2016. A protocol for collecting environmental DNA samples from streams. Gen. Tech. Rep. RMRS-GTR-355. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 18 p.

Eichmiller JJ, Bajer PG, Sorensen PW. 2014. The Relationship between the Distribution of Common Carp and Their Environmental DNA in a Small Lake. PLoS ONE 9(11): e112611. doi:10.1371/journal.pone.0112611

Littlefair JE, Hrenchuk LE, Blanchfield PJ, Rennie MD, Cristescu ME. 2021. Thermal stratification and fish thermal preference explain vertical eDNA distributions in lakes. Molecular Ecology, 30:3083–3096. https://doi.org/10.1111/mec.15623