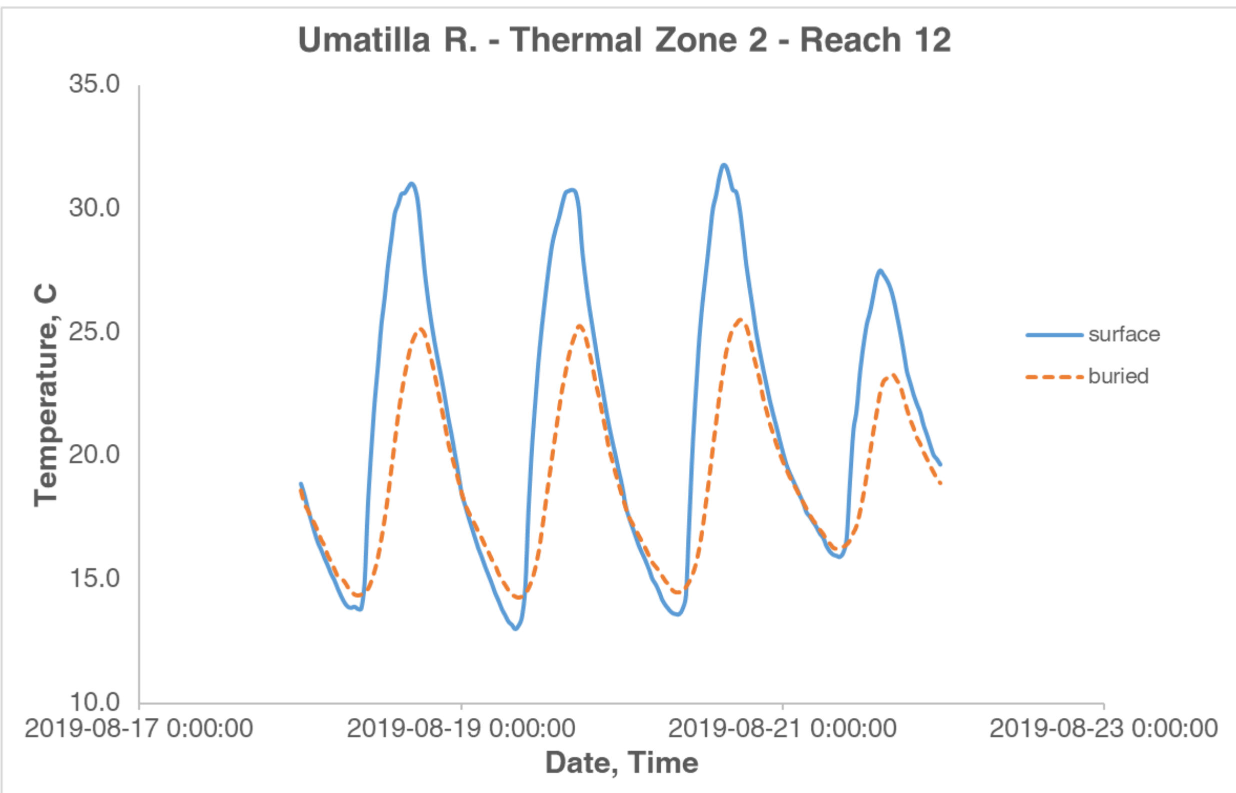
U.S. Fish and Wildlife Service

Columbia River Fish & Wildlife Conservation Office

What is the upper thermal tolerance limit of larval Pacific Lamprey?

Annual Report: 2019



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On the cover:

Temperature of the Umatilla River at the substrate surface (surface) and 4-7 cm below the substrate surface (buried), just upstream of the confluence with McKay Creek.

Disclaimers:

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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The correct citation for this report is:

Sankovich, P. M. and Whitesel, T.A. 2022. What is the upper thermal tolerance limit of larval Pacific Lamprey? Annual Report: 2019. U.S. Fish & Wildlife Service, Columbia River Fish & Wildlife Conservation Office, Vancouver, Washington (USA). 7 pp.

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Work funded by

U.S. Fish and Wildlife Service

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March 2022

Executive Summary:

Lampreys are obligate ectotherms and directly influenced by the ambient water temperature. In a variety of species other than Pacific Lamprey, evidence exists that lethal water temperatures for larvae occur near 27.0-31.0°C (e.g. Potter and Beamish 1975; Arakawa and Yanai 2021). Relatively few studies have addressed the thermal tolerance of larval Pacific Lamprey. Recently, Uh and Whitesel (unpublished data) conducted laboratory experiments suggesting the ultimate upper incipient lethal temperature (UUILT) for larval Pacific Lamprey is approximately 27.5-30.0°C and Whitesel and Sankovich (2021) observed larval Pacific Lamprey naturally occupying areas that exceeded 30°C. How climate change will influence the status of Pacific Lamprey is uncertain (see Wang et al. 2020). Currently, many of the locations where Pacific Lamprey rear naturally experience water temperatures near 26.0°C. With predictions that during the next 25-35 years in the Pacific Northwest air temperatures may rise 2-5°C (Wu et al. 2012), maximum water temperatures where some lamprey exist now may exceed the lethal limit for larval Pacific Lamprey. Whether the UUILT derived from larval Pacific Lamprey reared in a laboratory reflects their natural distribution (i.e. in a stream), or whether there are sublethal effects at temperatures approaching their UUILT, is not well understood. We propose to evaluate i) whether larval Pacific Lamprey occupy streams where water temperatures exceed 27.5°C, ii) whether larvae occupy areas that exceed 27.5°C at a similar rate than areas where temperatures do not exceed 27.5°C, iii) whether burrowing may provide refuge from warm water and iv) whether warm conditions that are not lethal influence larvae.

The study area for this project was the Umatilla River, Oregon (henceforth, river). Based on historical temperature data, we partitioned the river into four thermal zones (TZ1-4) (see Whitesel and Sankovich 2021). Thermal Zone 2 (TZ2) was characterized by summer maximum temperatures that were expected to approach 31.0°C and be relatively constant throughout the zone. Thermal Zone 4 (TZ4) was characterized by summer maximum temperatures that were expected to range from < 27.5°C at the downstream end to 19.9°C at the upstream end. We considered TZ4 as a control area (little to no thermal stress) and TZ2 as a treatment area (reaching or exceeding the UUILT for larval Pacific Lamprey). Both TZ2 and TZ4 were partitioned into a continuous layer of 50 m long reaches. We identified random and spatially-balanced sample reaches by using a generalized random-tessellation stratified (GRTS) approach (Stevens and Olsen 2004). Based on the GRTS approach, we selected the 10 highest priority reaches for occupancy surveys. Each sampling event consisted of electrofishing a 50 m reach to determine if larval lamprey were present (Silver et al. 2010). Each reach was electrofished using an AbP-2 backpack electrofisher. We spent relatively more effort (approximately 30 seconds/m^2) within each reach electrofishing Type I habitat (Slade et al. 2003) and relatively less effort (approximately 5 seconds/m^2) electrofishing Type II and type III habitats. Our sample events occurred before (B), during (D) and after (A) maximum water temperatures in both control (C) and treatment (I) TZs, or as a BDACI sample design (Whitesel and Sankovich 2022). If a larval Pacific Lamprey was detected, the reach and TZ were determined to be occupied and sampling in that reach was terminated. Otherwise, the entire reach was sampled. If larval Pacific

Lamprey were detected in at least five reaches of both TZs, sampling for that event was terminated. If Larval Pacific Lamprey were not detected in five reaches of both TZs during a given sample event, all 10 reaches were sampled within each TZ. During each sampling event we compared i) the occupancy of each TZ, ii) the proportion of reaches in which lamprey were detected in each TZ, and iii) whether occupancy or the proportion within a TZ varied among sampling events. In addition, we evaluated iv) the temperature in both TZ2 and TZ4 throughout the sample period. In each of five reaches from both zones, one temperature logger was deployed on the substrate surface and one temperature logger was deployed at the same point in the stream but 4-7 cm below the substrate surface, for a total of 10 deployed loggers.

In 2019, maximum water temperature occurred on 7 August (U.S. Bureau of Reclamation monitoring station, Pendleton, Oregon). In TZ2, the water temperature reached values > 27.5°C between 11 July and 5 September. During this time, in the most downstream reach of TZ2, temperature at the substrate surface ranged from 11.4-33.6°C and was significantly warmer than temperature below the substrate surface, which ranged from 11.8-29.0°C. Sample events occurred on 25-26 June (B), 21-22 August (D) and 23-24 September (A). Five reaches were sampled in both TZ2 and TZ4 during each of the B, D, and A sample events. In addition, on 25 June (B), 22 August (D) and 24 September (A), one reach in TZ1 was sampled opportunistically. Larval Pacific Lamprey were detected in all of the sample reaches in TZ2, TZ4, and TZ1 during each of the B, D, and A sampling events.

Larval Pacific Lamprey occupied an area in the river (TZ2) where the water temperature exceeded 27.5°C. Larval Pacific Lamprey occupied TZ2 before, during and after the period of maximum summer temperatures. Larvae did not appear to vacate TZ2 during or after maximum temperatures occurred. The proportion of reaches in which larval Pacific Lamprey were detected was high (1.00) and did not differ between either thermal zone or any sampling events. In TZ2, temperature below the substrate surface was colder than temperature at the substrate surface but still reached values exceeding 27.5°C between 3 August and 4 September. Whether occupancy in areas where the water temperature exceeds 27.5°C is common, the warmest areas larvae are able to occupy naturally, the importance of temperatures below the substrate as a thermal refuge, as well as if and how individual larvae moved into or out of thermals zones or burrows when the water is relatively warm, are unclear.

References:

- Arakawa, H., & Yanai, S. (2021). Upper thermal tolerance of larval Arctic lamprey (Lethenteron camtschaticum). *Ichthyological Research*, *68 (1)*, 158-163.
- Potter, I. C., & Beamish, F. W. H. (1975). Lethal temperatures in ammocoetes of four species of lampreys. *Acta Zoologica*, *56* (1), 85-91.
- Silver, G. S., Jolley, J. C., & Whitesel, T.A. (2010). White Salmon River Basin: Lamprey Project. National Fish and Wildlife Federation, Project #2006-0175-020, Final Programmatic Report.
- Slade, J. W., Adams, J. V., Christie, G. C., Cuddy, D. W., Fodale, M. F., Heinrich, J. W., & Young, R. J. (2003). Techniques and methods for estimating abundance of larval and metamorphosed sea lampreys in Great Lakes tributaries, 1995 to 2001. *Journal of Great Lakes Research*, *29*, 137-151.
- Stevens Jr, D. L., & Olsen, A. R. (2004). Spatially balanced sampling of natural resources. *Journal of the American statistical Association*, *99*(465), 262-278.
- Wang, C. J., Schaller, H. A., Coates, K. C., Hayes, M. C., & Rose, R. K. (2020). Climate change vulnerability assessment for Pacific Lamprey in rivers of the Western United States. *Journal of Freshwater Ecology*, *35*(1), 29-55.
- Whitesel, T.A. & Sankovich, P.M. (2022). What is the upper thermal tolerance limit of larval Pacific Lamprey? Annual Report: 2018. U.S. Fish & Wildlife Service, Columbia River Fish & Wildlife Conservation Office, Vancouver, Washington (USA). 7 pp.
- Wu, H., Kimball, J. S., Elsner, M. M., Mantua, N., Adler, R. F., & Stanford, J. (2012). Projected climate change impacts on the hydrology and temperature of Pacific Northwest rivers. *Water Resources Research*, *48*(11).

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