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: 2020

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U.S. Fish & Wildlife Service
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On the cover:

Sophia Love (student assistant) electrofishing for larval Pacific Lamprey in the Umatilla River. (Photo Credit: Tim Whitesel, U.S. Fish & Wildlife Service)

Disclaimers:

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Executive Summary:

Lampreys are obligate ectotherms and directly influenced by the ambient water temperature. In 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). Although few studies have addressed Pacific Lamprey, recent investigations indicated the ultimate upper incipient lethal temperature (UUILT) for larvae exceeds 27.5°C (Uh and Whitesel unpublished data) and provided preliminary evidence that larvae have the ability to occupy natural areas warmer than 27.5°C (Whitesel and Sankovich 2021). How climate change will ultimately influence the status of Pacific Lamprey is uncertain (see Wang et al. 2020). Currently, many of the locations where Pacific Lamprey rear naturally experience maximum water temperatures near 26.0°C. With predictions that during the next 25-35 years air temperatures in the Pacific Northwest may rise 2-5°C (Wu et al. 2012), maximum water temperatures where some Pacific Lamprey exist now may exceed the lethal limit for larvae. Whether the UUILT derived from laboratory experiments reflects the natural distribution of larval Pacific Lamprey, or there are effects at warm but sublethal temperatures, is not well understood. We propose to continue an evaluation of i) whether larval Pacific Lamprey occupy streams where water temperatures exceed 27.5°C, ii) whether larvae occupy areas these areas at a similar rate to areas where temperatures do not exceed 27.5°C, iii) whether burrowing may provide refuge from warm water and iv) whether sublethally warm temperatures influence larvae.

The study area for this project was the Umatilla River, Oregon (henceforth, river). Based on historical data, we partitioned the river into four thermal zones (TZ1-4) (see Whitesel and Sankovich 2022). 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 a control area (little to no thermal stress) and TZ2 as a treatment area (nearing or exceeding the UUILT for larval Pacific Lamprey). In both TZ2 and TZ4, we identified 10, random and spatially-balanced, 50-m sample reaches (see Stevens and Olsen 2004) for occupancy surveys (see Whitesel and Sankovich 2022). Each sampling event consisted of electrofishing a reach to determine if larval lamprey were present (Silver et al. 2010). Each reach was electrofished using an AbP-2 backpack electrofisher with relatively more effort spent in Type I habitat (Slade et al. 2003) and relatively less effort spent in Type II and Type III habitats (see Whitesel and Sankovich 2022). 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 the most downstream and upstream sample reach of both zones, a temperature logger was deployed on the substrate surface and another at the same point in the reach but 4-7 cm below the substrate surface.

In 2020, the maximum water temperature occurred on 30 July (U.S. Bureau of Reclamation monitoring station, Pendleton, Oregon). In TZ2, the water temperature above the substrate reached values > 27.5°C between 19 July and 18 August and below the substrate reached values > 27.5°C between 21 July and 18 August. In TZ4, the water temperature above the substrate reached values > 27.5°C between 15 July and 10 August whereas below the substrate never exceeded 27.5°C. During these respective periods, when compared to temperature at the substrate surface, temperature below the substrate surface was less variable in both TZs, had a colder average in TZ2 and a warmer average in TZ4. Sample events occurred from 25-29 June (B), on 13 August (D) and on 21 September (A). In both TZ2 and TZ4, five, six and five reaches were sampled during the B, D and A sample events, respectively. Larval Pacific Lamprey occupied an area in the river (TZ2) where surface and subsurface water temperatures exceeded 27.5°C. Larval Pacific Lamprey occupied TZ2 and TZ4 before, during and after the period of maximum summer temperatures. Larvae did not appear to vacate TZ2 during or after the period of maximum temperatures. The proportion of reaches in which larval Pacific Lamprey were detected was high (0.83-1.00) and did not differ between either thermal zone or any sampling events. Temperatures below the substrate surface were less extreme than temperatures at the substrate surface but in the warmest areas, still reached values exceeding 27.5°C. Larval Pacific Lamprey occupied these areas between 19 July and 18 August. During the entirety of this study (see Whitesel and Sankovich 2022, Sankovich and Whitesel 2022), larvae demonstrated the ability to occupy areas where the maximum water temperature above and below the substrate reached values of 33.6°C and 29.0°C, respectively, suggesting that their UUILT is at least 29.0°C. It is unclear whether occupancy is common in other rivers that reach these temperatures. The importance of temperatures below the substrate as a thermal refuge, as well as how individual larvae behave or if they experience sublethal effects when the water is relatively warm, are unknown.

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