Developing metrics to characterize heat budgets in off-channel habitats, Willamette River, OR

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Motivation

Fish Need to Cool Off, Too

- The Willamette River exceeds regulatory temperature standards during late spring, summer, and early fall.
- Cold water in side channels and alcoves provide ecosystem services critical for cold water fishes.
- Thermal regimes vary between and within off-channel habitat sites.

Willamette River at Harrisburg, OR, USGS Gage 14166000

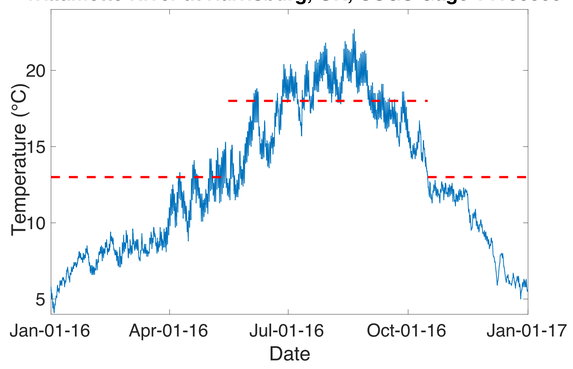


Figure 1. Dashed red lines indicate temperature standards for spawning (13 °C) , and rearing and migration (18 °C) for Chinook salmon and cutthroat trout.

Study Site and Methods

Upper Willamette River: the Most Dynamic Reach

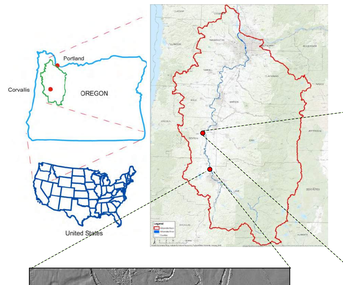


Figure 2. High concentration of off-channel sites allowed collection of temperature measurements at 9 sites between July and September, 2017. Oregon map adapted from Kepner et al. 2012.

9 Sites x 9 loggers/site = 81 temperature records (3 to 47 days ea.)

Temperature Logger Deployments: Characterizing Thermal Regimes by Length and Depth

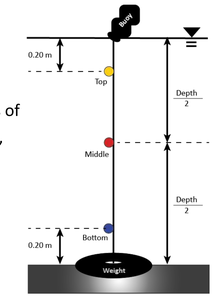
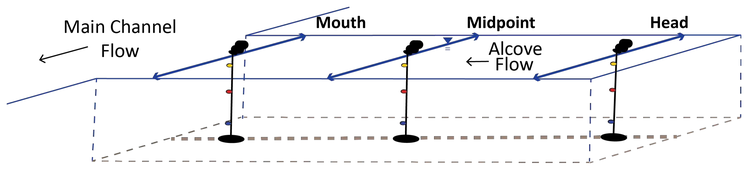


Figure 3. Columns of loggers at bottom, middle, and top depths record temperature.

Figure 4. Three deployment locations at the head, midpoint, and mouth continuously monitored water temperature.



Emerging Stories

Hierarchy of Control ?

Advection

Heat carried by flowing surface water dominates heat budgets in channel

Insolation

Typically dominant among external heat sources and sinks unless shaded

Stratification

Water near surface shades deeper water (Richardson trumps Reynolds!)

Hyporheic

Supplies cool water, but typically overpowered by advection and insolation

$$Re = \frac{inertial\ forces}{viscous\ forces} = \frac{uL}{\nu} \quad < \quad Ri = \frac{buoyancy\ term}{flow\ shear\ term} = \frac{\frac{g}{\rho}\frac{\partial \rho}{\partial z}}{\left(\frac{\partial u}{\partial z}\right)^2}$$

Beavers!

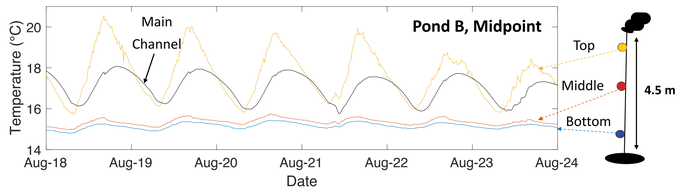
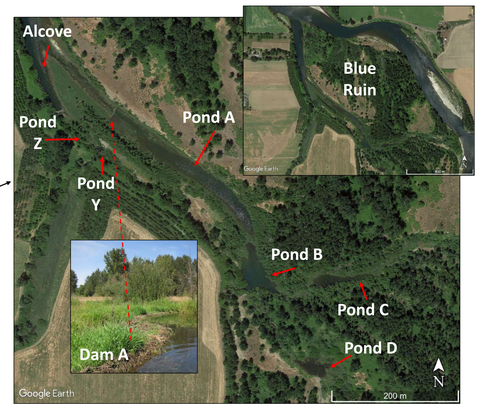


Figure 8. Cold water refuge: temperature in ponds is 2 °C cooler than main channel

Blue Ruin Beaver Ponds

Presence of beavers may increase cold water habitat available



Results

Temperature Varies in Time, with Depth, and over Distance

Blue Ruin Alcove

View looking upstream from mouth to head

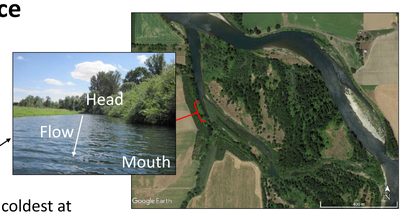


Figure 5. Temperature is coldest at bottom and head

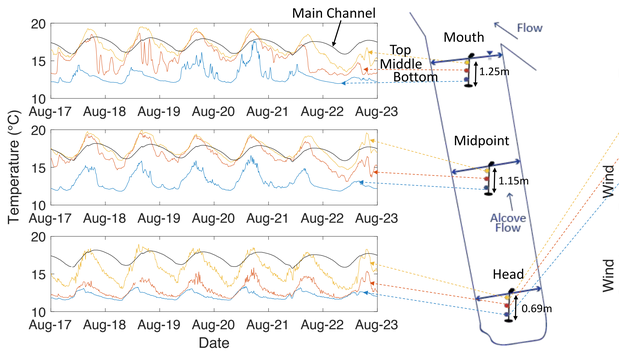
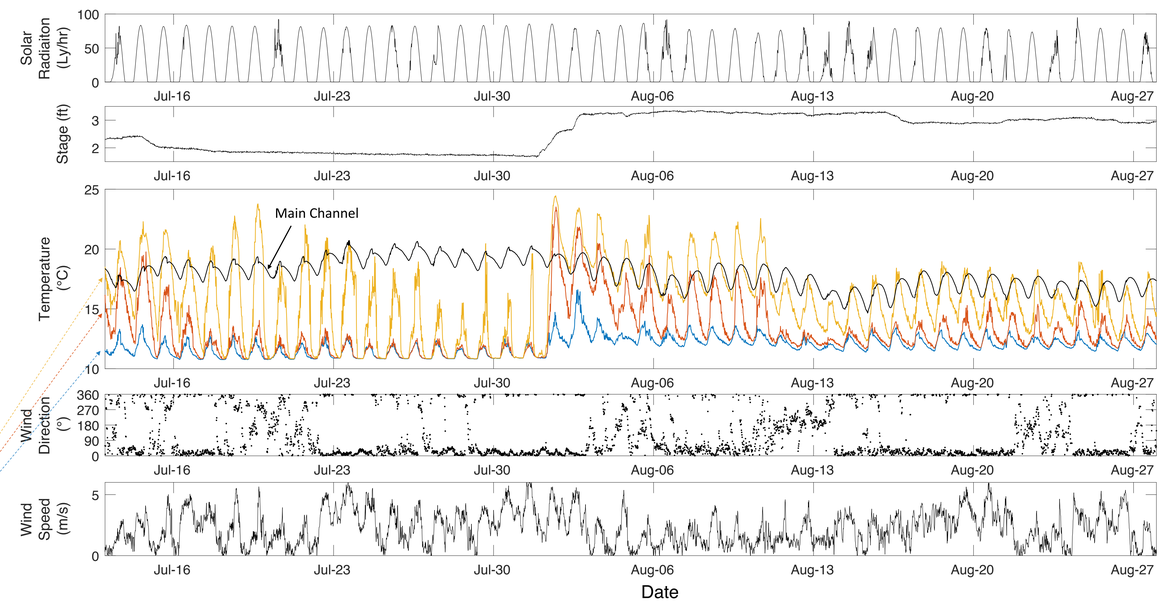


Figure 6. Variations in temperature at alcove head may be explained by solar radiation, stage, and/or wind



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