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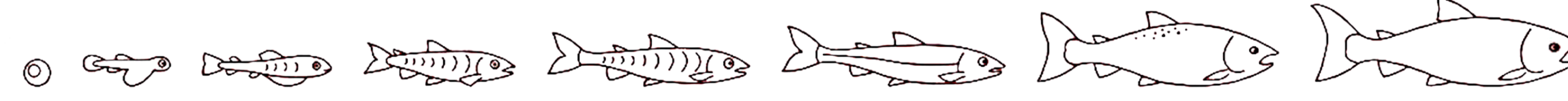
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Treva Coe, Michael Maudlin - Nooksack Natural Resources
Susan Dickerson-Lange - Climate Impacts Group
Tim Abbe, Davey French - Natural Systems Design + Coastal Geologic Services



The Nooksack River is located in the ancestral homelands of the Coast Salish Peoples, who have lived in the Salish Sea basin since time immemorial. I express my deepest respect and gratitude for our Indigenous neighbors, the Lummi Nation and Nooksack Tribe, for their enduring care and protection of our shared lands and waterways.

Hyporheic Upwellings, Cool-Water Refuge, and Hope for Chinook Salmon:

Engineered Log Jam Effectiveness Monitoring on the South Fork Nooksack River (*Nuxw7iyem*)



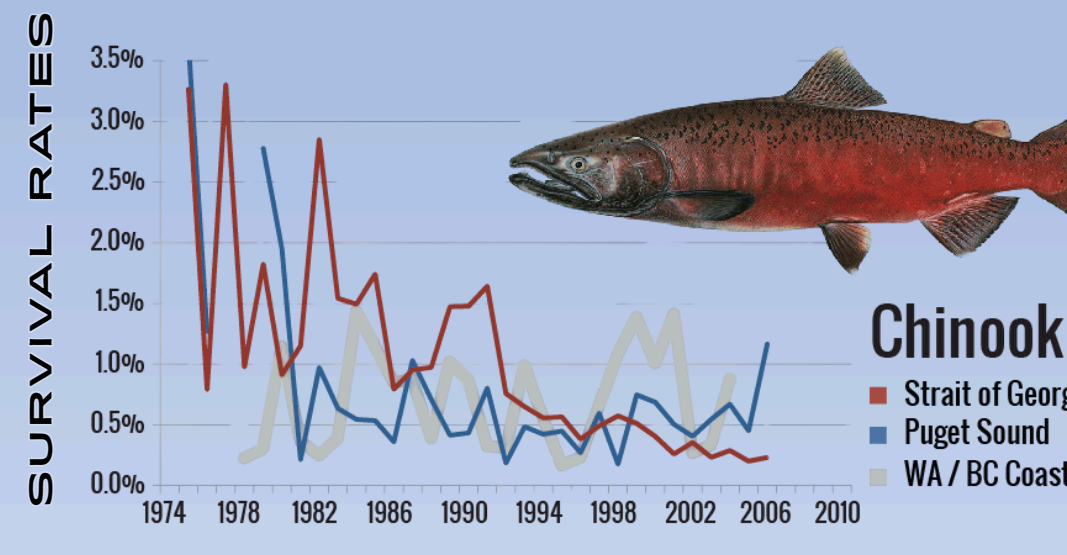
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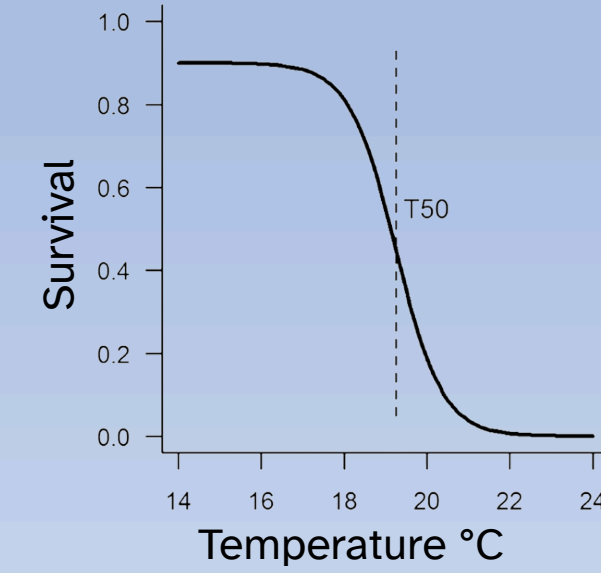
Funding Provided By:



BACKGROUND

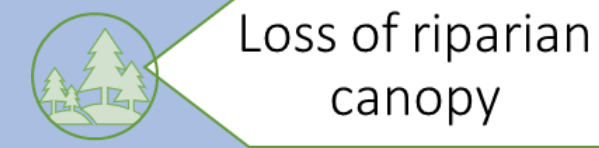


Chinook survival rates are on the decline...



...and rising temperatures are strongly tied to decreased survival rates

Causes of warming:



Loss of riparian canopy



Climate change



Loss of instream wood

Cold water and quality habitat are key to salmon survival

Instream wood supports fish populations by providing:

cover from predation
low-flow refugia
complex habitat
deep, cool pools

hyporheic flux
which drives:
nutrient retention
denitrification and oxygenation



Engineered log jams can help!

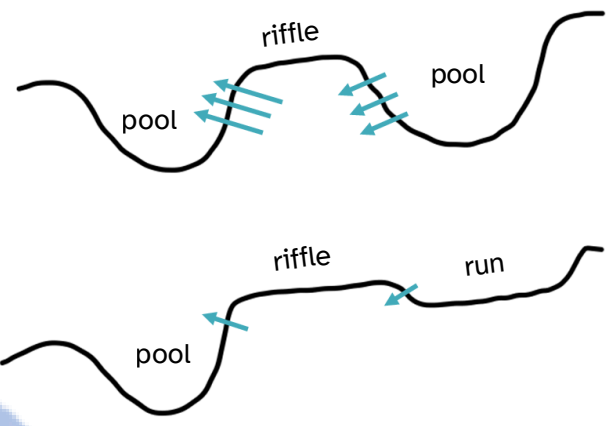
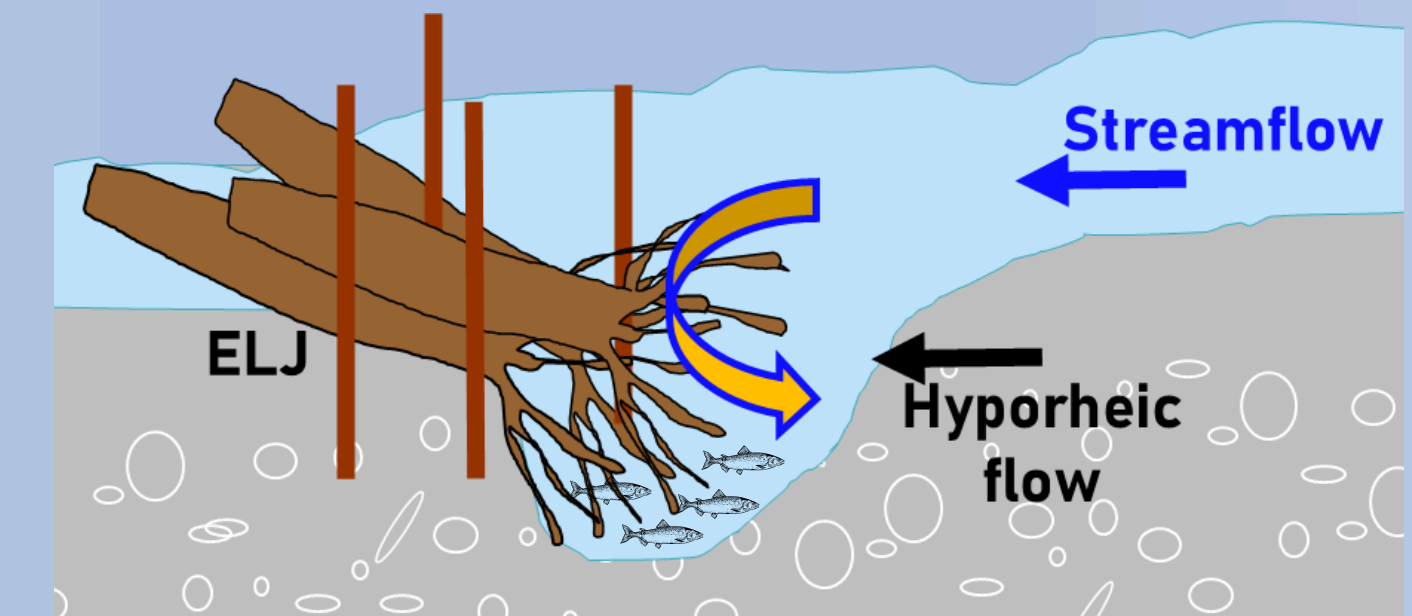


Engineered Log Jam (Site A2) on the South Fork Nooksack River, with piezometers in riverbed

A strategy that can help salmon populations persist in warming rivers involves the construction of engineered log jams (ELJs)

ELJs Promote Hyporheic Exchange

ELJ-formed pools can be utilized to enhance localized upwellings of hyporheic water



In this study, pool temperature was measured in the deepest part of the pool, though it is possible that hyporheic upwellings can provide cool-water refuge in other locations within the pool...

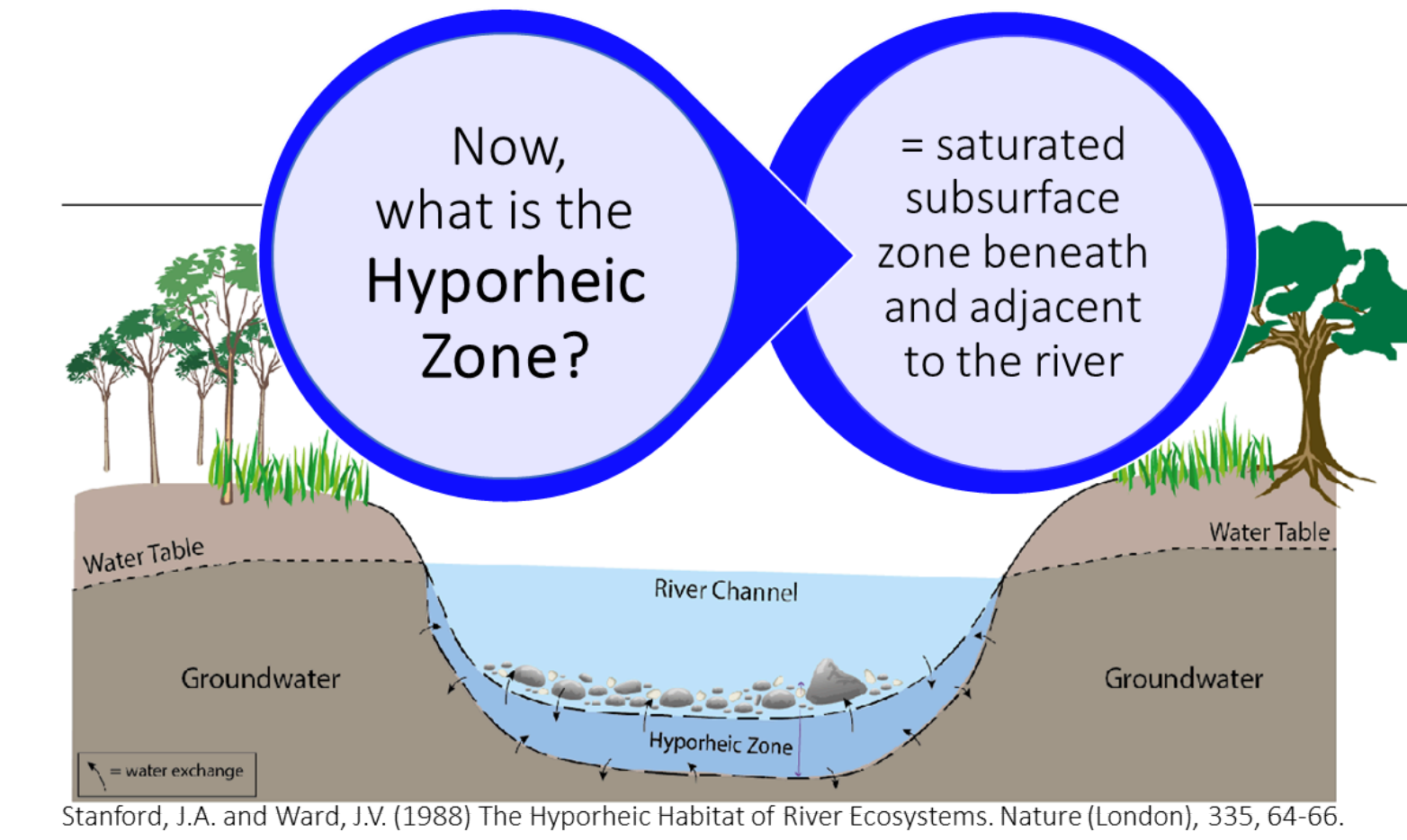


...Head of the pool? Future studies: longitudinal temperature profile (along pool bottom from head to tail), and/or a lateral temperature profile from surface, to mid-depth, to bottom, with intervals in between



TO SAVE THE SALMON, WE MUST CREATE COOL-WATER REFUGE. STEPS WE CAN TAKE TO TURN SCIENCE INTO ACTION:

- Build ELJs downstream of forested meander bends on the adjacent side of the river to optimize groundwater cooling and encourage cool hyporheic upwellings downstream
- Build ELJs near known cold-water sources (such as tributaries, shaded side channels, wetlands, known groundwater upwellings, etc)
- Prioritize Apex ELJs, they may be more effective than Meander ELJs - further studies are needed
- Increase floodplain groundwater levels. Higher floodplain groundwater elevations can contribute to greater upwellings at the head of ELJ-formed pools (Gendaszek 2014). How do we do this?
 - Build more channel-spanning ELJs (ideally downstream of known cold-water sources)
 - Encourage river meandering and increased sinuosity
 - Increase shading via riparian plantings, especially on meander bends and tributaries
 - Focus on the protection/restoration of tributaries and their associated cold water inputs



Apex vs. Meander ELJs

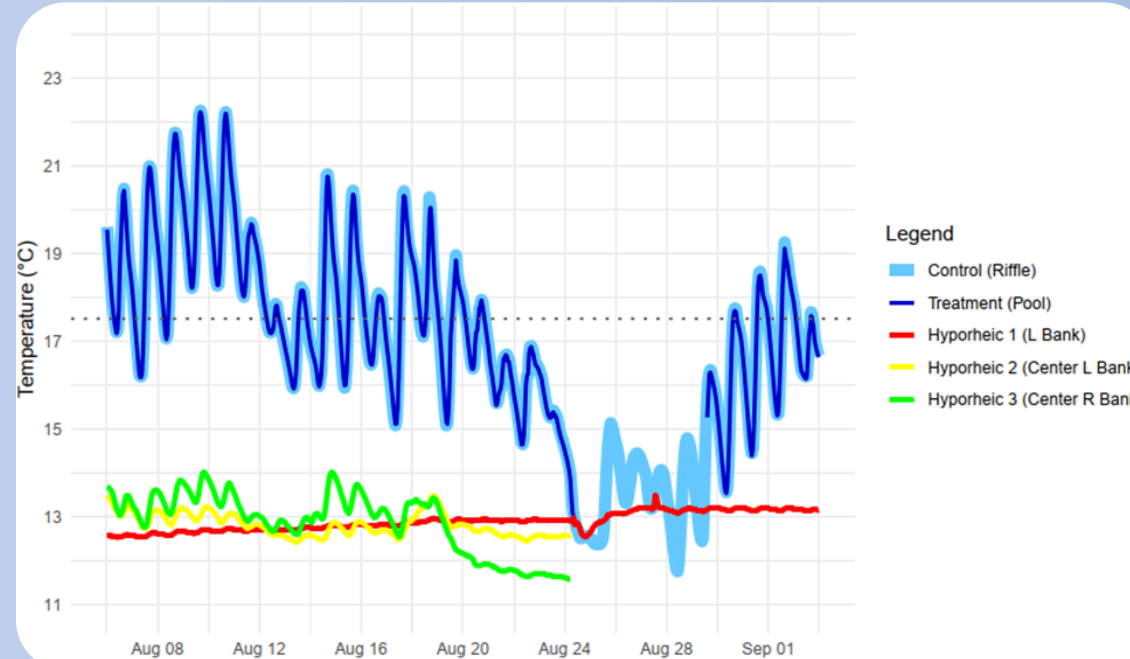
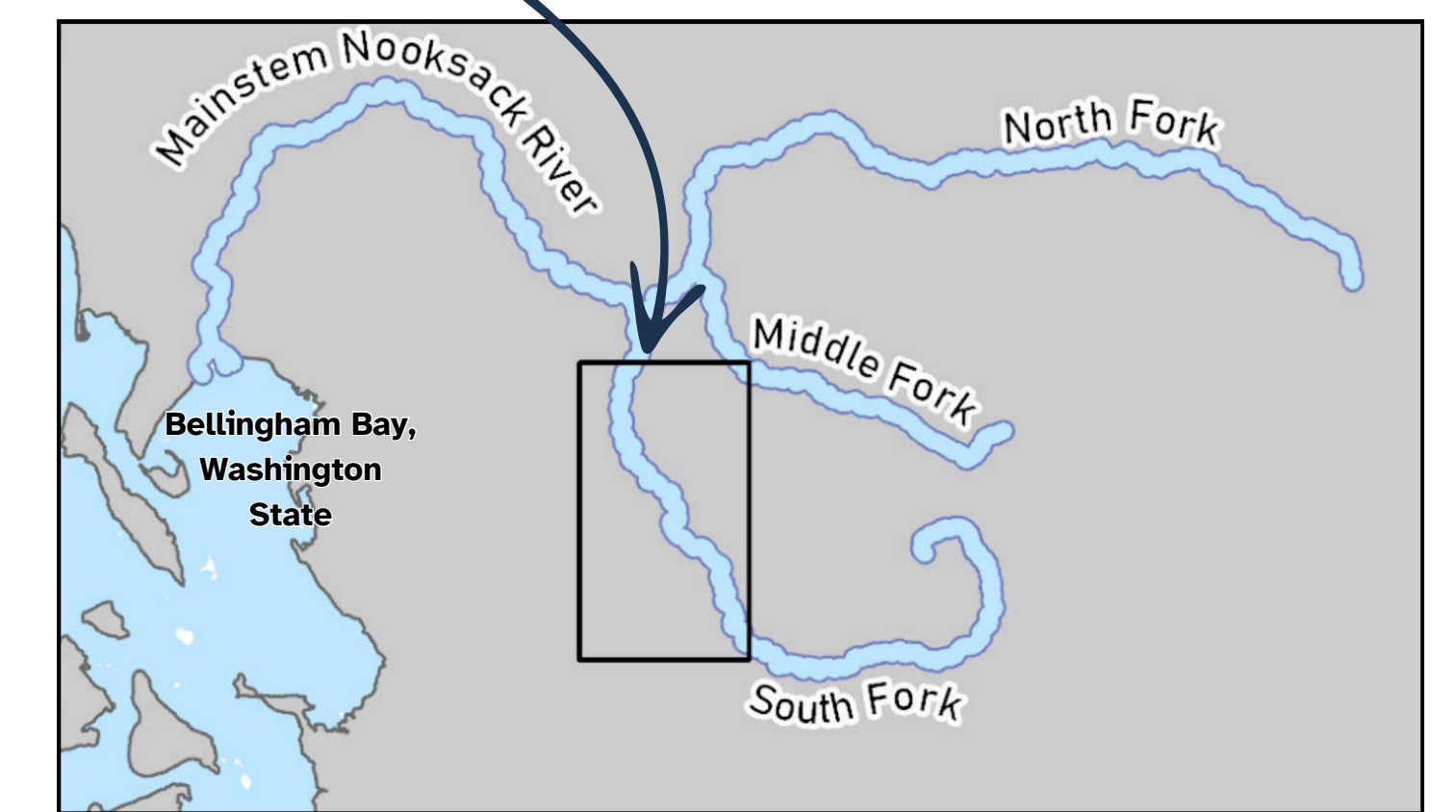
Apex ELJs (Bar Apex): bi-directional flow diversion structures built in the main channel to split or deflect flow around a gravel bar; reducing erosion, protecting banks, enhancing complexity, and creating forest refugia

Meander ELJs: flow diversion structures placed on the outer bend of a meander to deflect flow away from the bank, limit channel migration, restore aquatic habitat, and protect the floodplain and riparian forests (Abbe et al. 2003)

Apex!

- The seven-day average of the daily maximum temperature (7DADM) boxplots for the Apex ELJs indicate that the pool temperature was slightly lower at sites A1-A3, while the treatment and control temperatures at Meander sites are almost identical
- Total hours at Apex sites where the treatment temperature stays below the 17.5°C thermal threshold for salmon exceed those at the control sites

STUDY SITE: South Fork Nooksack River



Control, treatment, and hyporheic temperatures at Site M3; dotted line represents 17.5°C thermal threshold for salmon.

However, permutation test results at 9 out of 10 sites present no significant temperature differences between the treatment and the control, with the exception of **Site A2**.

ELJs are still a valuable habitat restoration measure, even in cases where they do not provide cool-water refuge.



These temperature differences are both **biologically** (<17.5°C) and **opportunistically** significant (2°C below control temperature)

SITE A2

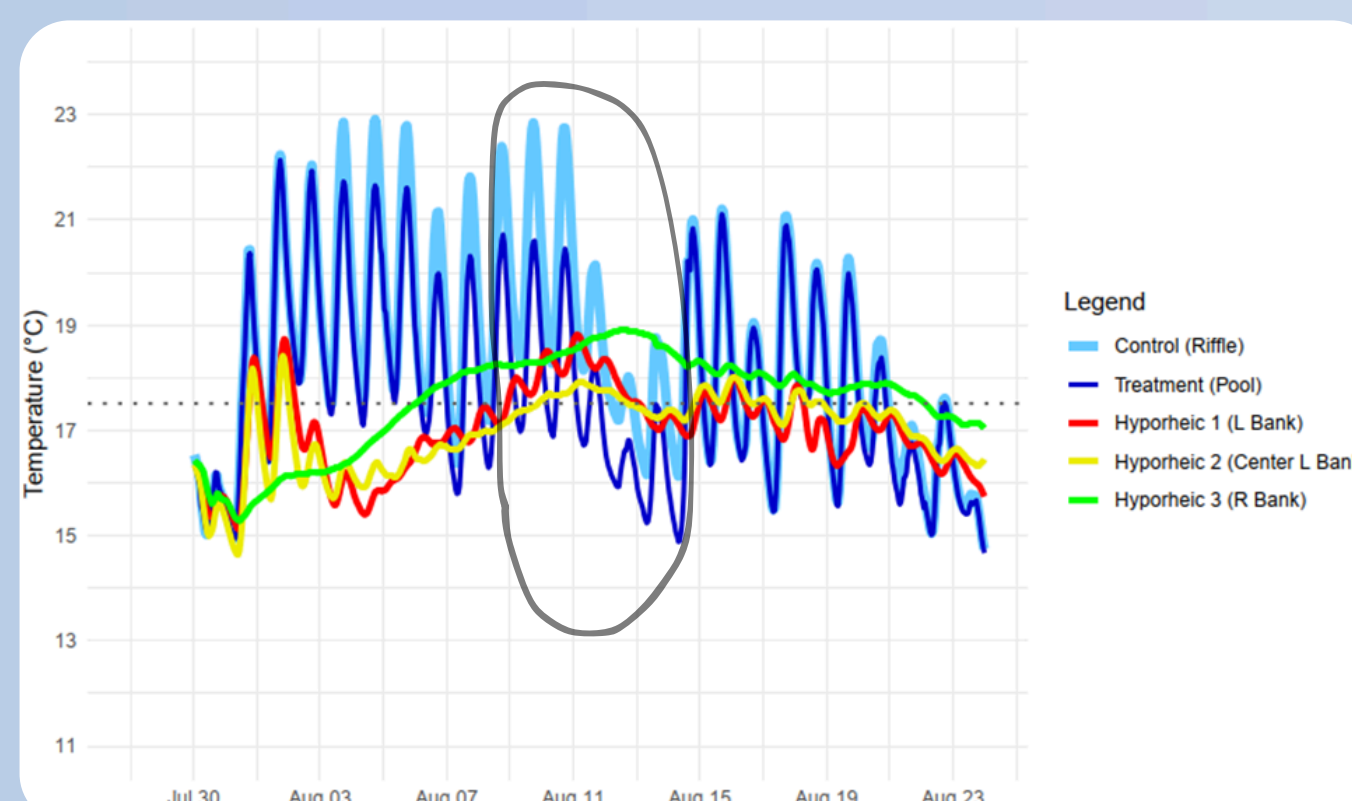
- On 8/9/24 and 8/10/24, the temperature measured in the treatment was 2°C below the control for seven hours, from 1 - 7 PM
- On 8/14/24, the treatment temperature was 2°C below the control for one hour, at 12 PM
- During the study, the treatment temperature was below 17.5°C for 62 more hours than the control

- Hyporheic upwellings don't always lead to cooler temperatures in the deepest part of the pool



In some cases, ELJ-formed pools can create thermal refuge for salmon at certain times of the day

-Wide variation in hyporheic temperatures
-Treatment & Control temperatures were nearly identical at all sites
Exception August 9th-14th, 2024, Site A2:



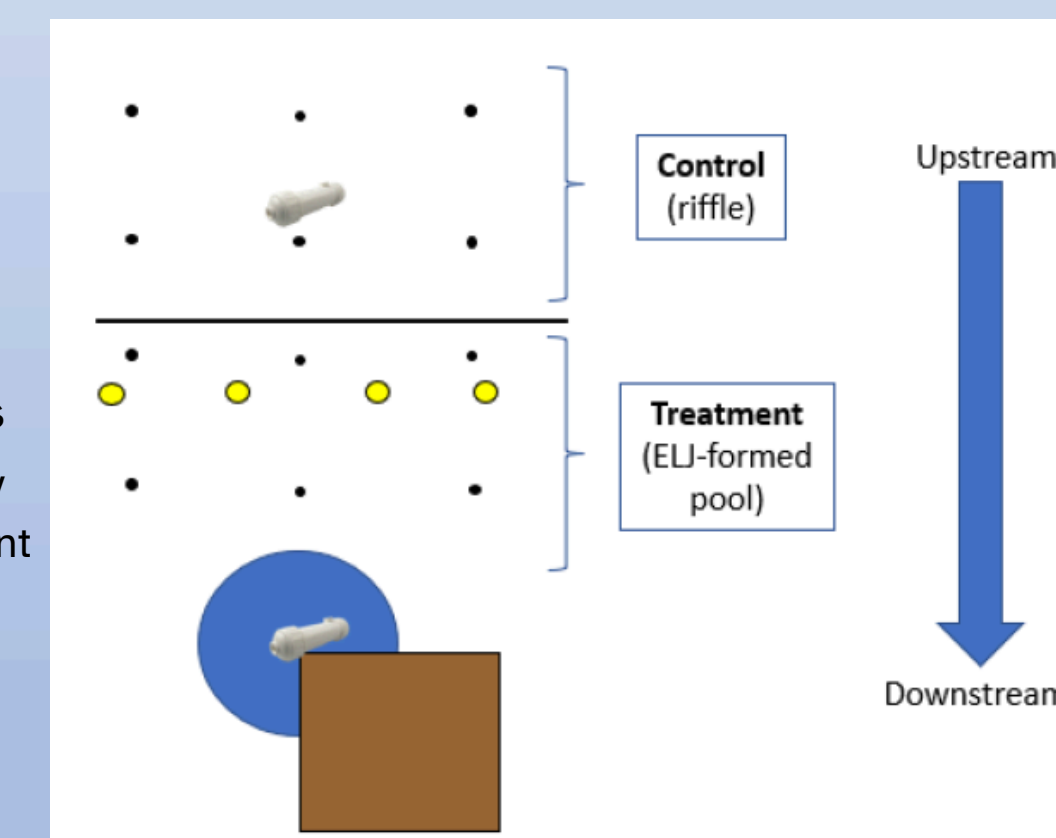
Control, treatment, and hyporheic temperatures at Site A2; dotted line represents 17.5°C thermal threshold for salmon. Significant temperature differences circled.

RESULTS

Response Variables
Streambed Topography
Vertical Hydraulic Gradient
Water Temperature
Fish use

- Preliminary results suggest that adult salmonids prefer ELJ-formed pools over other habitats

10 Experimental Study Plots



Hyporheic temperature was gathered from four piezometers installed into the hyporheic zone



Each study site included one ELJ and associated pool

Researchers evaluated the effectiveness of ELJs to promote localized upwellings of hyporheic flow to offer cool-water refuge for salmon