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Priest River thermal patterns and implications for coldwater fishes

Francine H. Mejia

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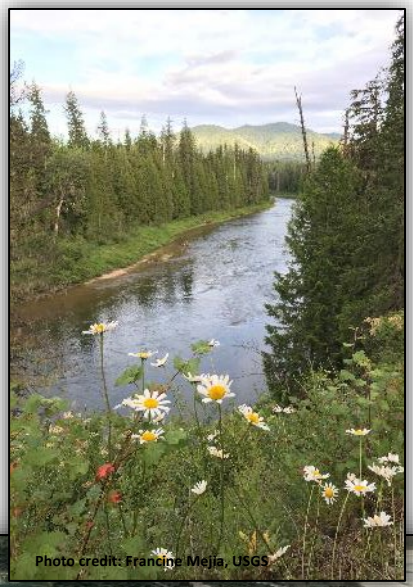
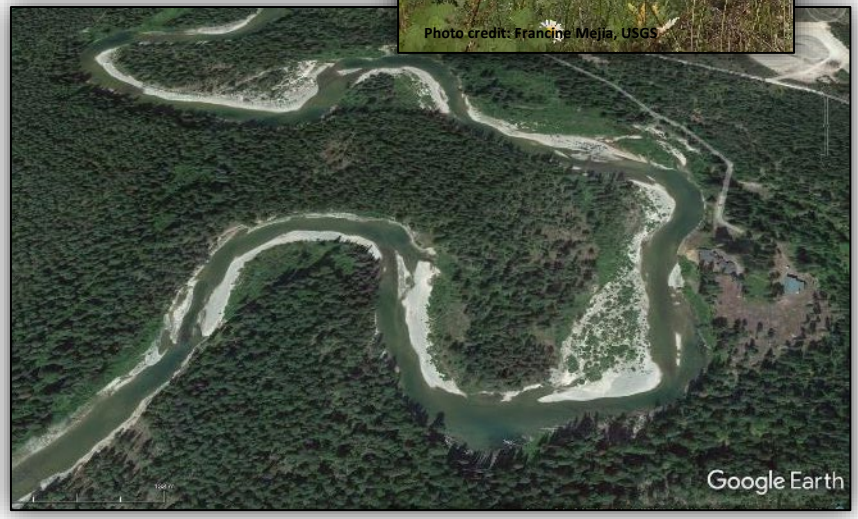


Photo credit: Francine Mejia, USGS



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U.S. Geological Survey

The work presented is a collaboration between USGS and the Kalispel Tribe of Indians

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Presentation outline

- Priest River comparison to other PNW mid-size rivers (NorweST)
- Future water temperature scenarios (NorweST)
- Water temperature effects on coldwater fishes
- Preliminary results of USGS/KNRD studies
  - Food quantity/quality @tributary confluences (2019 data)
  - Thermal patterns mainstem, pools & tributary confluences (2018, 2019 & 2022 data)

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Temperature data are publicly available from:

Mejia, F.H., Torgersen, C.E., Berntsen, E.K., Johnsen, A., and Andersen, T., 2020, Water temperature data from the Priest River, Idaho, 2018-2019: U.S. Geological Survey data release, https://doi.org/10.5066/P9A5MMTN.

https://www.usgs.gov/data/water-temperature-data-priest-river-idaho-2018-2019

Mejia F.H., Connor, J.M., Kaufmann, P.R., Torgersen, C.E., Berntsen, E.K., and Andersen, T. 2021 Integrating regional and local monitoring data and assessment tools to evaluate habitat conditions and inform river restoration. Ecological Indicators. 2021 Nov;131:1-108213. DOI: 10.1016/j.ecolind.2021.108213

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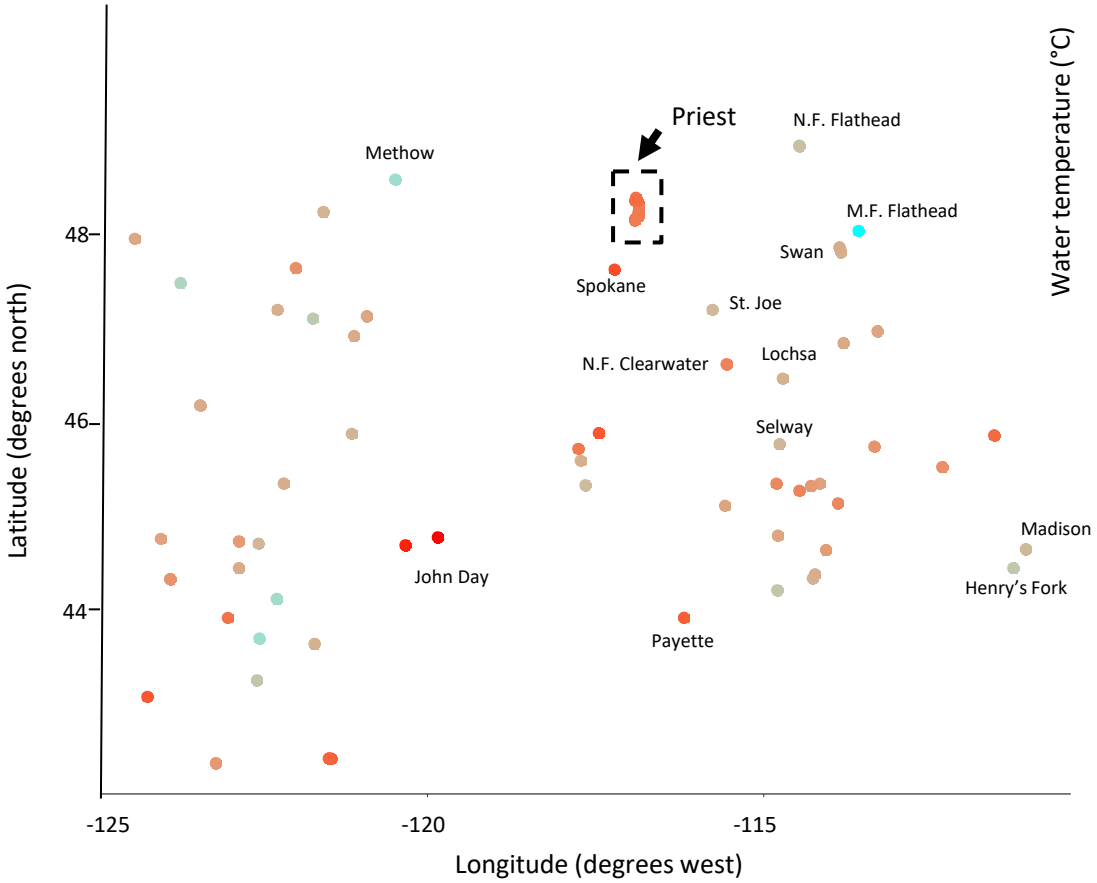
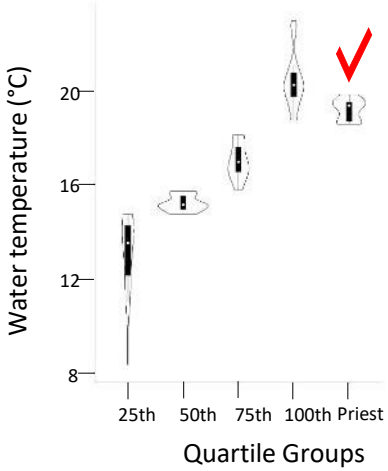
How does the Priest River compare to other rivers?

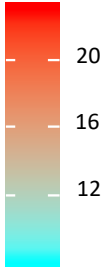
Data source: NorWeST





Violin plots: box plots showing probability density distribution

Water temperature (°C)



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Kalispel natural resources

Water temperature (°C)

- 9.0
- 12.0
- 15.0
- 18.0
- 21.0
- 24.0

Isaak, D.J.; Wenger, S.J.; Peterson, E.E.; Ver Hoef, J.M.; Hostetler, S.W.; Luce, C.H.; Dunham, J.B.; Kershner, J.L.; Roper, B.B.; Nagel, D.E.; Chandler, G.L.; Wollrab, S.P.; Parkes, S.L.; Horan, D.L. 2016.

NorWeST modeled summer stream temperature scenarios for the western U.S. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2016-0033.

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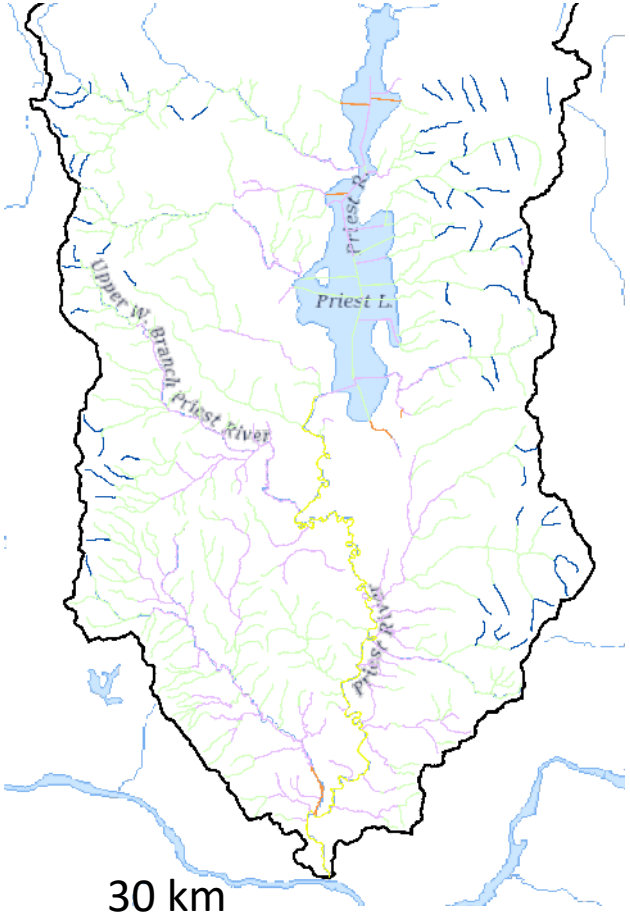
N

Current conditions (1993-2011)



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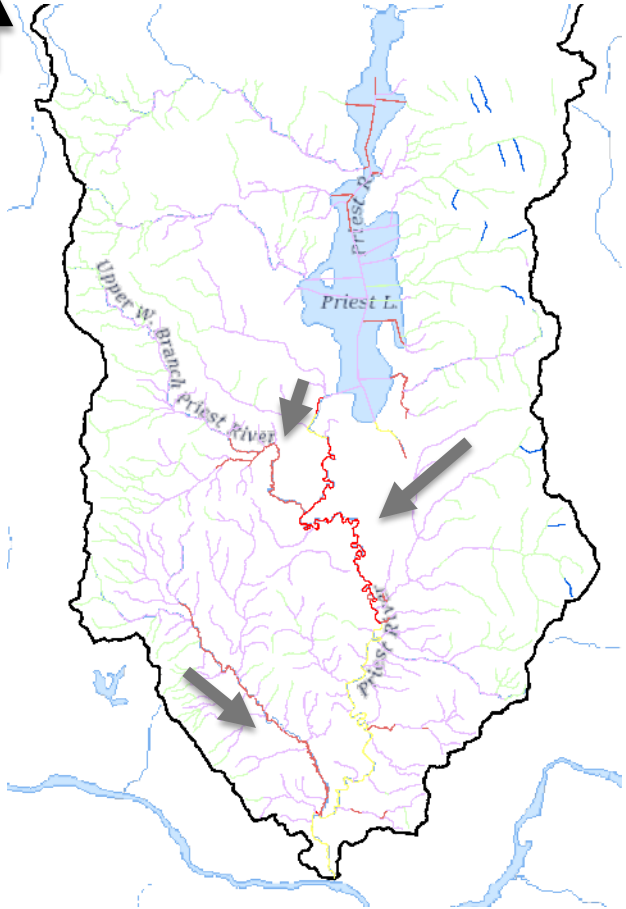
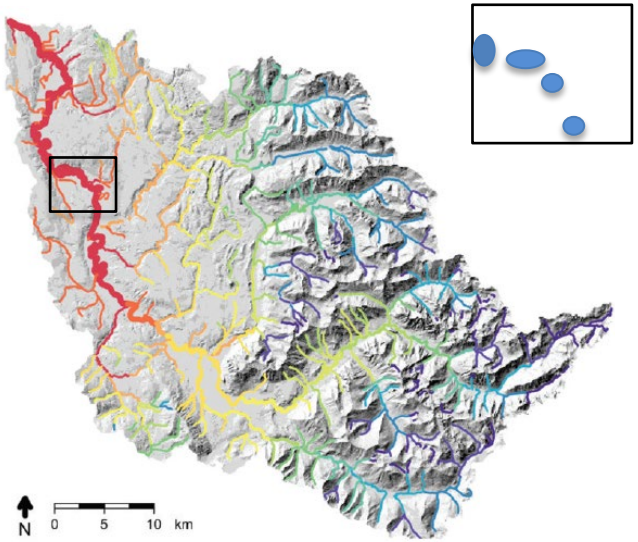
Future (2040)

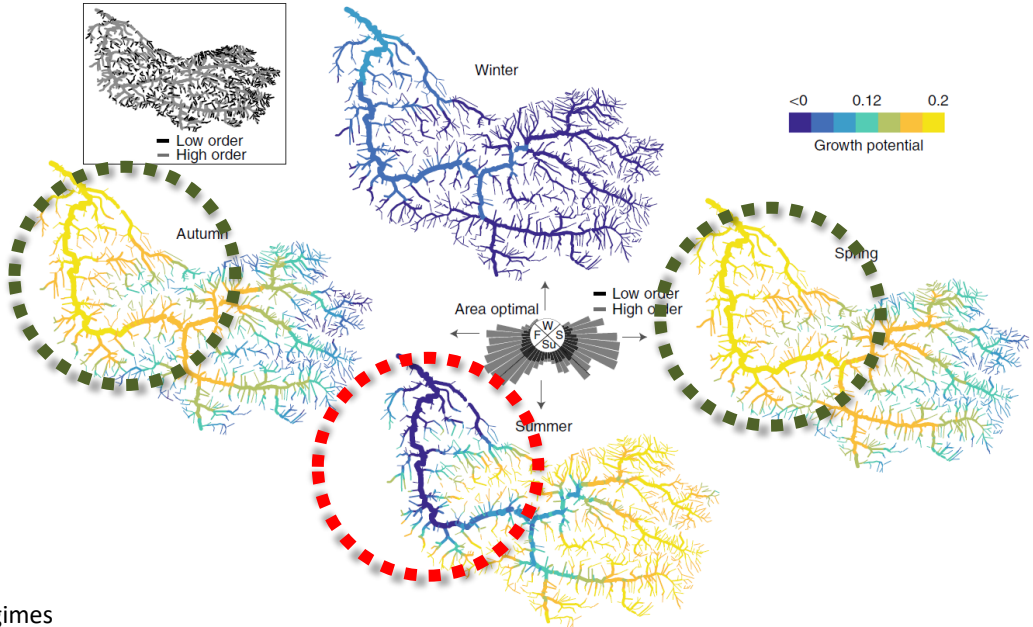


Thermal heterogeneity is important



Temperature variability in Snoqualmie River, WA

Steel et al. (2017). Envisioning, Quantifying, and Managing Thermal Regimes on River Networks. Bioscience, 67(6), 506-522. doi:10.1093/biosci/bix047



Seasonal variation in the landscape patterning of fish growth potential in the John Day River Basin, OR

Armstrong et al. (2021). The importance of warm habitat to the growth regime of cold-water fishes. Nature Climate Change, 11(4), 354-361. doi:10.1038/s41558-021-00994-y

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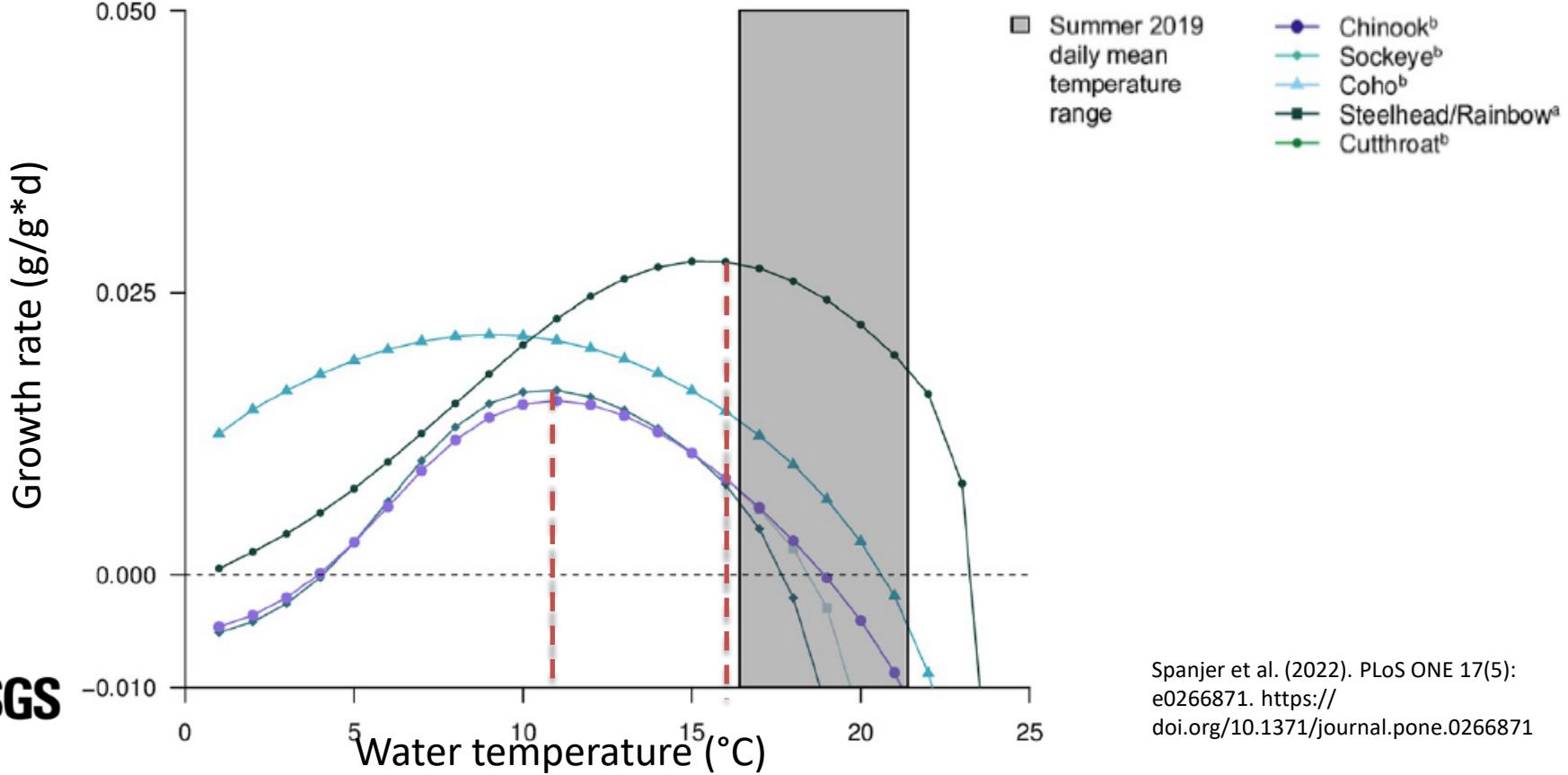
How does water temperature affect coldwater fish?



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Spanjer et al. (2022). PLoS ONE 17(5): e0266871. https://doi.org/10.1371/journal.pone.0266871

How does water temperature affect coldwater fish?

- Metabolic rate changes (energy balance & behavior)
- Movement & feeding -**Bigger Fish!**
- Predation/competition
- Disease
- Food web changes: aquatic Invertebrates
  benthic algae composition

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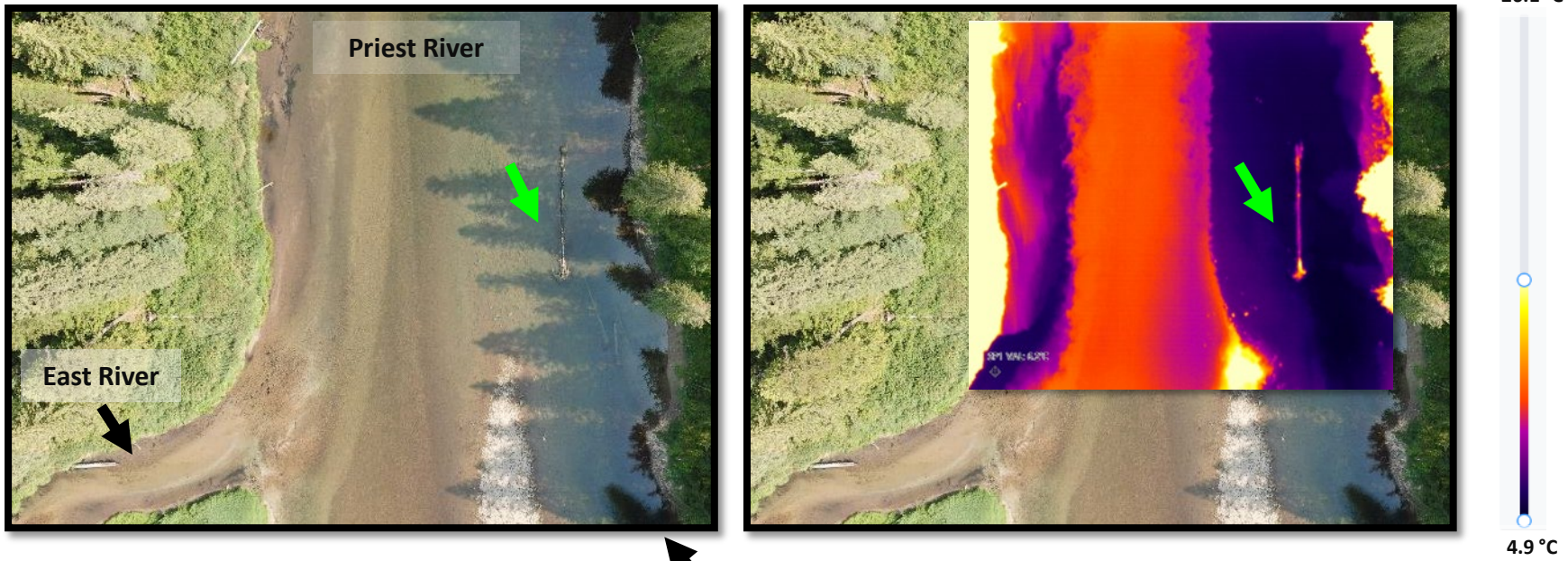

Unnamed cold-water source

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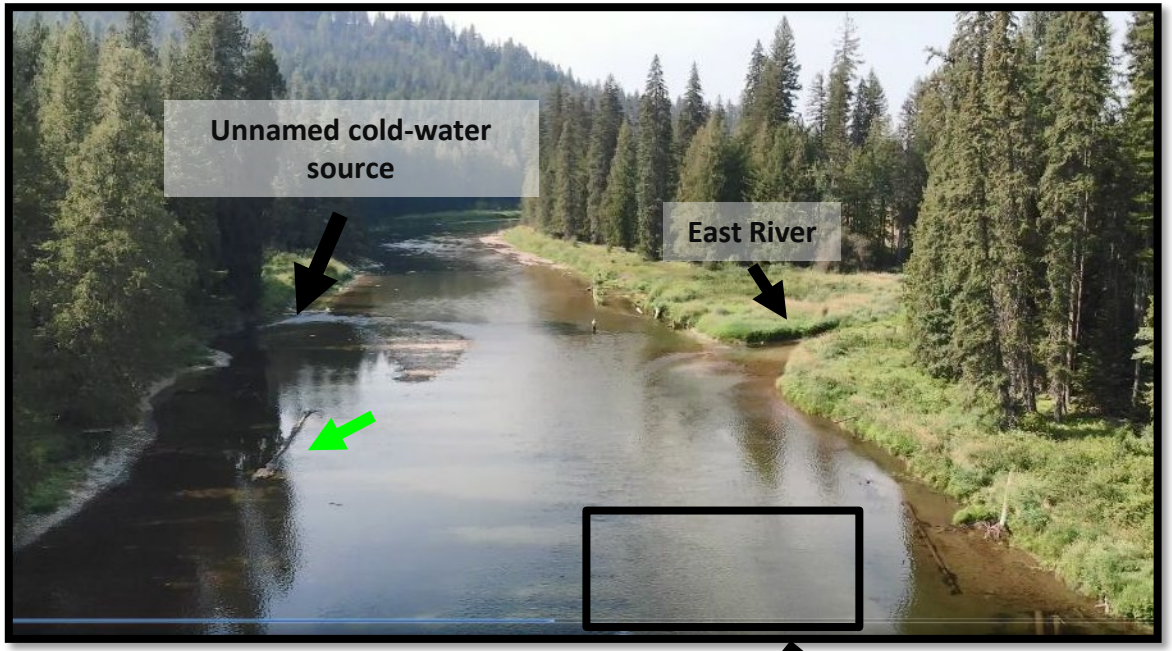
Drone imagery: Kalispel Natural Resources Department



Drone imagery: Kalispel Natural Resources Department

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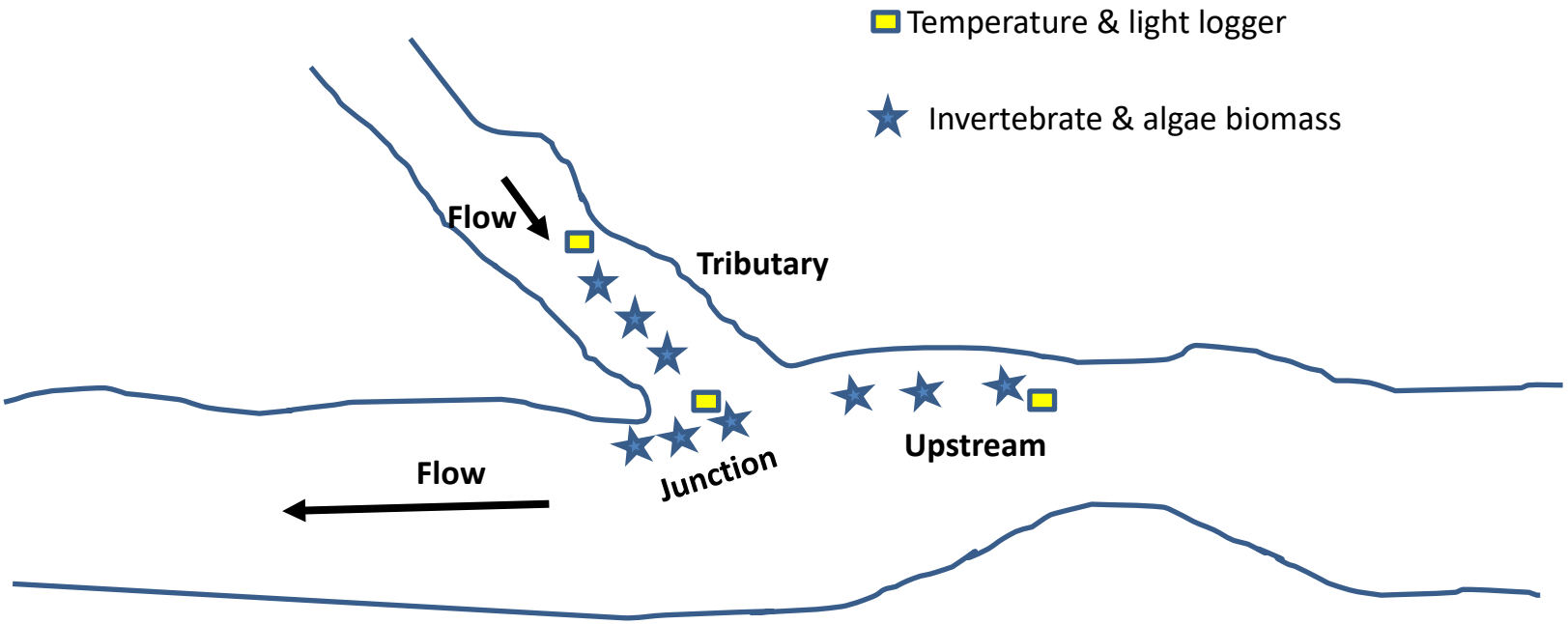
Temperature effects on food quantity & quality

Schematic of sampling



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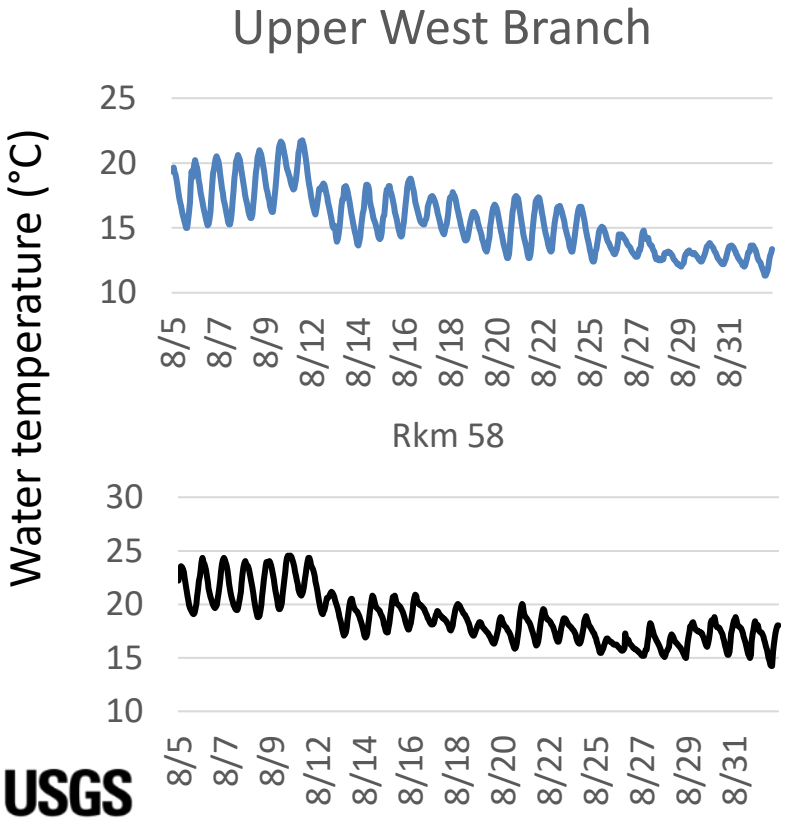
Upper West Branch Priest River

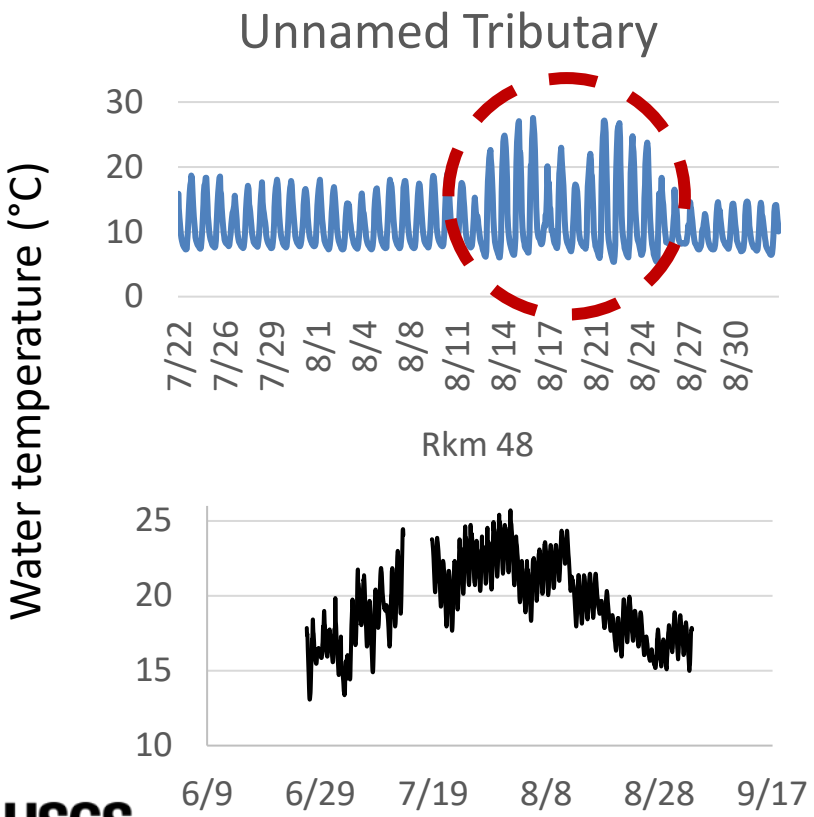
W= 10 m



Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Unnamed trib rkm 47.8

W= 10 m



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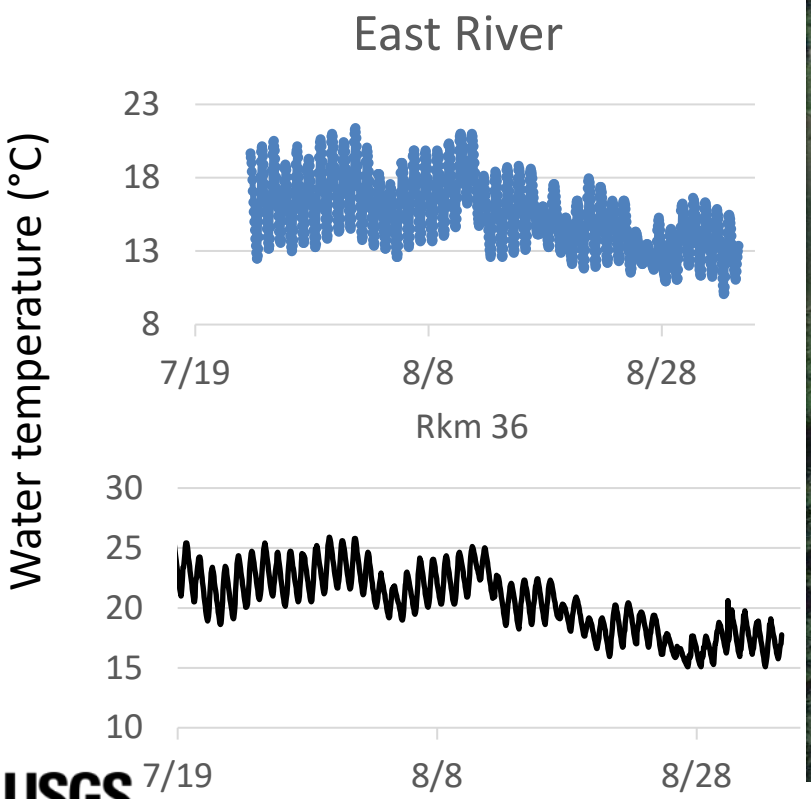
East River

W= 14 m



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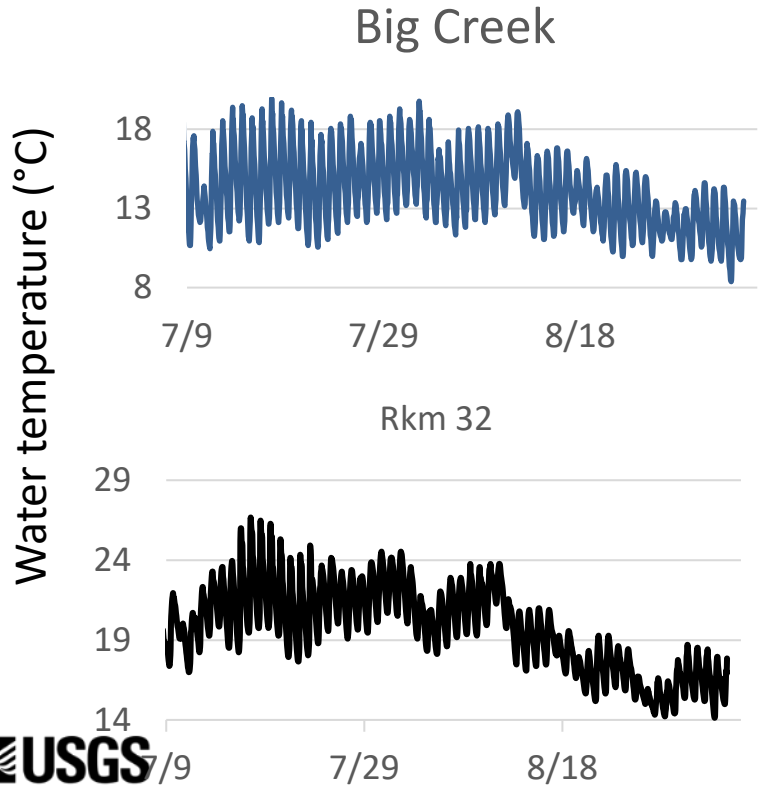
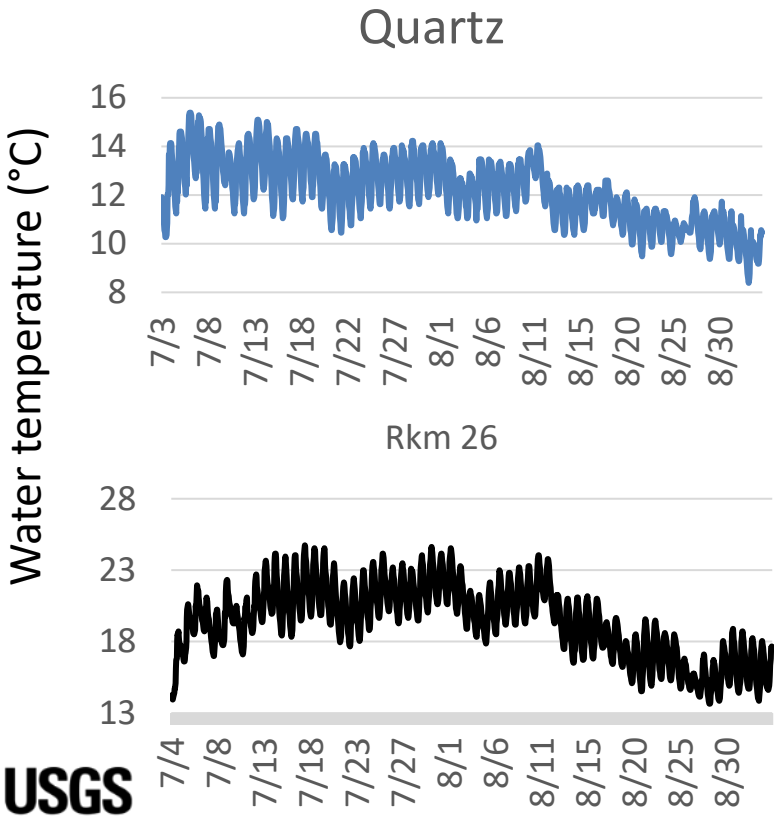
Big Creek

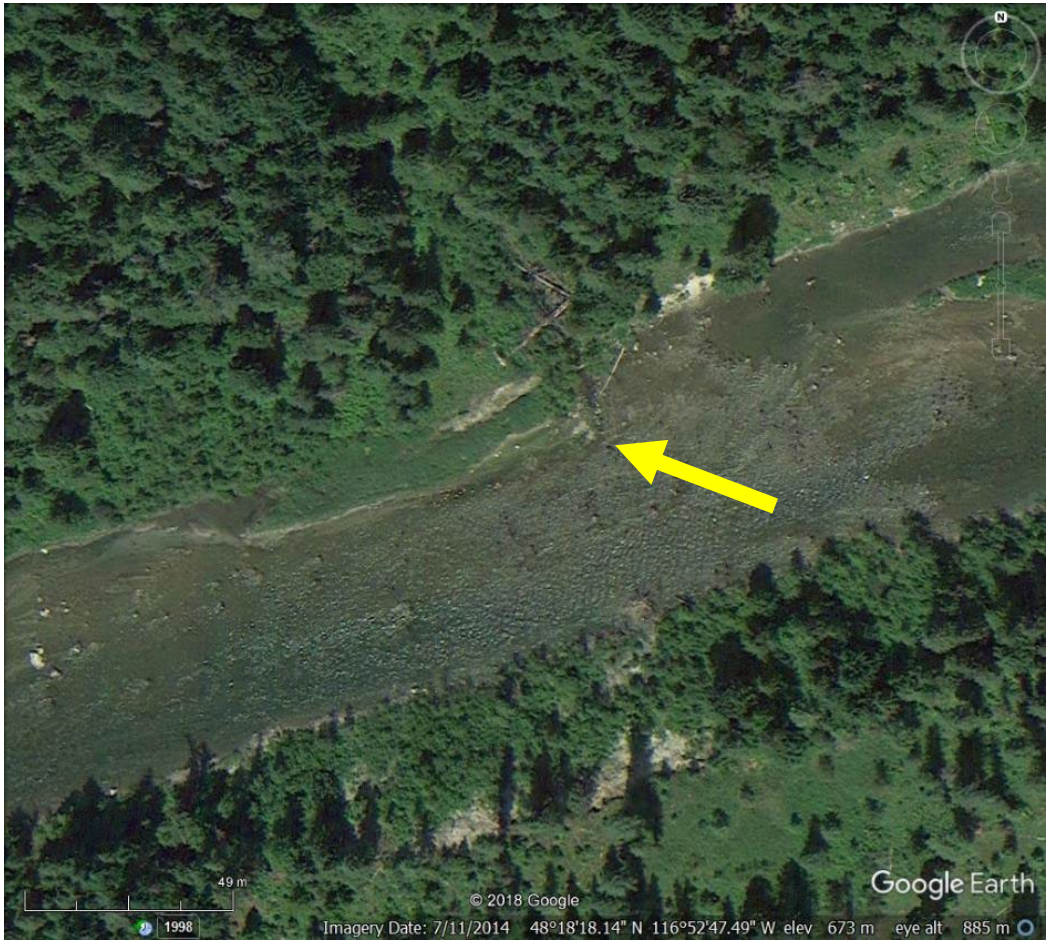
W= 8 m



Quartz Creek

W= 10 m





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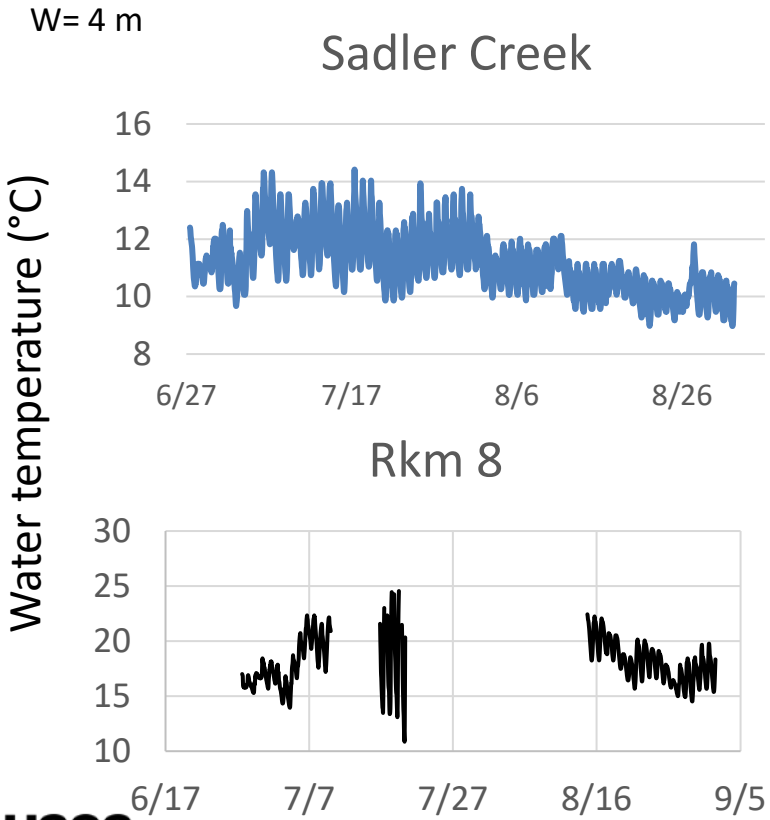
Sadler Creek

W= 4 m



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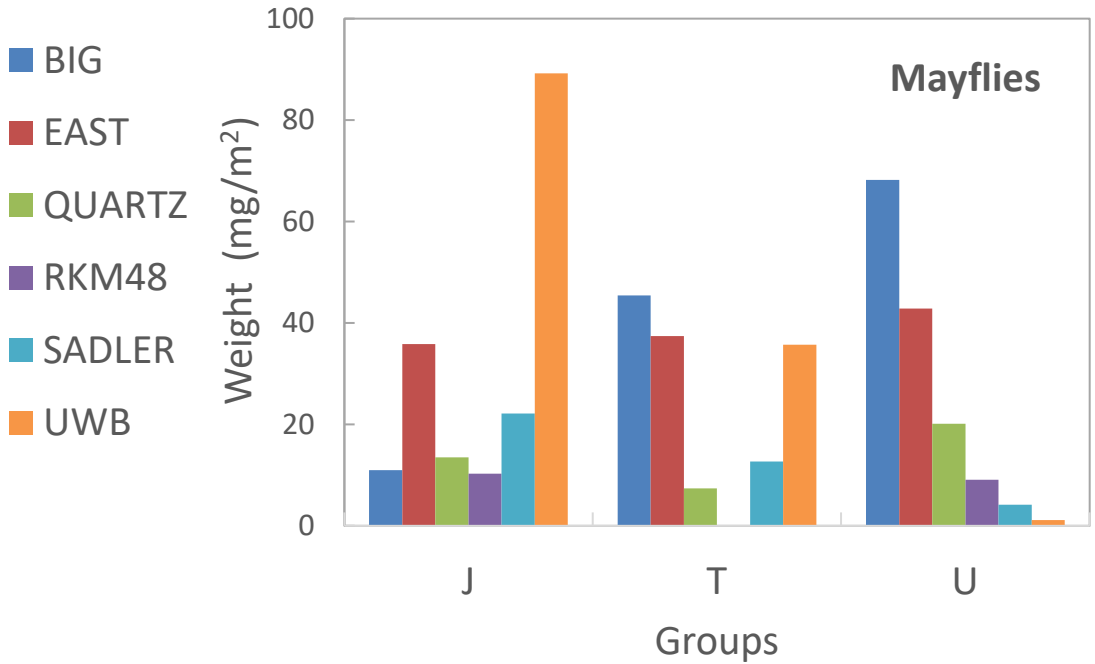
Temperature effects on food quantity & quality

Preliminary Information-Subject to Revision. Not for Citation or Distribution.



Quantity

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J= junction, T=tributary, U=mainstem upstream of confluence

Temperature effects on food quantity & quality

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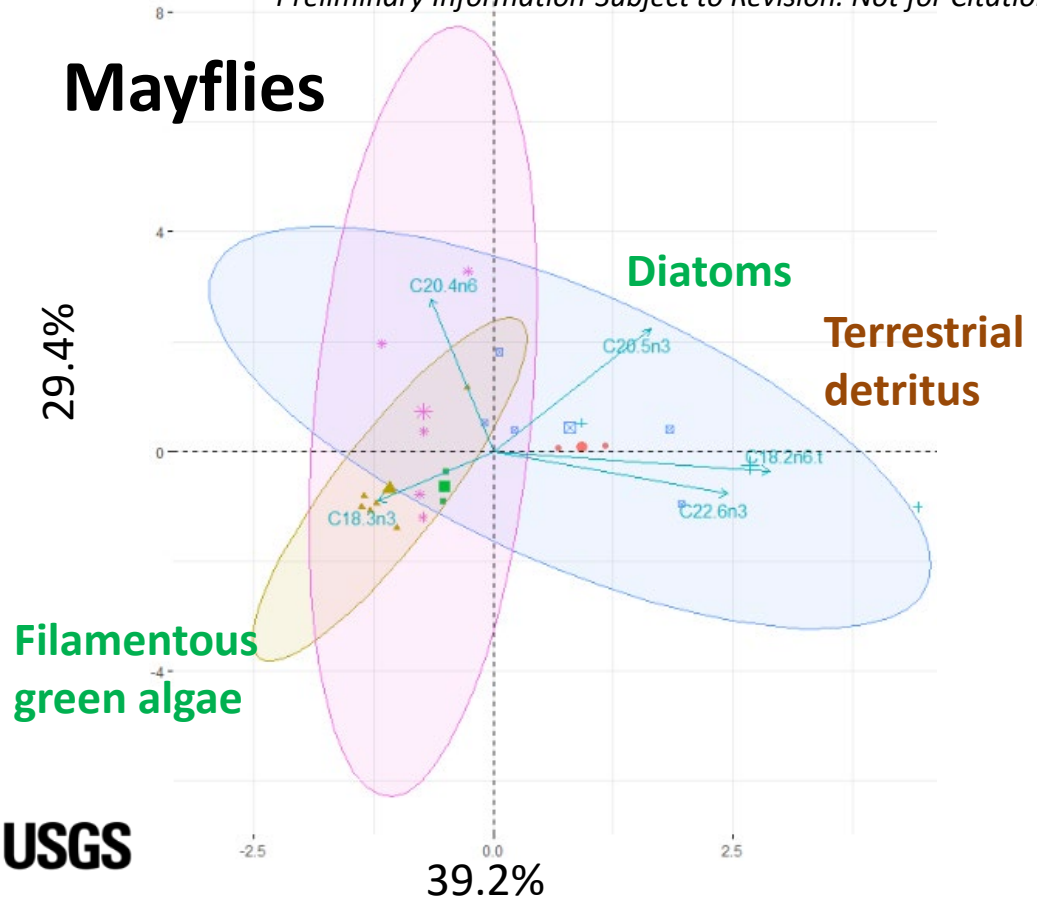

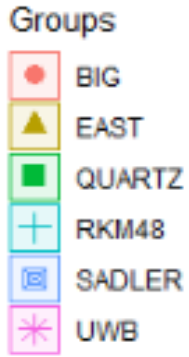

Quality

long-chain polyunsaturated fatty acids (LC-PUFA)

eicosapentaenoic acid; 20:5n-3

arachidonic acid; 20:4n-6

docosahexaenoic acid; 22:6n-3

α-linoleic acid; 18:3n-3

linoleic acid; 18:2n-6

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Temperature effects on food quantity & quality

- Tributary confluences are dynamic areas that have potential for enhancement

- Need to understand the role of thermal refuges in relation to periphyton & invertebrate quality & quantity

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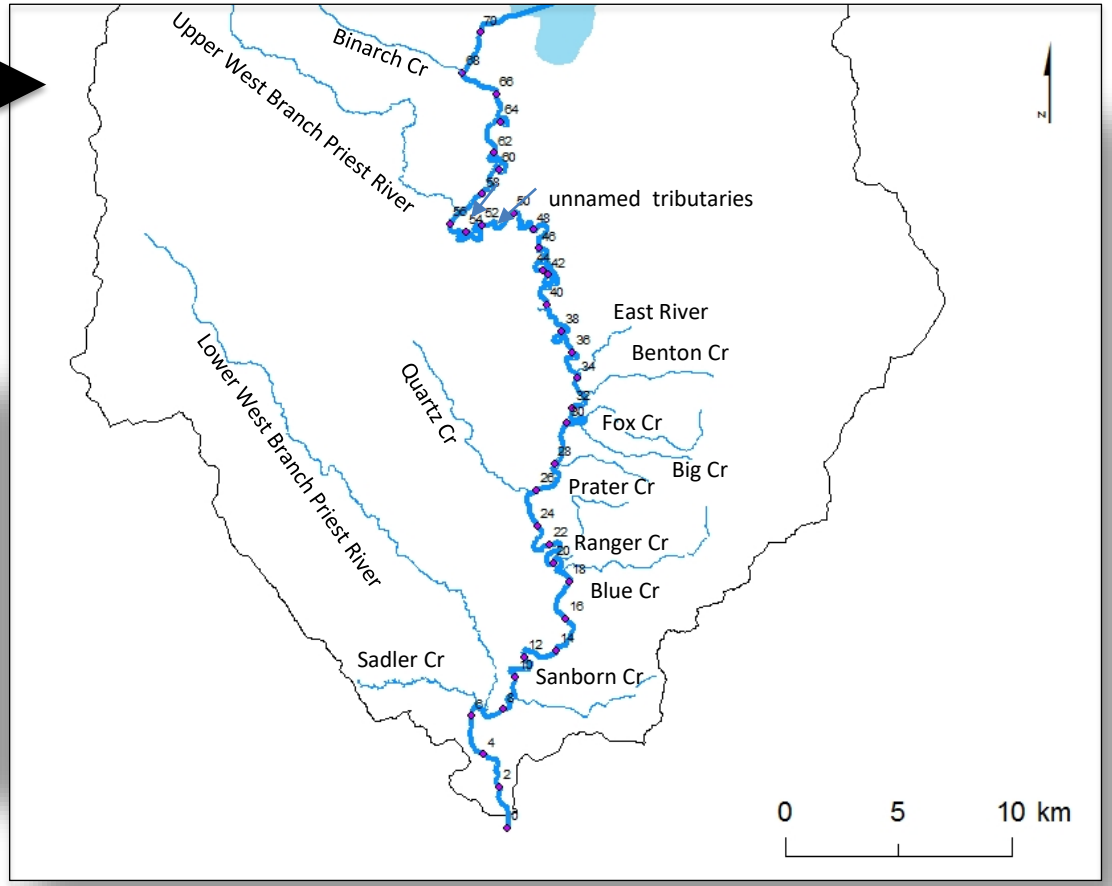
Study area

Picture credit: Christian Torgersen, USGS

Picture credit: Bryan Witte, KNRD



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Methods

Longitudinal profiling

- Temperature
- Bathymetry & water velocity

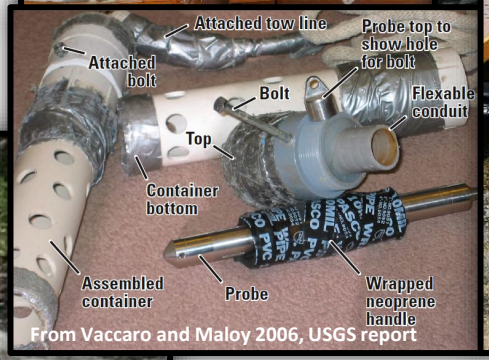

Photo credit: FreshwaterMap

Whole-river surveys!

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Methods

In-situ thermographs for temporal context

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Photos credit: Francine Mejia, USGS

August 21, 2018

Raw data

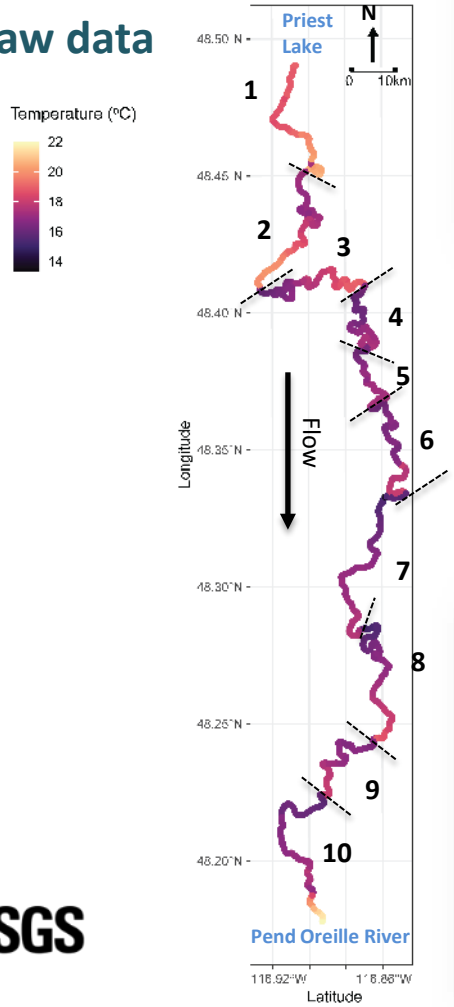

Photo credit: Christian Torgersen, USGS

Photo credit: Francine Mejia, USGS

Photo credit: J. Jaeger, TU

Photo credit: Jonathan Quinn-Hurst, TU

Photo credit: Jonathan Quinn-Hurst, TU

Photo credit: Stephanie Snook, TU

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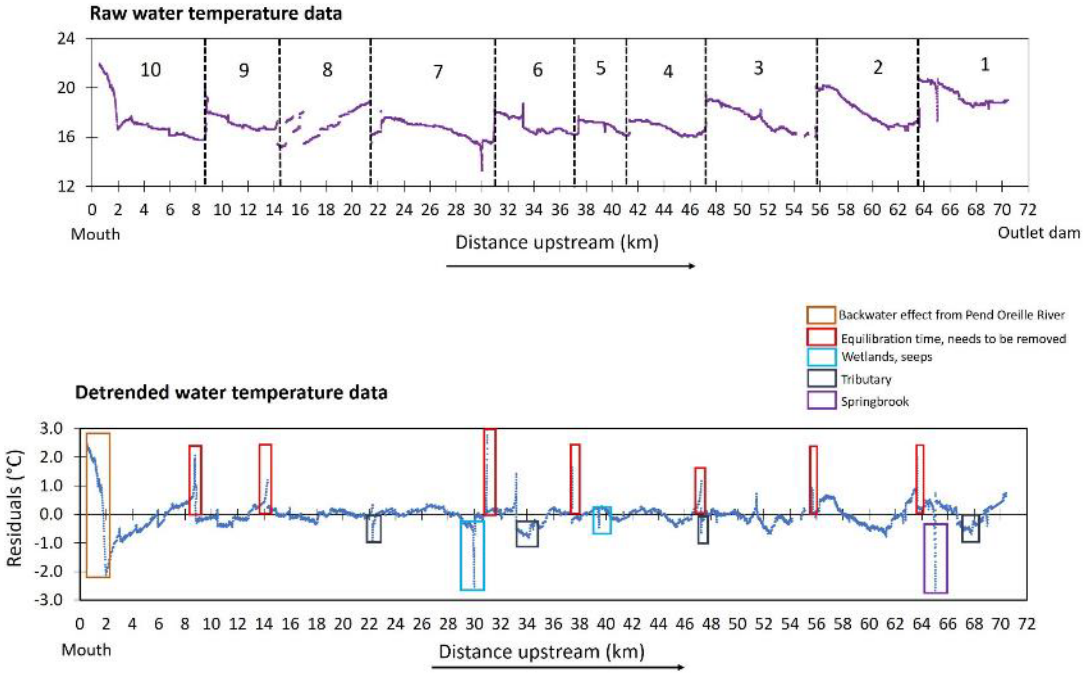
Temperature longitudinal profile

August 21, 2018



Anomalies

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Data interpretation is preliminary

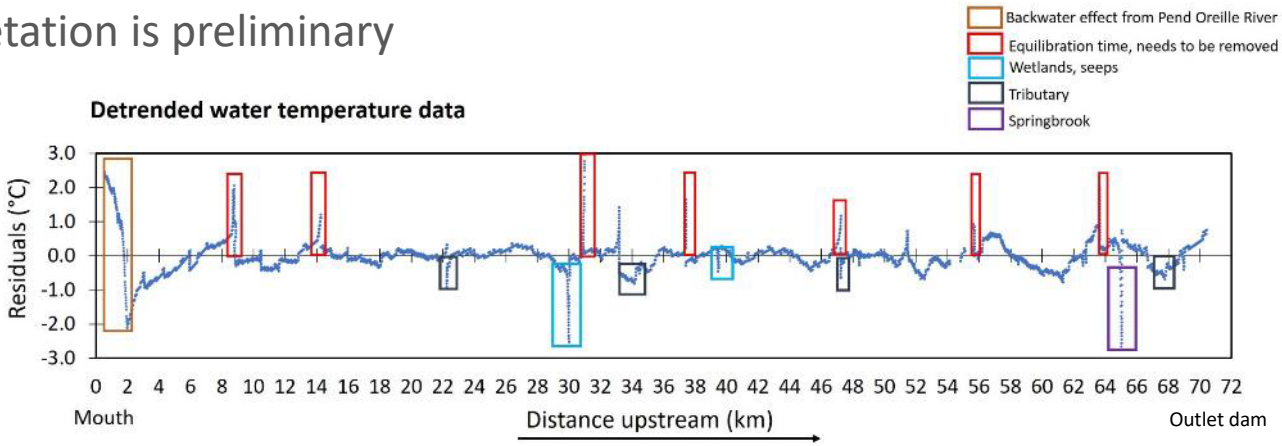
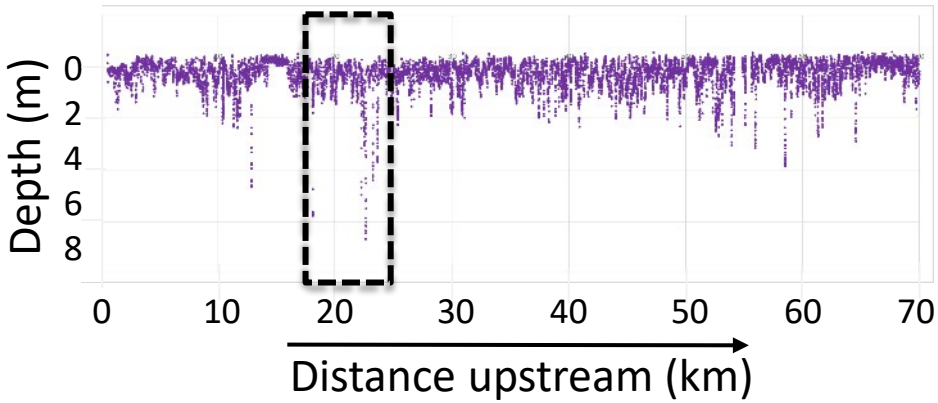
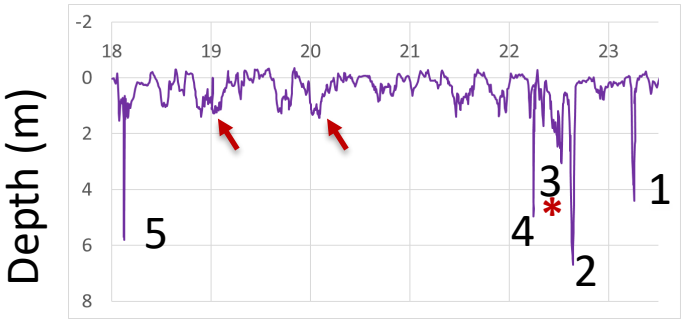


Photo credit: Francine Mejia, USGS

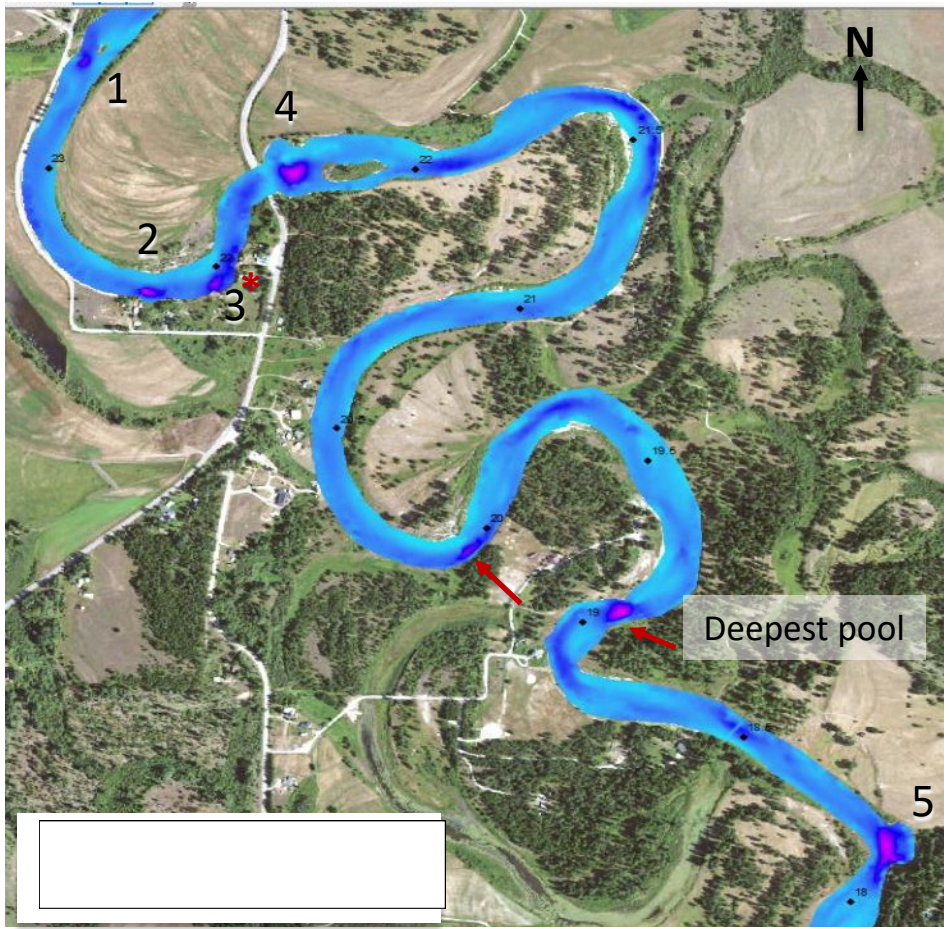
All aerial images from Google Earth

Pressure transducer data (river float)





Bathymetry data (ADCP survey)



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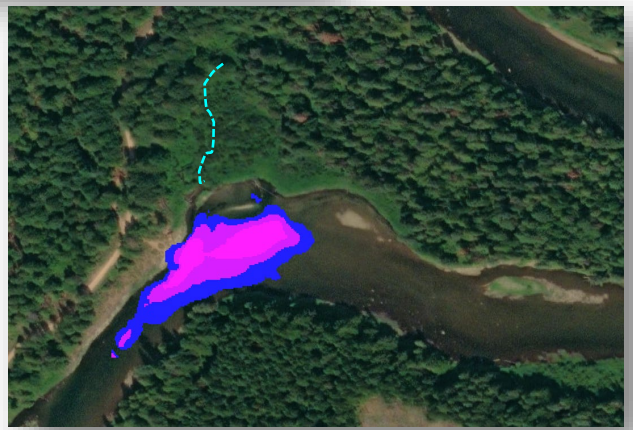
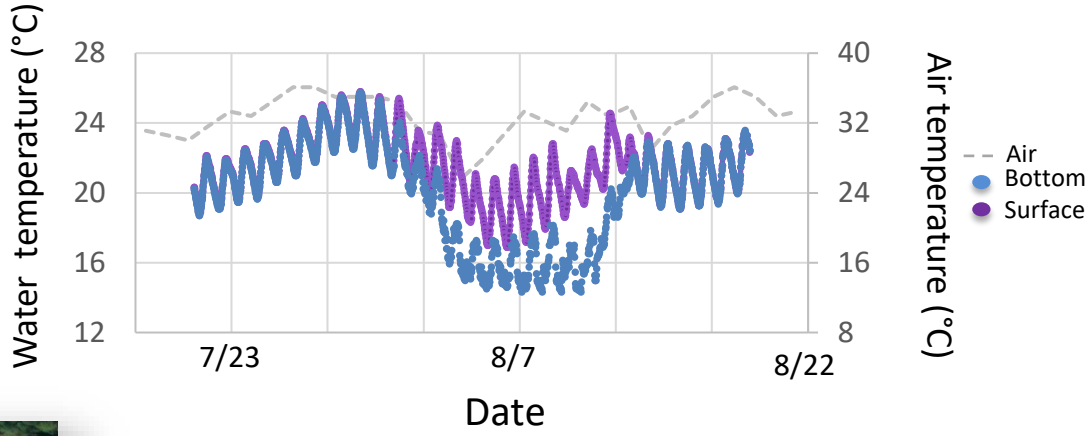
Aerial image: Google Earth

Pools 2022 data

Groundwater/hyporheic connection





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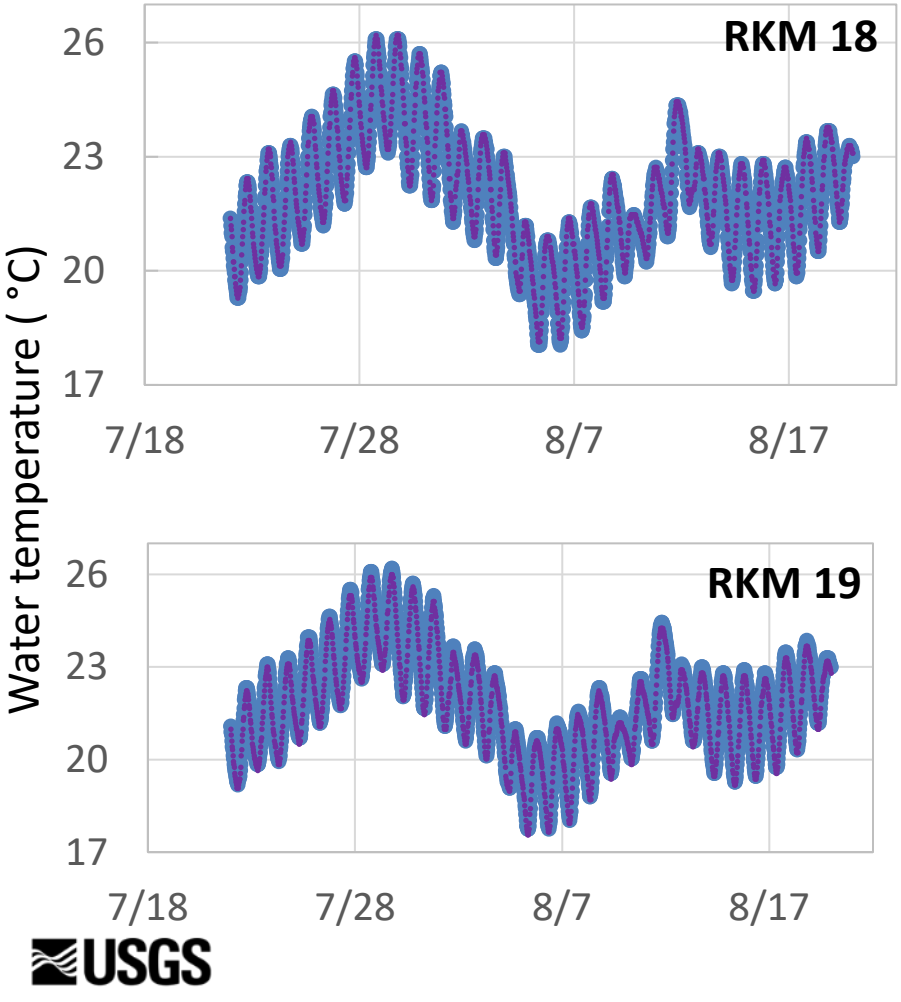
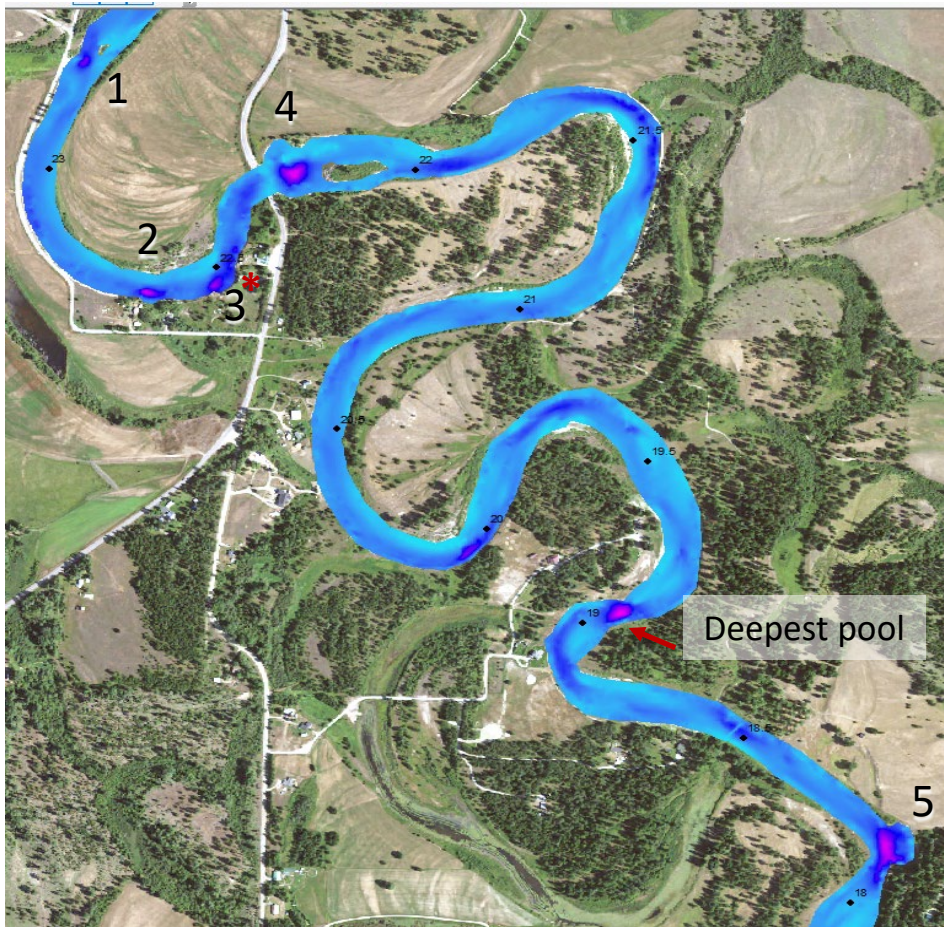
Bathymetry data (ADCP survey)





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Number of residual pools per reach	Q1	Q2	Q3	Q4	Priest
Residual depth > 50 cm	5 (0–8)	4 (0–8)	5 (0–8)	3 (0–6)	9 (0–12)
Residual depth > 75 cm	3 (0–6)	3 (0–7)	3 (0–7)	2 (0–5)	6 (0–9)
Residual depth > 100 cm	2 (0–6)	2 (0–6)	3 (0–7)	2 (0–5)	4 (0–9)

Mejia et al. 2021

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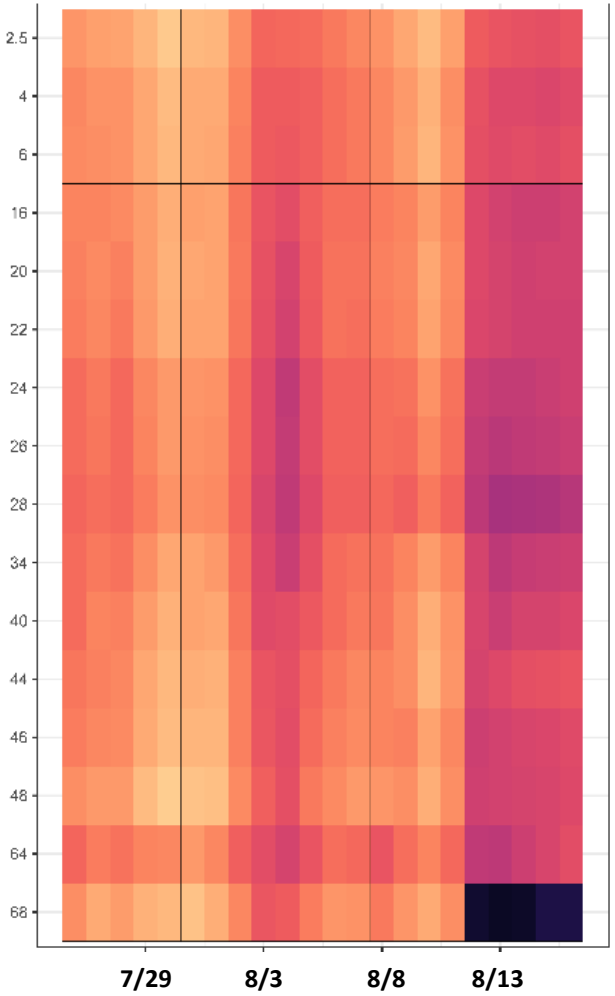
Mainstem

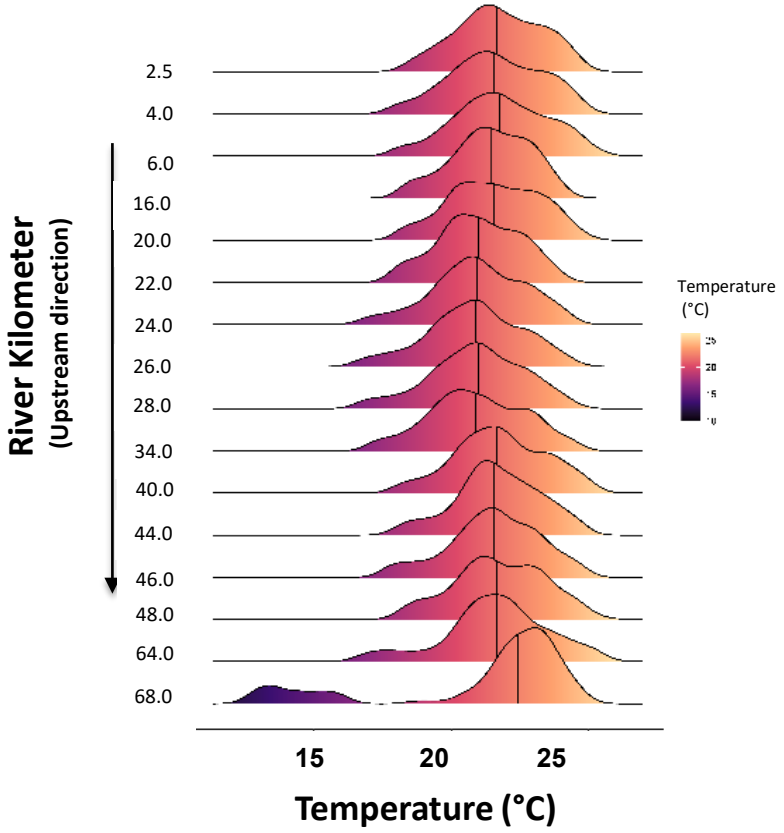
Temperature (°C)

25.0
22.5
20.0
17.5
15.0

Daily



Jul 29-Aug 16, 2018



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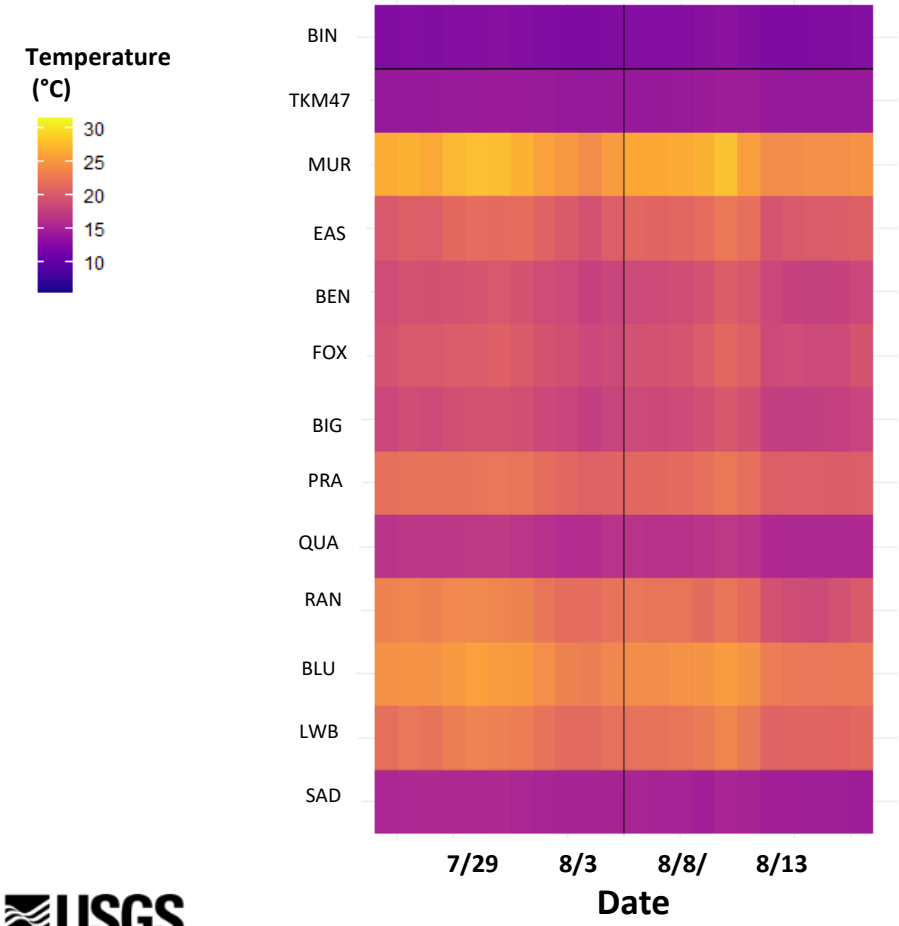
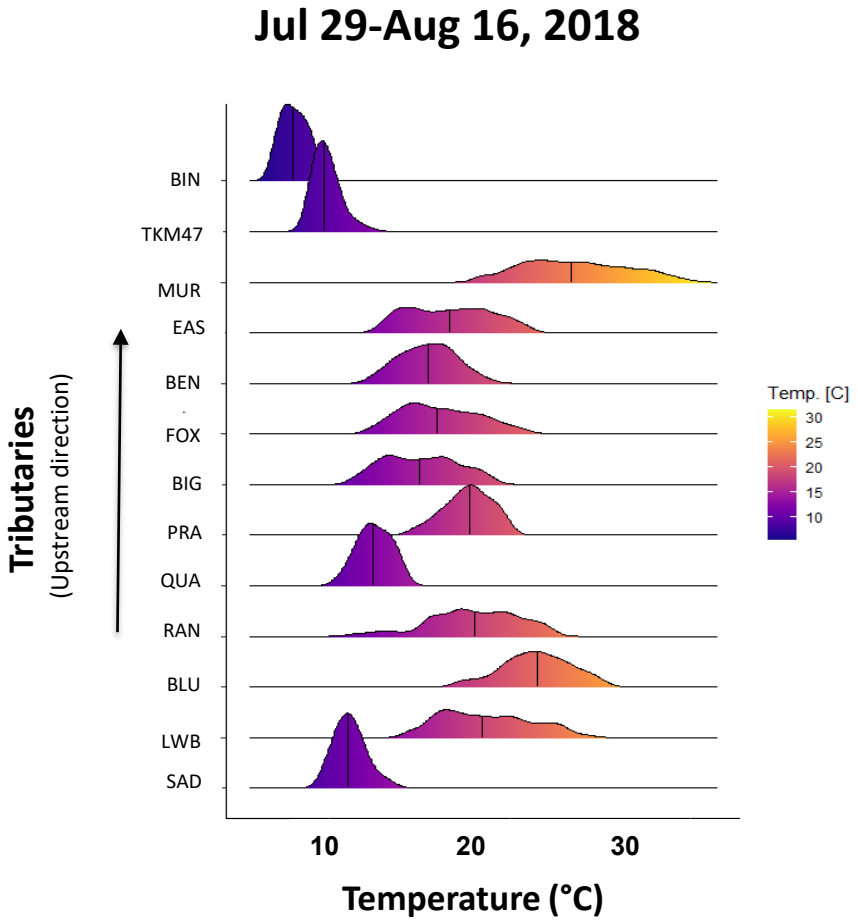
Tributaries





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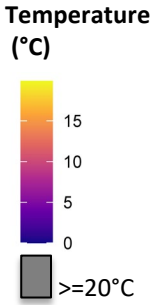
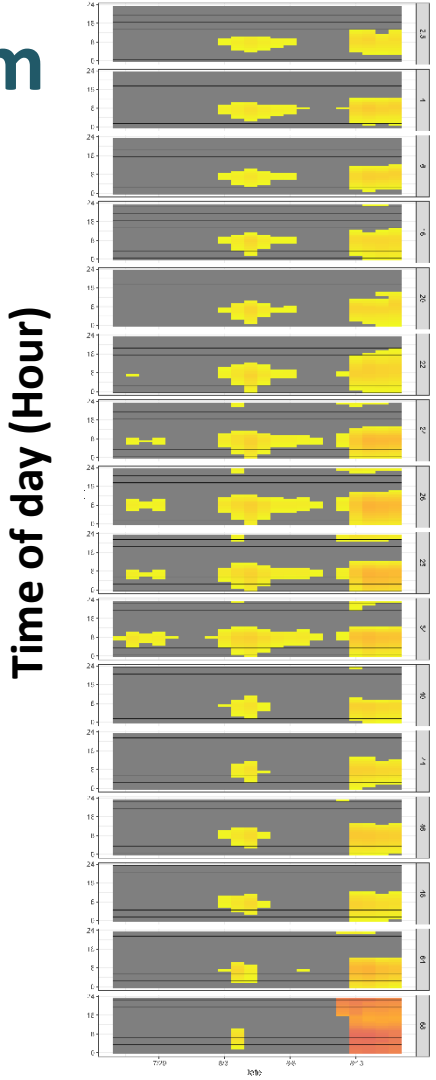
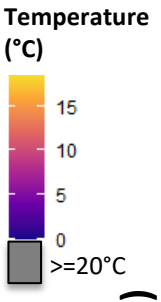
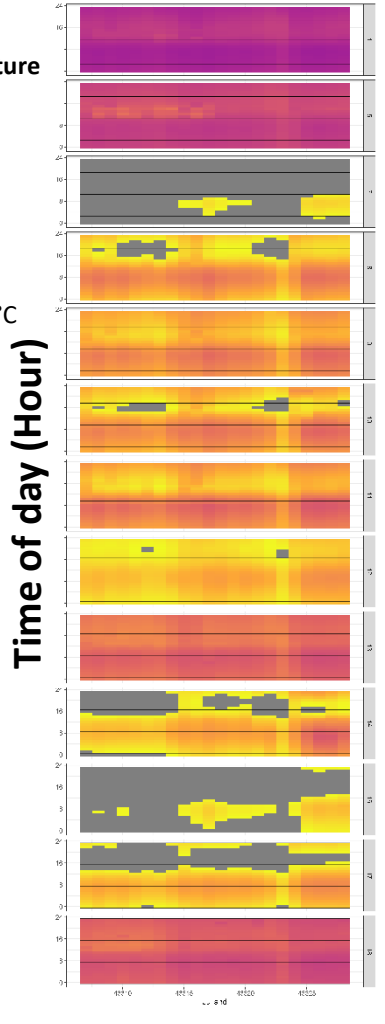
Mainstem





Tributaries





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Temperature patterns

- Mean mainstem water temperature along the longitudinal profile of the river is consistent.
- Major temperature changes are associated with tributary confluences, and groundwater inputs.
- Most pools do not stratify, but when clustered may have a slight cooling effect in the river segment.

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Take home messages

- Water temperatures exceed native salmonids' thermal limits, but thermal heterogeneity provides access to cool water to cope with thermal stress.

- Need to understand water temperature patterns during the "shoulder" seasons. These seasons are important for growth.

- Spatially and temporally dynamic areas such as tributary junctions provide thermal heterogeneity and may be important to provide high quality food.

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Next steps…

Photo credit: Eric Berntsen, KNRD

- Statistical analysis – develop associations between temperature patterns & physical habitat (past & present)
- Relate this information to biological data (e.g., invertebrate production, where are the fish?)

USGS

Acknowledgments

Photo credit: Eric Berntsen, KNRD

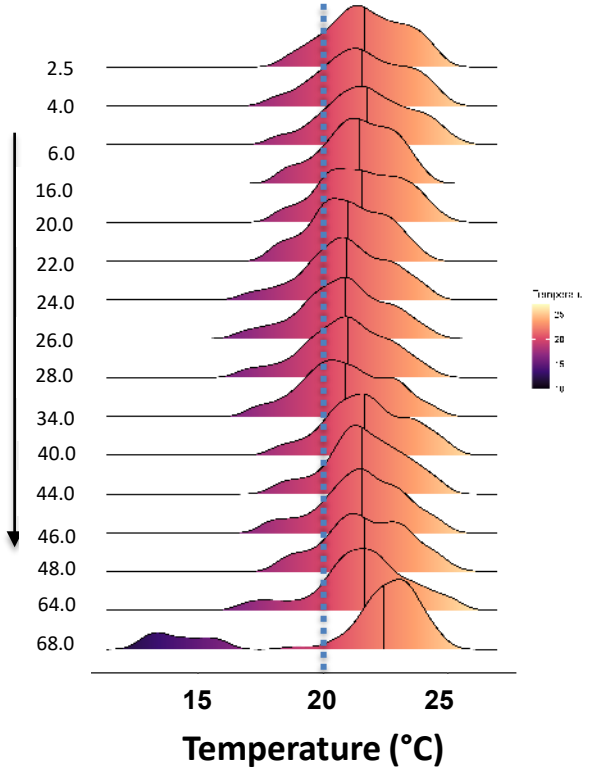
Trout Unlimited Panhandle Chapter
Sean Stash, IPNF
Idaho Master Naturalists
Angel Klock & Zach Johnson, University of Washington
David Bluff, Darren Reeves, Jim LeMieux, Mike Lithgow, Krista Harrington,
Kalispel Tribe Department Natural Resources

USGS

RKM	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
68	12.6	21.0	22.4	21.0	23.3	25.0
64	16.5	20.6	21.7	21.6	22.8	25.7
48	18.0	20.6	21.7	21.8	23.0	25.7
46	17.6	20.5	21.6	21.5	22.8	24.9
44	18.0	20.8	21.6	21.7	22.7	24.8
40	18.0	20.6	21.7	21.8	23.0	25.3
34	16.9	19.8	20.9	20.9	22.3	24.6
28	16.5	19.8	21.0	20.9	22.1	24.7
26	16.5	19.8	20.9	20.8	22.1	24.6
24	16.7	20.0	21.0	21.0	22.2	24.5
22	17.9	20.0	21.0	21.0	22.2	24.2
20	18.1	20.3	21.6	21.6	22.8	25.1
16	18.1	20.5	21.5	21.4	22.5	24.2
6	17.9	20.6	21.8	21.8	23.0	25.6
4	17.6	20.4	21.6	21.6	22.9	24.9
2.5	18.1	20.7	21.7	21.8	23.0	24.9

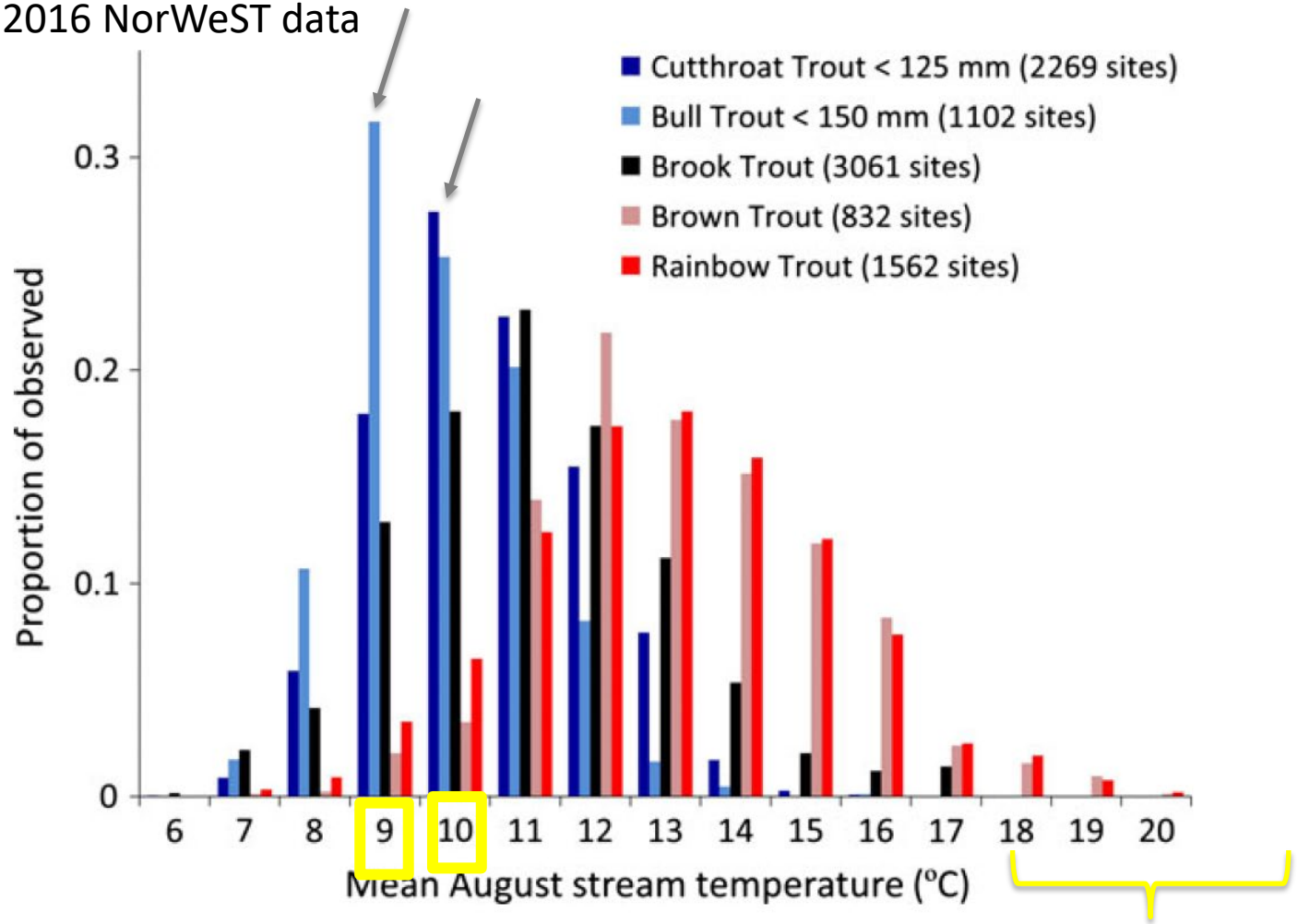
Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
12.6	20.3	**21.5**	**21.4**	22.7	25.7

This is to answer questions:



, we collected high-resolution water temperature and physical habitat data in the lower 73 km of the Priest River in northern Idaho, USA. We towed temperature data loggers and acoustic Doppler current profilers (ADCP) with watercraft in a streamwise direction to create temperature longitudinal profiles and characterize river morphology. We also deployed in-situ thermographs every 2 km in the mainstem, at pools, and at tributary junctions. The collection of these spatially intensive data over a relatively large spatial extent allowed us to (1) examine thermal heterogeneity across space and time, (2) identify potential cold-water refuges for salmonids, and (3) prioritize cold-water areas for habitat restoration. We mapped thermal longitudinal profiles and paired with the morphological metrics derived from ADCP and aerial imagery to assess associations with landscape features that could be

Isaak et al. 2016 NorWeST data



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