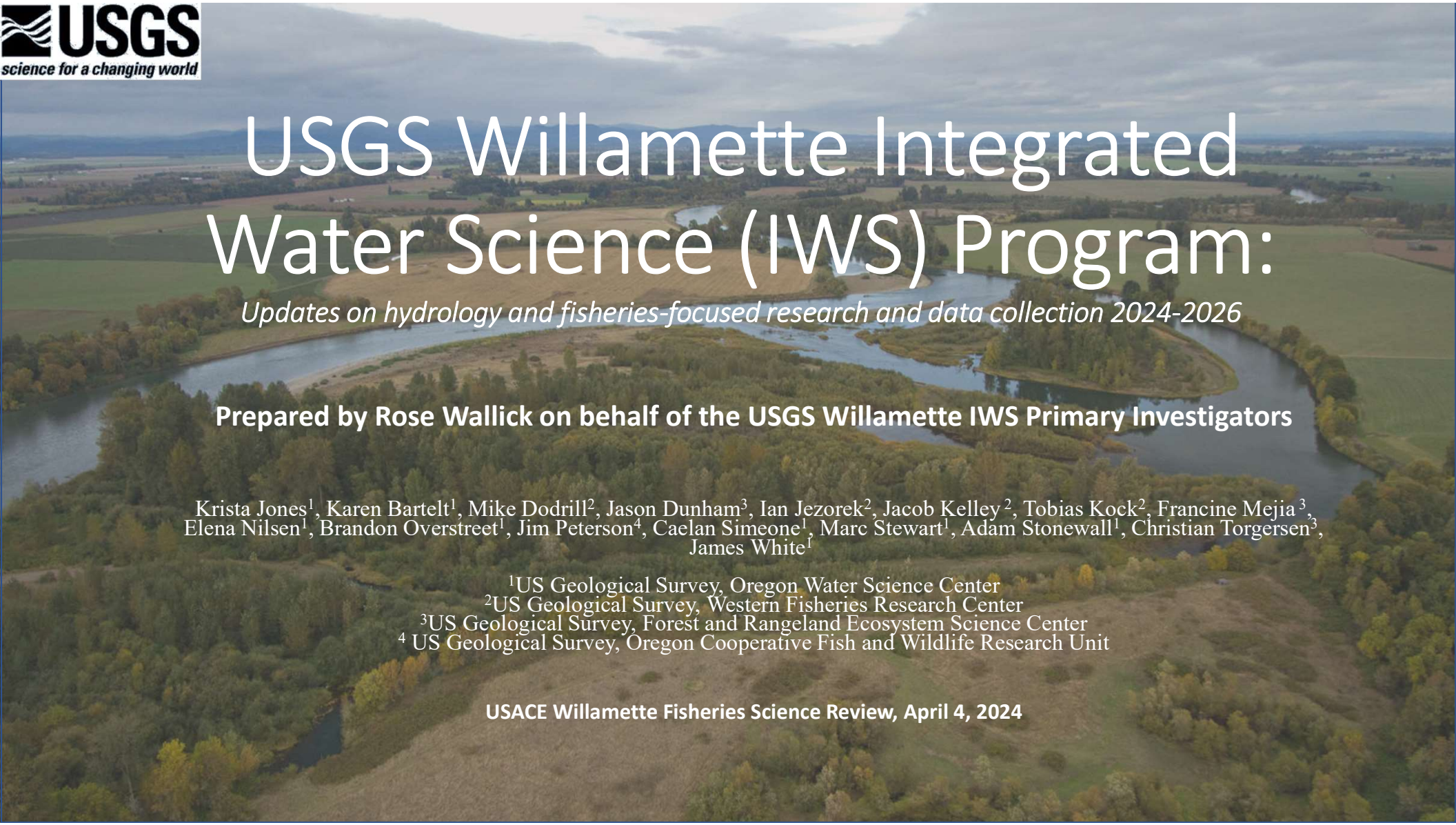


USGS Willamette Integrated Water Science (IWS) Program:

Updates on hydrology and fisheries-focused research and data collection 2024-2026

Prepared by Rose Wallick on behalf of the USGS Willamette IWS Primary Investigators

Krista Jones[1], Karen Bartelt[1], Mike Dodrill[2], Jason Dunham[3], Ian Jezorek[2], Jacob Kelley[2], Tobias Kock[2], Francine Mejia[3], Elena Nilsen[1], Brandon Overstreet[1], Jim Peterson[4], Caelan Simeone[1], Marc Stewart[1], Adam Stonewall[1], Christian Torgersen[3], James White[1]

[1]US Geological Survey, Oregon Water Science Center
[2]US Geological Survey, Western Fisheries Research Center
[3]US Geological Survey, Forest and Rangeland Ecosystem Science Center
[4] US Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit

USACE Willamette Fisheries Science Review, April 4, 2024

Acknowledgments

Numerous agency and academic partners have shaped our understanding of water availability tradeoffs in the Willamette Basin, advised new work and provide science foundation for new work

USACE: Salena Hart, Rich Piaskowski, Norm Buccola, Kathryn Tackley, Paul Sclafani, Fenton Kahn, Greg Taylor, Jake MacDonald (and many more)

NOAA: Anne Mullan, Aimee Fullerton, Morgan Bond, Jim Meyers, Lee Harrison

ODFW: Luke Whitman, Jeremy Romer, Elise Kelly, Ben Clemens, Jeff Ziller, Spencer Sawaske, Kara Anlauf-Dunn, Kelly Reis, Tom Friesen

OWRD: Laurel Stratton Garvin, Alyssa Mucken

DEQ: Debra Sturdevant, Ryan Michie

USFS: Gordon Grant, Becky Flitcroft, Sherri Johnson

UI & OSU: Matt Keefer, Brooke Penaluna, Stan Gregory, Desiree Tullos, David Hulse, Jonny Armstrong, Ivan Arismendi

Numerous USGS scientists are assisting with new science and data collection:

Stewart Rounds, Jim Tesoriero, Heather Bervid, Jay Spillum, Rod Owre, Dalton Hance, Gabriel Hansen, Jon Haynes, Mackenzie Keith, Chrissy Murphy, Alex Etheridge, Russell Perry, Max Schwid, Chauncey Anderson, Julia Grabowski, Carl Legleiter, Paul Kinzel (and more)

USGS

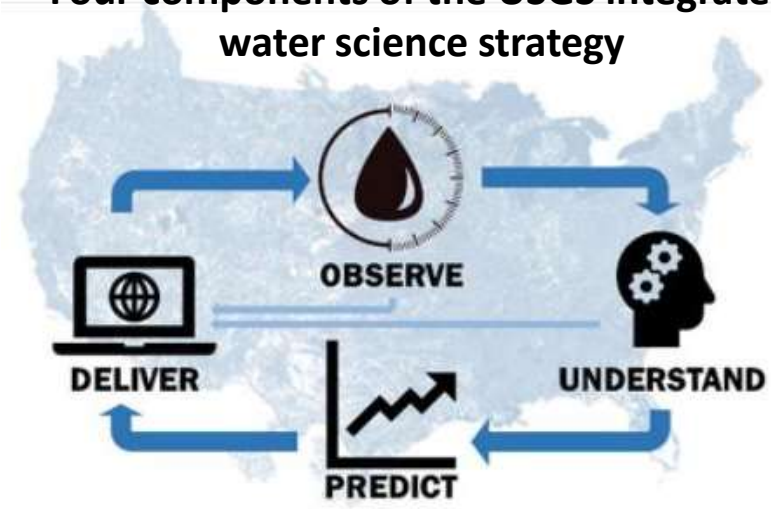
We are still early in our engagement process--conversations will expand to many other entities soon.

North Santiam River near Wiseman Island, Courtesy of NOAA Fisheries

USGS Integrated Water Science (IWS) Basins

USGS Definition of Water Availability

Four components of the USGS integrated water science strategy



Integrated water science strategy is implemented in 10 IWS Basins

Willamette is 4th of 10 IWS Basins

Each IWS Basin tackles a unique water availability issue using integrated water science

USGS

Evenson, E.J and others, 2013, U.S. Geological Survey water science strategy—Observing, understanding, predicting, and delivering water science to the Nation: U.S. Geological Survey Circular 1383–G, 49 p.

https://www.usgs.gov/mission-areas/water-resources/science/integrated-water-science-iws-basins

Willamette IWS Focal Topic:
Evaluating Water Availability for People and Spring Chinook Salmon

People

Year-round
- Public water supply
- Commercial and industrial uses
- Hydropower

Summer
- Irrigation and other seasonal withdrawals
- Lake-based recreation

Fall, winter and spring
- Flood protection downstream of dams

Focus for 2023-2026

How does streamflow and water temperature vary across salmon-bearing streams?

What are the implications for people and salmon?

What tradeoffs result from different management actions?

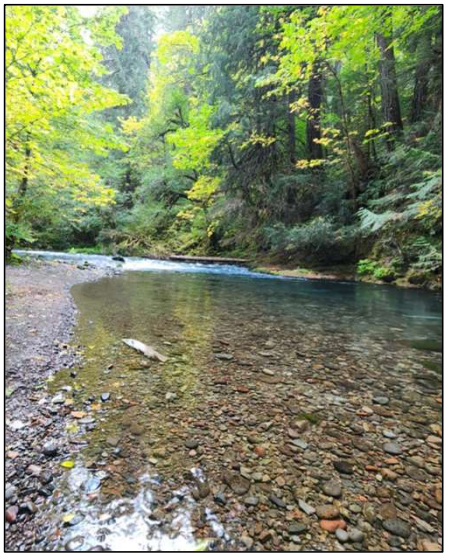
Spring Chinook Salmon

Year-round
- Suitable habitat conditions for various life stages

Summer
- Suitable water temperatures and depths for adults and juveniles

Fall
- Suitable water temperatures and hydraulic conditions for spawning and incubation

Winter and spring
- Suitable conditions for rearing and migration

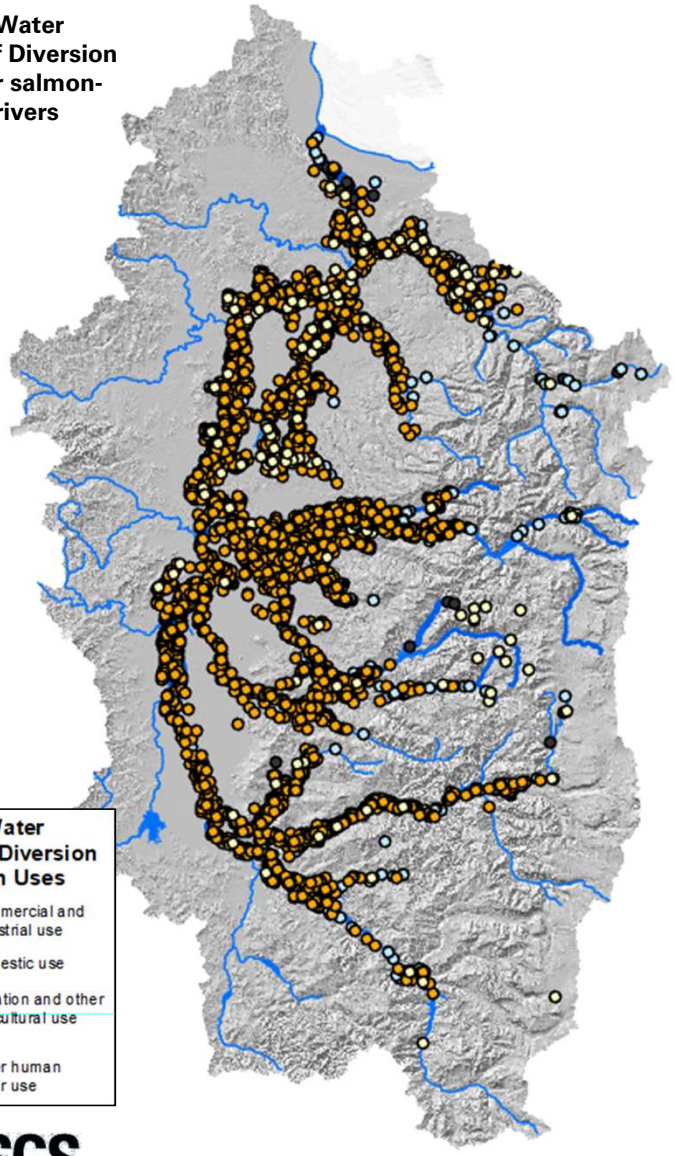


South Fork McKenzie above Cougar Dam

Examples of surface water needs for people and salmon in the Willamette River Basin

All photos from USGS unless otherwise attributed.

Surface Water Points of Diversion on major salmon-bearing rivers



Surface Water Points of Diversion for Human Uses

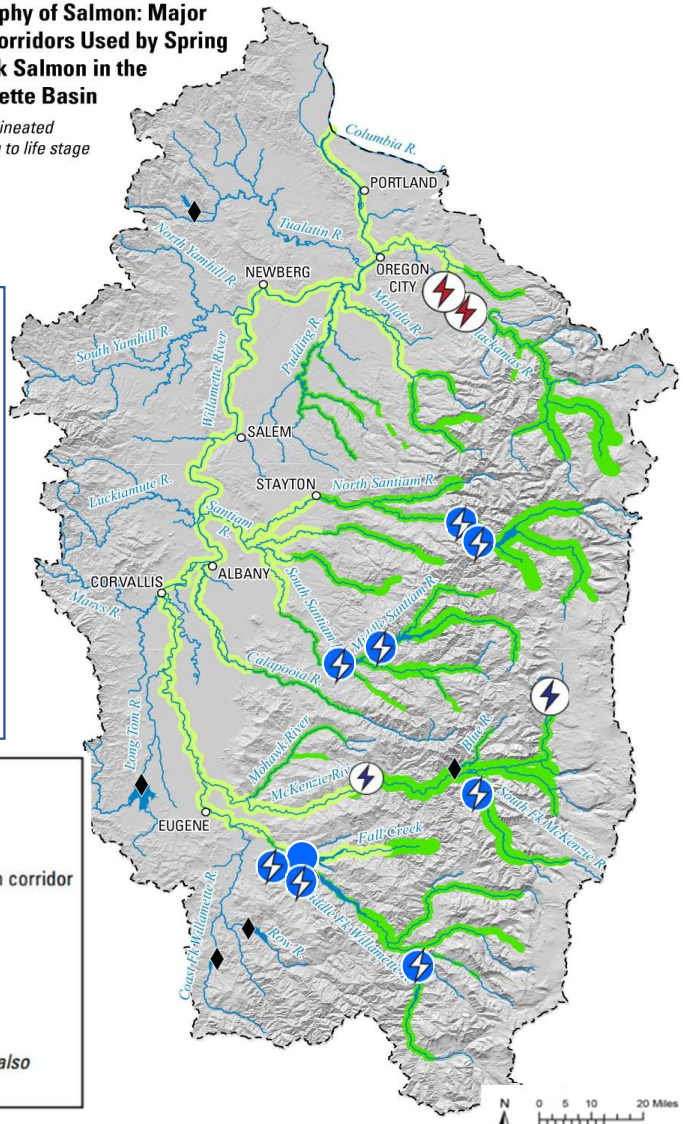
- Commercial and Industrial use
- Domestic use
- Irrigation and other agricultural use
- Other human water use

Dams on major salmon-bearing rivers

- PGE Dams (hydropower)
- EWEB Dams (hydropower)
- USACE Dams (multi-purpose)
- USACE Dams (with hydropower)
- Large dam on rivers without major Chinook population

Geography of Salmon: Major River Corridors Used by Spring Chinook Salmon in the Willamette Basin

Rivers delineated according to life stage



Explanation

- Large dams

Spring Chinook habitat

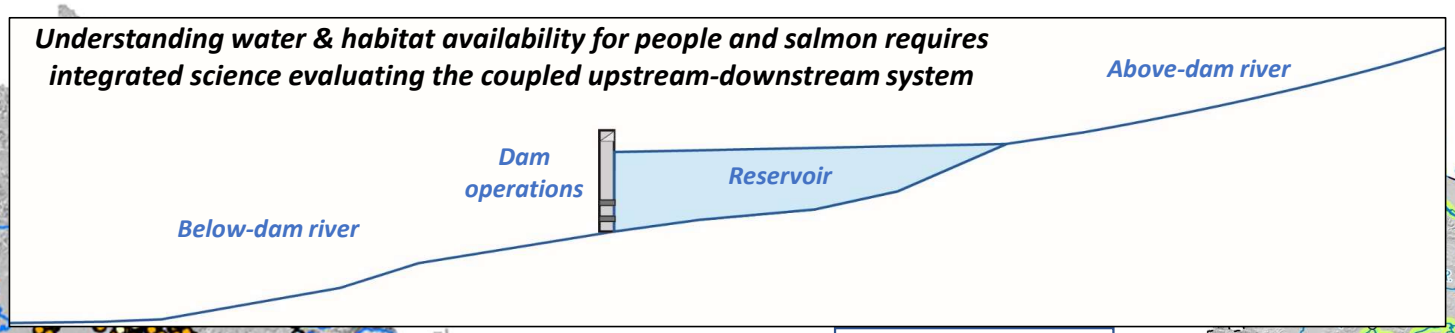
- Mostly rearing & migration corridor
- Main spawning areas
- Moderate spawning
- Minimal spawning
- Lesser used tributaries

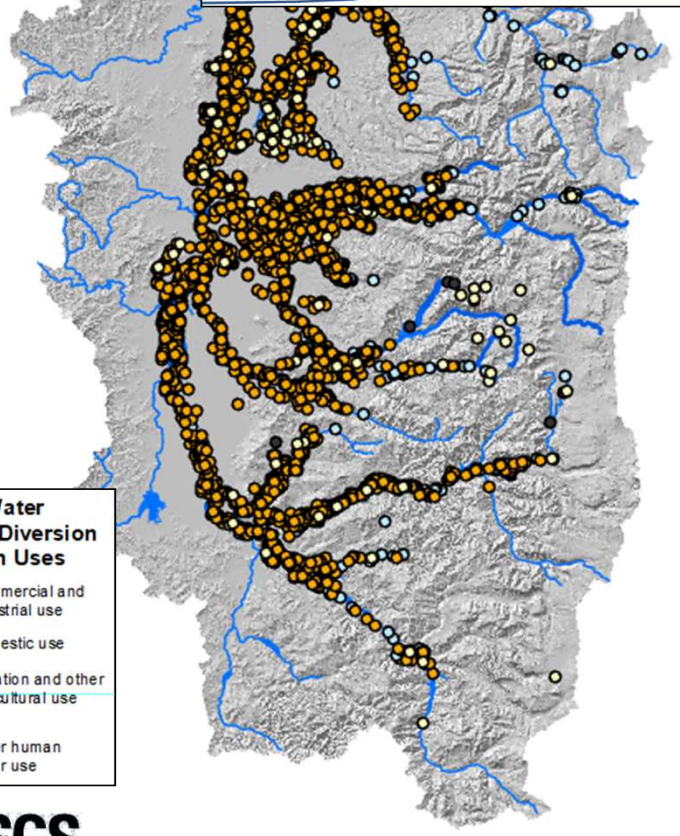
Adult holding and juvenile rearing also occur in spawning reaches

USGS

Sources: Points of diversion from Oregon Water Resources Department; Provisional mapping by Jacob Kelley based on literature review. Subject to revision.

Surface Water Points of Diversion on major salmon-bearing rivers





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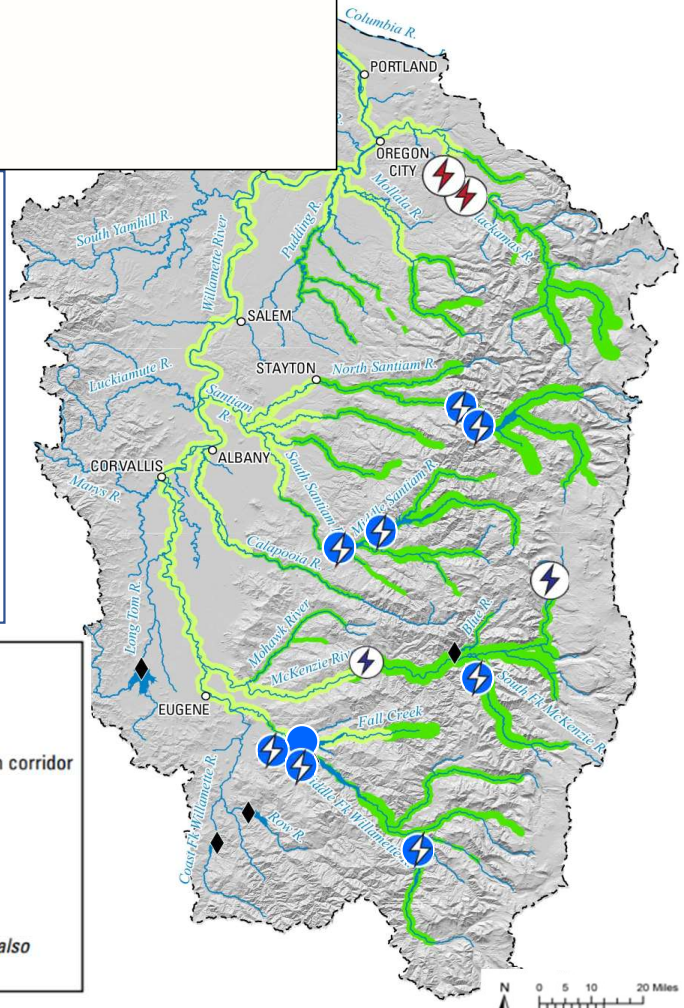

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USGS

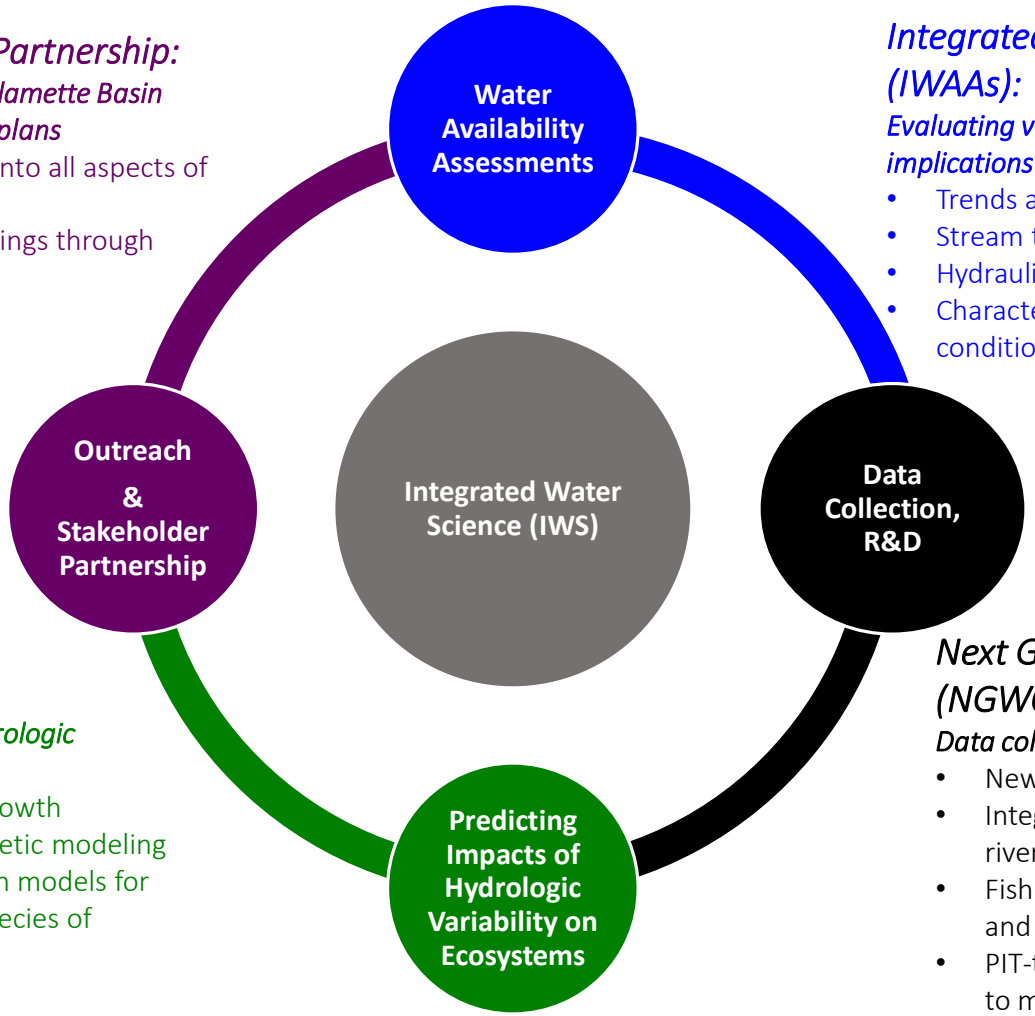
Sources: Points of diversion from Oregon Water Resources Department; Salmon distributions compiled from literature review by Jacob Kelley.

Fisheries-focused Willamette IWS Activities 2022-26

Outreach & Stakeholder Partnership:

Knowledge sharing to inform Willamette Basin water management and science plans

- Integrate stakeholder input into all aspects of IWS
- Share science plans and findings through variety of platforms



Integrated Water Availability Assessments (IWAAs):

Evaluating variability in streamflows and temperature and implications for people & spring Chinook salmon

- Trends analysis of historical flow and temperature data
- Stream temperature compilation, analysis, visualization
- Hydraulic and temperature modeling
- Characterizing historical, current, future habitat conditions & human water uses

EcoFlows:

Predicting consequences of hydrologic variability on ecosystems

- Evaluate juvenile salmon growth dynamics utilizing bioenergetic modeling
- Develop species distribution models for Pacific Lamprey and two species of freshwater mussels

Next Generation Water Observing Systems (NGWOS):

Data collection, R&D focused on salmon habitats

- New gages in key habitat reaches
- Integrated River Mapping Program to characterize river conditions
- Fish sampling to describe above-dam distributions and ground truth habitat metrics
- PIT-tagging R&D effort at streamflow gaging station to monitor fish and gravel transport

USGS

NGWOS, IWAAs and Outreach extend through 2031, but will shift to a basin-wide water availability focus 2027-2031

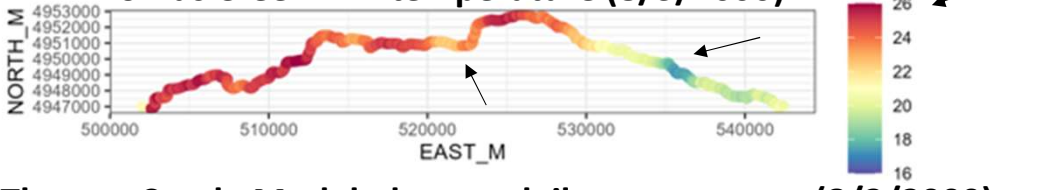
Integrated "Thermalscape" of Salmon-bearing Rivers

Program name: *IWAAs Phase 1 (Integrated Water Availability Assessments)*
Goal: *Characterize thermal heterogeneity over space, and time, at multiple scales*
PI: *Caelan Simeone, Christian Torgersen, Francine Mejia, Matt Barker, Brandon Overstreet*
Focal area*: Major rivers used by spring Chinook salmon*

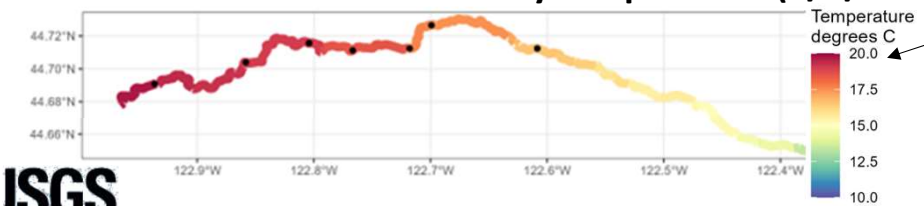
General Approach:

- Develop a holistic picture of thermal patterns at multiple scales—from the entire stream network to microhabitats.
- Incorporate new and existing information:
  - Thermal infrared (TIR) mapping
  - In-situ observations from multiple organizations
  - Modeling

Thomas Creek: TIR temperature (8/3/2000)



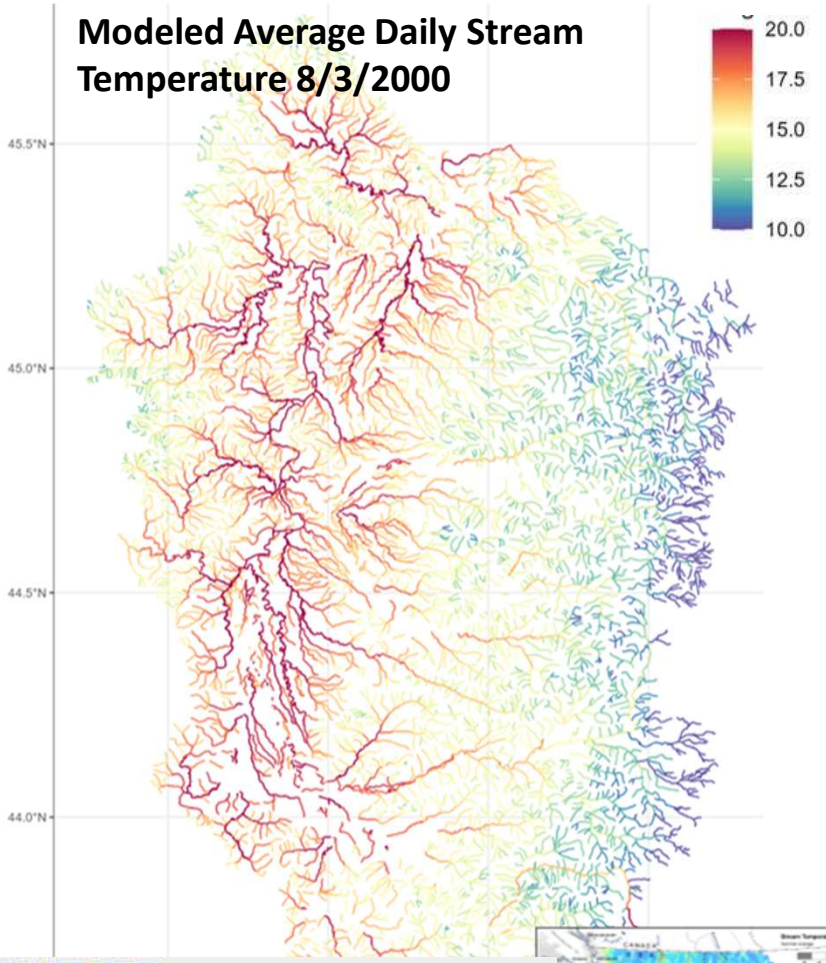
Thomas Creek: Modeled mean daily temperature (8/3/2000)



USGS

TIR data courtesy of DEQ and NV5. Modeled data from Siegel et al 2023.

Modeled Average Daily Stream Temperature 8/3/2000

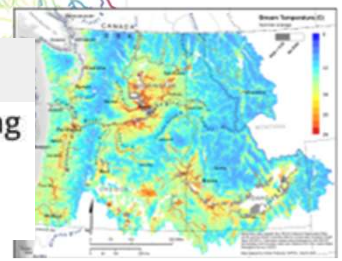


PLOS WATER

Daily stream temperature predictions for free-flowing streams in the Pacific Northwest, USA

Jared E. Siegel, Aimee H. Fullerton, Alyssa M. FitzGerald, Damon Holzer, Chris E. Jordan

Published: August 30, 2023 • https://doi.org/10.1371/journal.pwat.0000119



Spatial and Temporal Trends in Streamflow and Water Temperature and Responses to Extreme Events

Program name: *IWAAs Phase 1 (Integrated Water Availability Assessments)*

Goal: *Evaluate spatial and temporal trends in streamflow and water temperature time series. Evaluate drivers of observed trends.*

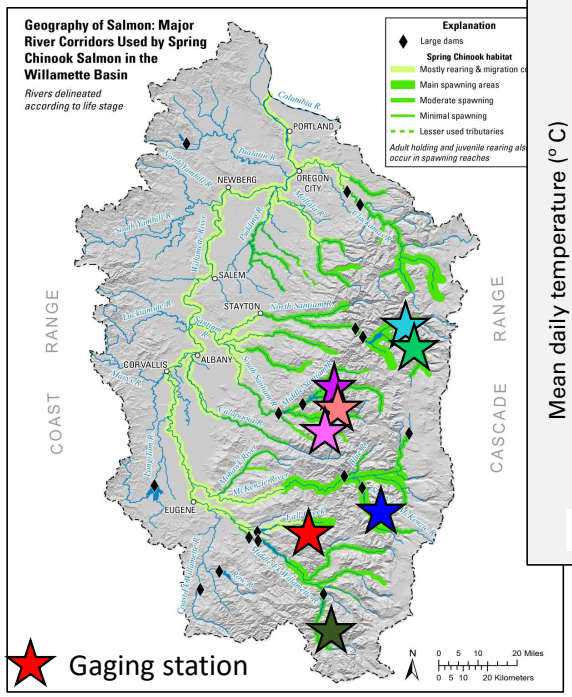
PI: *Adam Stonewall, Caelan Simenone, Krista Jones, Mackenzie Keith*

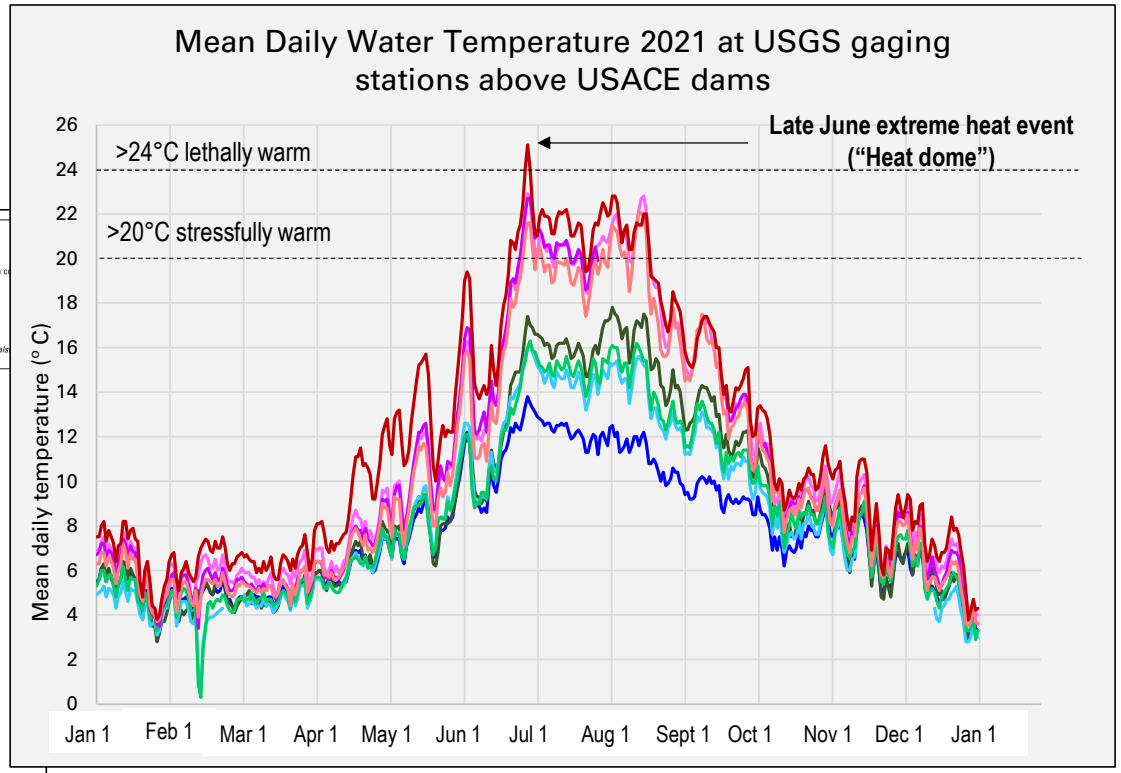
Focal area*: Major rivers used by spring Chinook salmon*

General approach:

- Assess spatial patterns across the river network and trends over time

- Evaluate controls and drivers:
  - Dam management
  - Withdrawals
  - Geology
  - Physiography
  - Shade
  - Hydroclimatic conditions
  - Other influences



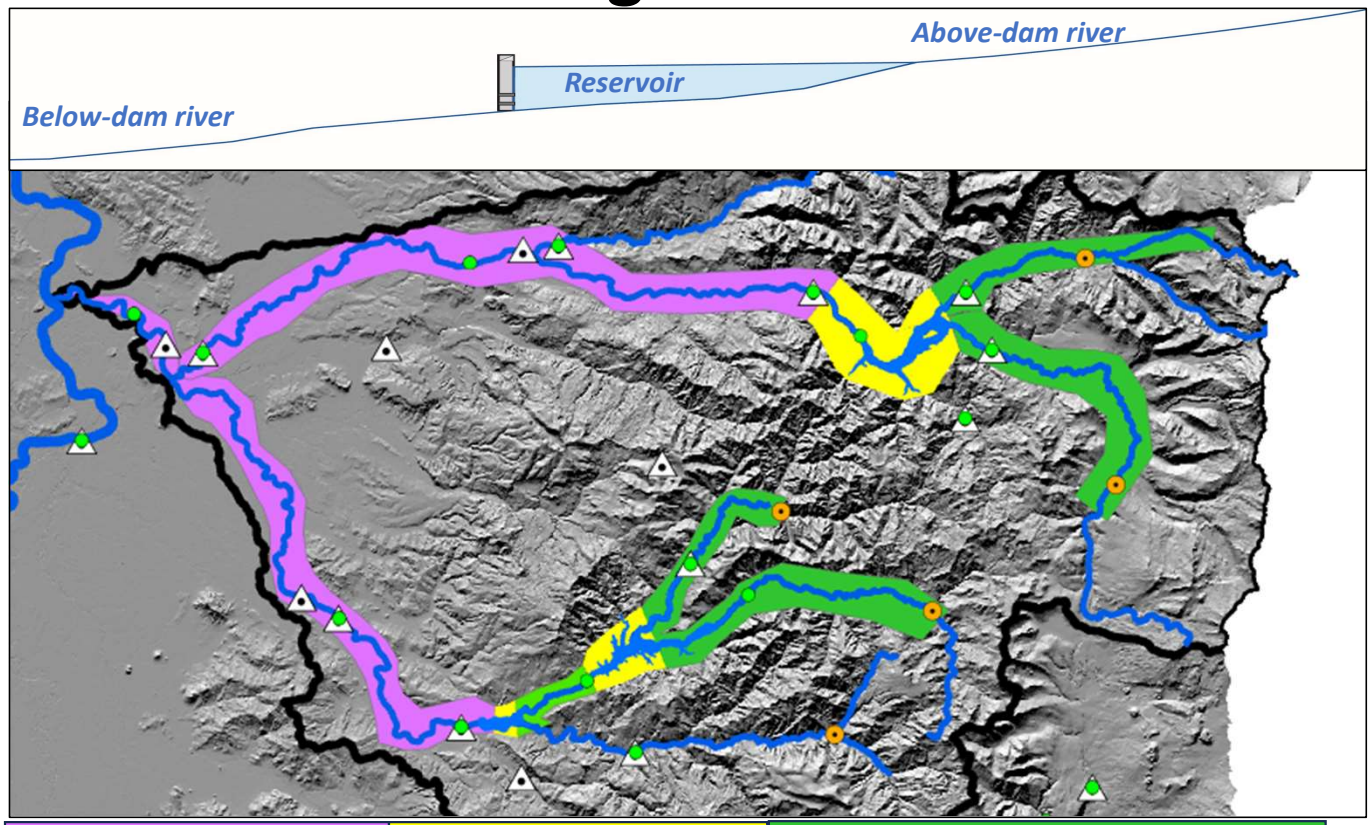


Source: USGS NWIS

USGS

Detailed Habitat and Water Use Modeling in Santiam Basin

Program name: *IWAAs Phase 1*
Goal: *Quantify water temperature and hydraulics under range of scenarios to evaluate implications for human uses and salmon habitats above and below USACE dams*
PI: *James White, Karen Bartelt, Stewart Rounds, Caelan Simeone, Rose Wallick, Krista Jones*
Focal area*: Santiam River Basin*



Modeling will evaluate:

- "Rigorous case study" comparing North Santiam and South Santiam rivers
- Range of hydroclimatic scenarios
- Range of water management and dam operational scenarios

Below-dam river models in progress	**Reservoir modeling completed**	**Above-dam modeling in 2024-2025**
• 2D HEC-RAS • CE-QUAL-W2 • Base models completed for USACE EIS and BiOP studies	• CE-QUAL-W2 water temperature models • Base models completed for USACE EIS	• New statistical and possible process-based water temperature models • New 2D HEC-RAS hydraulic models

USGS

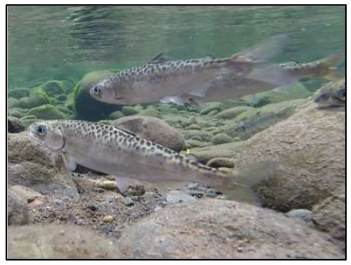
Stakeholder team will advise

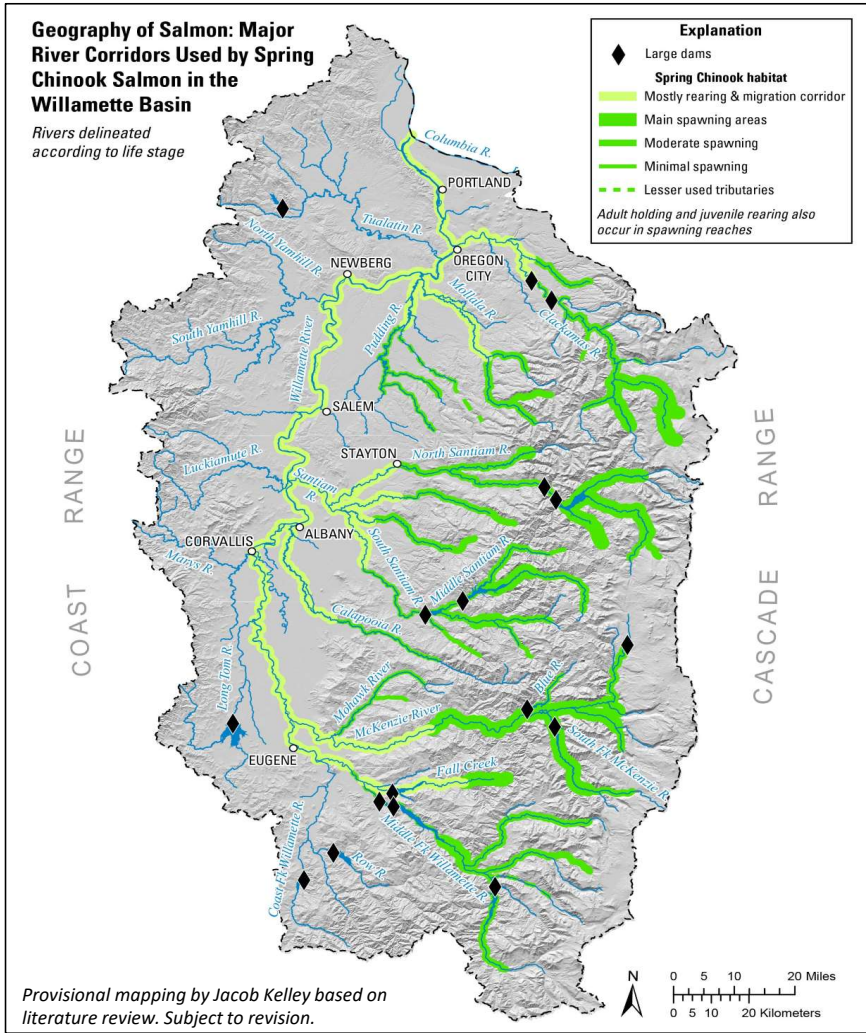
Characterizing Current and Future Habitat Conditions & Implications for Spring Chinook Salmon

Program name: *IWAAs Phase 1 (Integrated Water Availability Assessments)*
Goal: *Characterize historical, current, and potential future habitat conditions for spring Chinook salmon across the Willamette Basin*
PI: *Toby Kock, Matt Keefer, Russell Perry, Jacob Kelley, Gabe Hansen*
Focal area*: Major rivers used by spring Chinook salmon*

General Approach:

- Develop maps of Chinook distributions at different points in time
- Develop detailed habitat criteria for all freshwater life stages
- Quantify historical and current patterns of habitat availability across the Willamette Basin
- Detailed evaluation of current and future habitat availability under different scenarios in the Santiam River Basin utilizing high-resolution model output
- Conduct fish sampling during 2024-2025 in above-dam rivers of the Santiam Basin to describe fish distributions and ground-truth habitat metrics





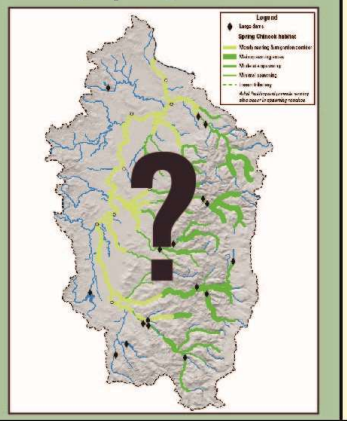
USGS

Synthesize Findings to Address Key Water Availability Questions and Build a Framework to Inform Decisions

Stakeholders will help refine these example questions, advise the science and provide guidance so that outcomes are as useful as possible

Which river reaches in the Santiam River Basin are likely to reliably support spawning and incubation by Spring Chinook salmon, now and in the future?

- Considering the combined effects of human water management decisions, hydroclimatic variability, and intrinsic factors such as physiography, which river reaches may be the 'salmon strongholds' and focus for future restoration and recovery actions?

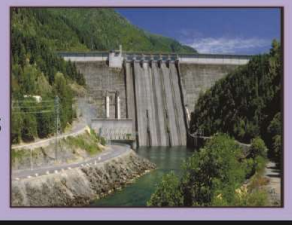


How might large storage reservoirs in the Santiam River Basin buffer downstream river corridors against climate change?

- What combinations of hydroclimatic conditions and reservoir operations would ensure suitable habitats below large dams?
- Under what operational and hydroclimatic conditions are large reservoirs most effective at ameliorating downstream effects of climate change?

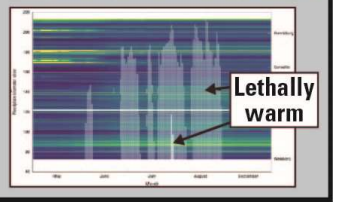
What is the relative magnitude of influence for various natural and anthropogenic factors affecting river hydraulics and stream temperature?

- What is the scale and magnitude of dam operations on downstream river temperatures compared with scale and magnitude of air temperature warming that may result from climate change?
- Which river reaches are inherently resistent to water temperature changes and where is stream temperature most sensitive?



Considering the above questions, and other pressing water management challenges facing the Santiam River Basin, how must water management decisions evolve to better support human water uses and salmon habitats?

- Are there management regimes or hydroclimatic conditions where some river corridors may not support human water needs or salmon habitats?
- What additional new forecasting and water management modeling tools are needed to better inform management decisions?



USGS

New “Salmon Habitat Gages” to Monitor Streamflow and Water Temperature Gages in Upper Basin Spawning Reaches

Program name: *NGWOS (Next Generation Water Observing Systems)*
Goal: *Monitor water level and water temperature in key unregulated river reaches used for spawning by spring Chinook salmon (and some cases, winter steelhead)*
PI: *Karen Bartelt, Jay Spillum, Rod Owre, Mark Stewart, James White*
Focal area*: Major rivers used by spring Chinook salmon*

Sites installed August 2023:

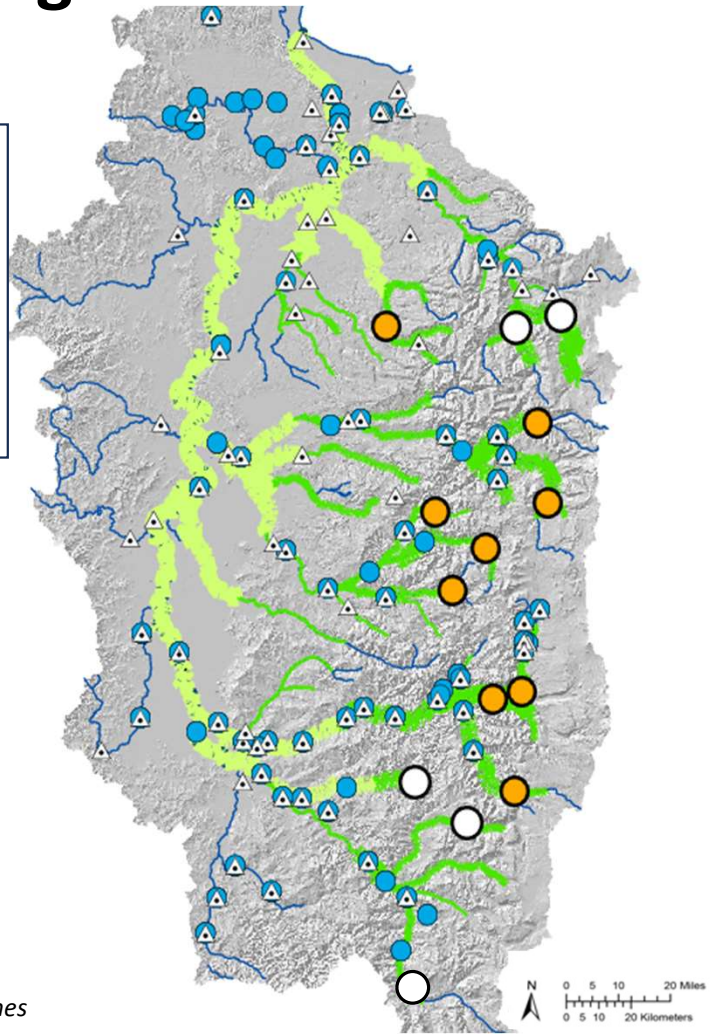
- South Fork McKenzie River
- Horse Creek
- Lost Creek
- South Santiam River
- Quartzville Creek
- Middle Santiam River
- North Santiam River
- Breitenbush River
- Molalla River

Planned for June 2024:

- Fall Creek
- Middle Fork Willamette River
- North Fork Middle Fork Willamette River
- Collowash River
- Clackamas River

USGS continuous streamflow and water temperature monitoring sites

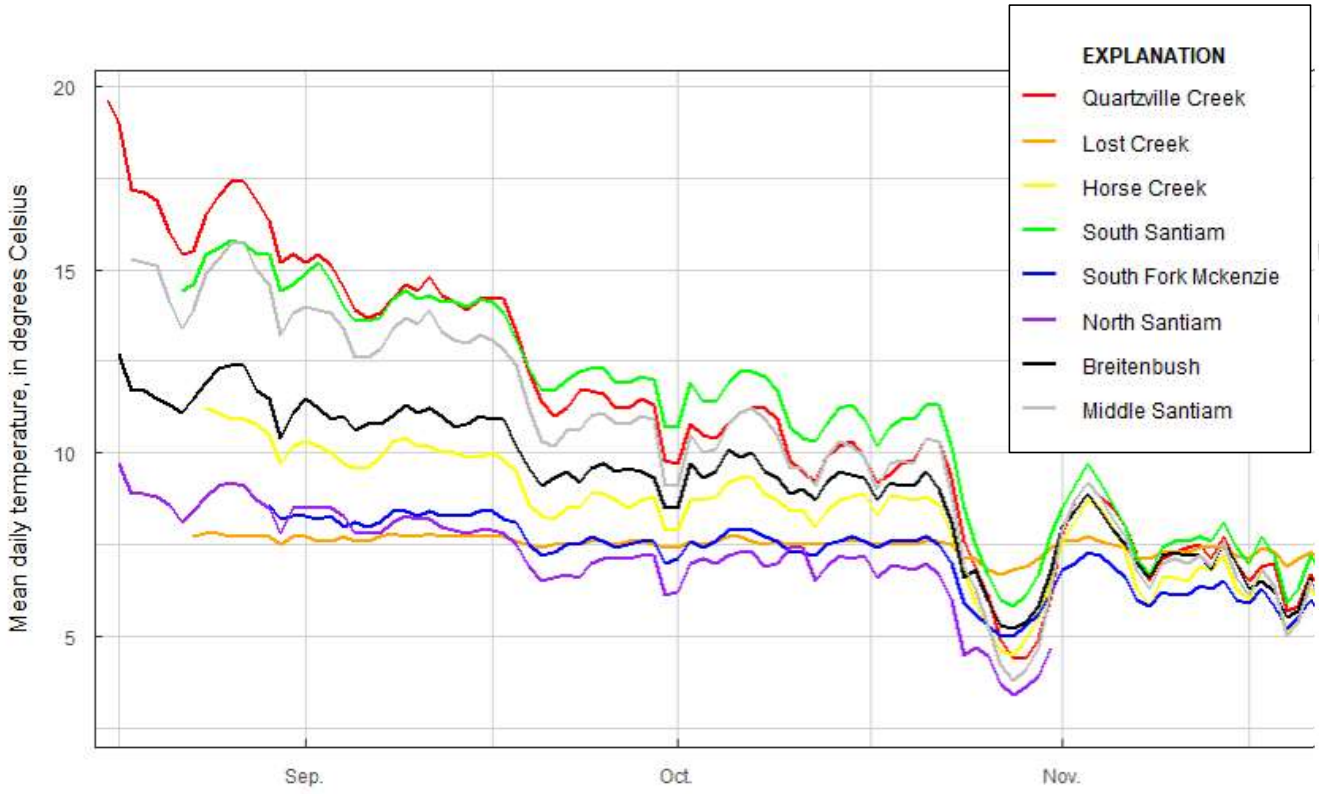
- Discharge
- Water temperature
- New water level and water temperature (2023)
- Planned water level and water temperature (2024)

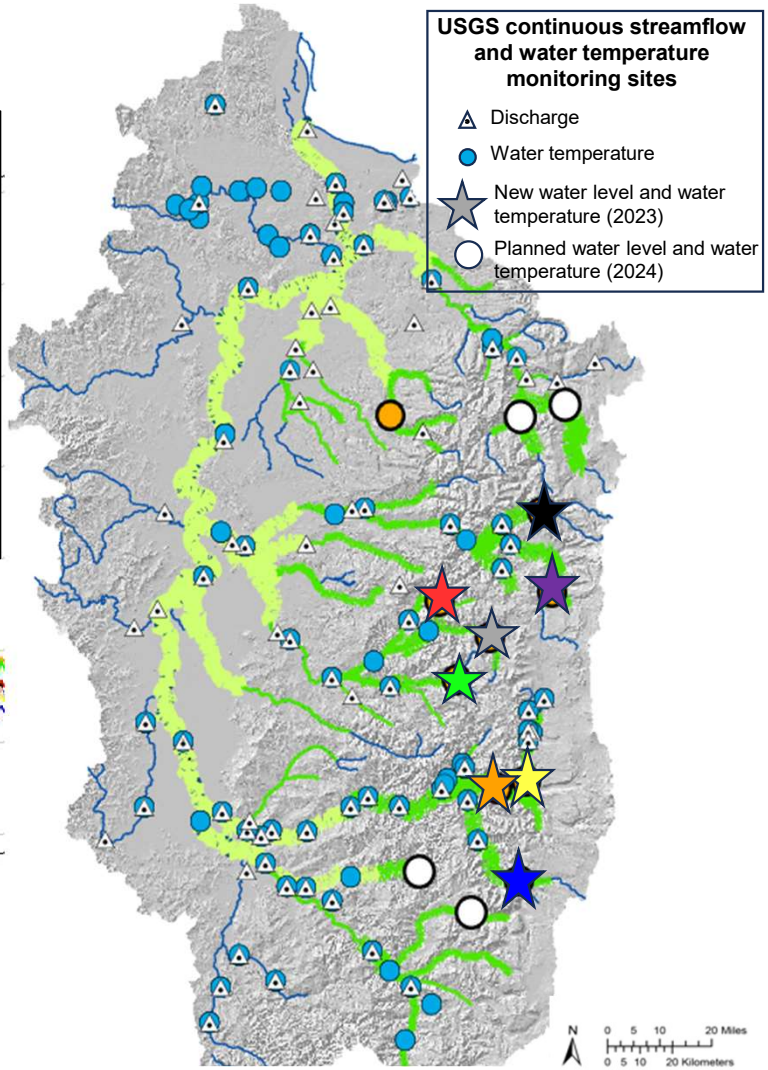


New gages coincide with approximate head of spawning in above-dam, unregulated reaches

USGS

Early Insights: Water Temperature from Autumn 2023





USGS

Source: Provisional data from USGS NWIS, data compilation and plotting by K. Bartelt

Integrated River Mapping

Program name: *NGWOS and IWAAs, supplemented with 3DEP and USACE*
Goal: *Characterize hydrogeomorphic and thermal conditions across the continuum of river corridors used by spring Chinook salmon. Develop cost-effective tools for future monitoring.*
PI: *Brandon Overstreet, James White, Carl Legleiter, Paul Kinzel, Christian Torgersen*
Focal area*: Major rivers used by spring Chinook salmon*

River-scale remote sensing and mapping

Topographic-bathymetric lidar

- 2023: >100 km of stream corridors in Santiam Basin
- 2024: Upper South Fork McKenzie, Fall Creek, Middle Fork Willamette, Thomas Creek, Crabtree Creek

Satellite-derived bathymetry

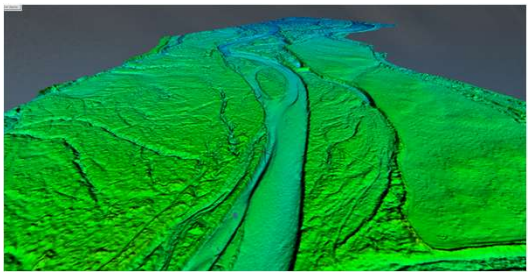
- >200 km of river corridors in Clackamas, Molalla, Middle Fork Basins

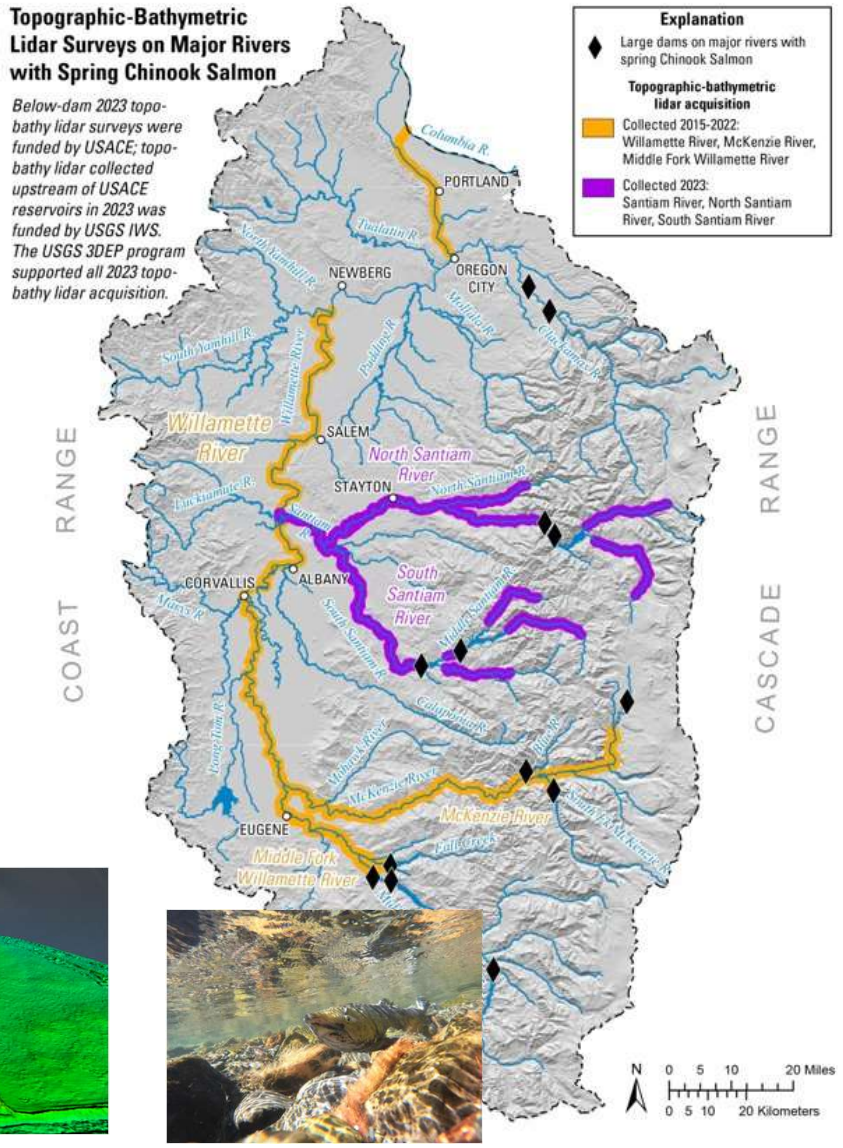
Intensive field surveys

- Surveying deep pools and features not captured in lidar
- Collecting substrate data and other river attributes

River mapping technology development

- *Testing multi-sensor airborne camera pod*
- *Integrated boat-based river mapping system*





USGS

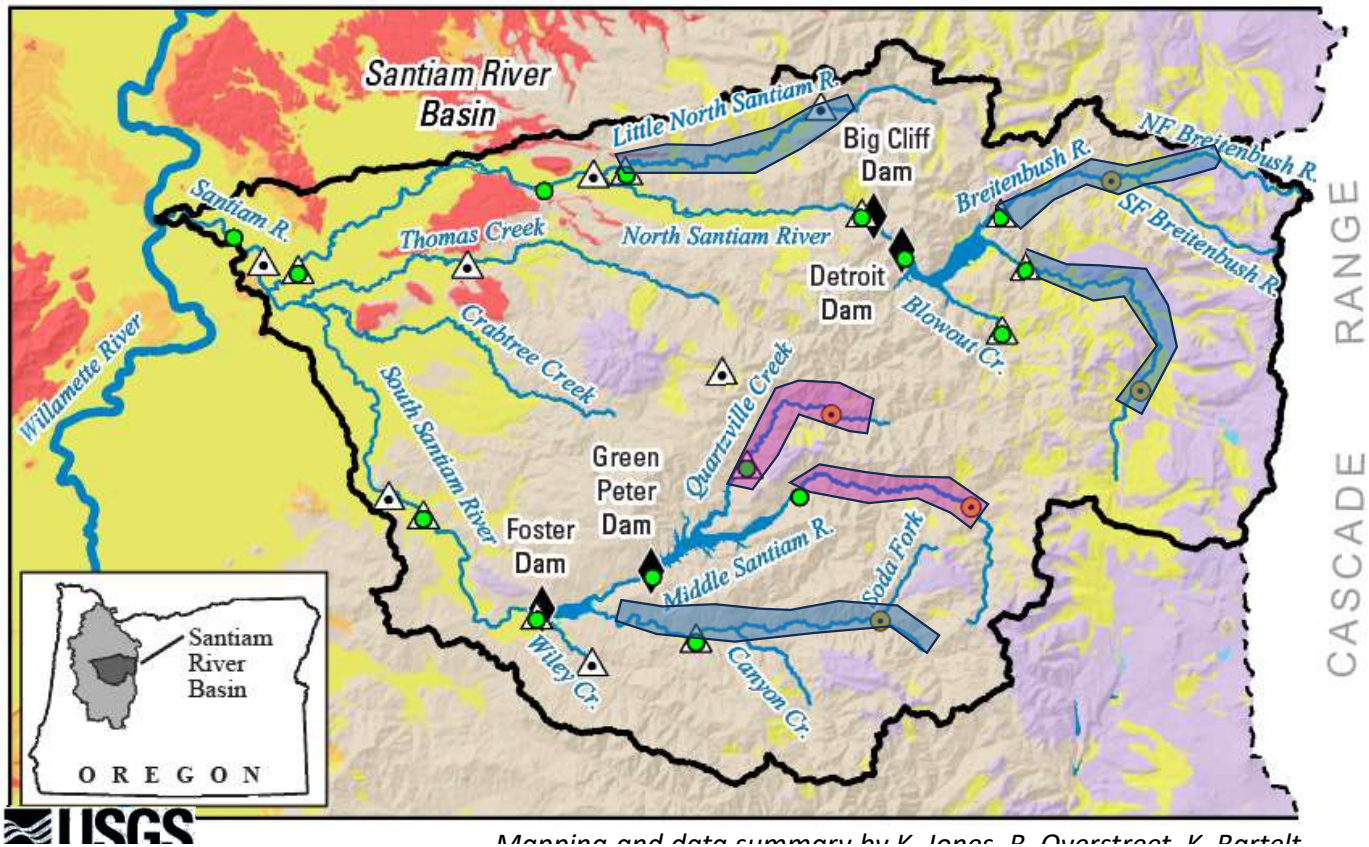
Multi-scale Characterization of Stream Temperature: Santiam River Basin, Summer 2024

Program name: *NGWOS and IWAAs*

Goal: *Characterize thermal heterogeneity to support modeling and analysis of unregulated rivers of Santiam River Basin*

PI: *Brandon Overstreet, Krista Jones, Christian Torgersen, Caelan Simeone, Karen Bartelt*

Focal area*: Major rivers of the Santiam River Basin used by spring Chinook salmon*



EXPLANATION

- Large dams on major rivers with spring Chinook Salmon

USGS stream gages

- New IWAAs stage and temperature gages (2023)
- Existing USGS temperature sites (2022)
- Existing USGS discharge sites (2022)

Data collection tier

- Thermal infrared imagery and calibration data
- Thermal infrared imagery and calibration data Dense water temperature monitoring to capture thermal heterogenity

Geologic Provinces

- Quaternary Deposits
- Coast Range Sediments
- High Cascades
- Coast Range Volcanics & Columbia River Basalts
- Western Cascades

0 5 10 Miles

N

USGS

Mapping and data summary by K. Jones, B. Overstreet, K. Bartelt

New R&D: PIT Tagging at USGS Streamflow Gages

Program name: *NGWOS ((Next Generation Water Observing Systems)*
Goal: *R&D project to test and evaluate passive integrated transponder (PIT) technologies at USGS gaging stations to monitor fish and gravel movements*
PI: *Ian Jezorek, Toby Kock*
Focal area*: South Fork McKenzie River above Cougar Reservoir*

General Approach:

- PIT antennas will be developed and evaluated for dual purpose of detecting PIT-tagged fish and gravel transport.
- Evaluate and streamline technology and potentially expand to other sites throughout the US
- Installation planned July-August 2024

PIT antenna will be evaluated using tagged fish released by USACE and bull trout previously tagged by ODFW

Example of tracer stone with PIT tag, Liebult and others, 2011

Construction of antenna array: 5 antennas 6.3 x 7-m

South Fork McKenzie USGS gaging site above Cougar Reservoir

Acquisition and preparation of anchoring, electronics and power system is underway.

USGS

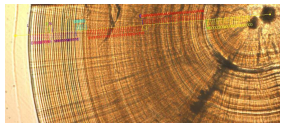
Drift-Foraging Bioenergetics Modeling to Evaluate Juvenile spring Chinook Salmon Growth Dynamics

Program name: *EcoFlows Bioenergetics Study*
Goal: *Develop drift-foraging bioenergetics models to link existing 2D hydraulic and temperature models with foraging ecology to understand juvenile spring Chinook salmon growth dynamics.*
PI: *Mike Dodrill, Russell Perry, Toby Kock*
Focal area*: Select reaches of Upper Willamette, McKenzie, North Santiam Rivers*

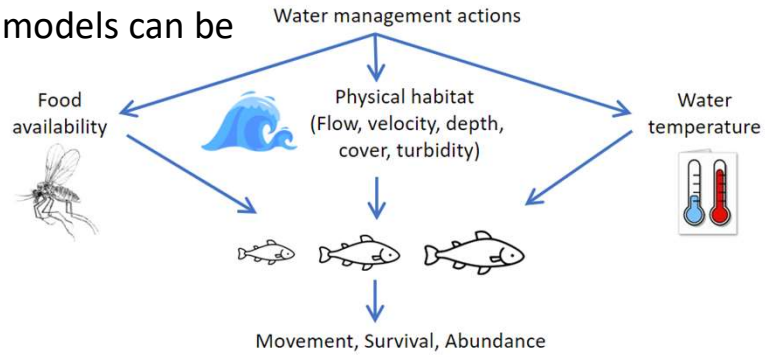
General Approach:

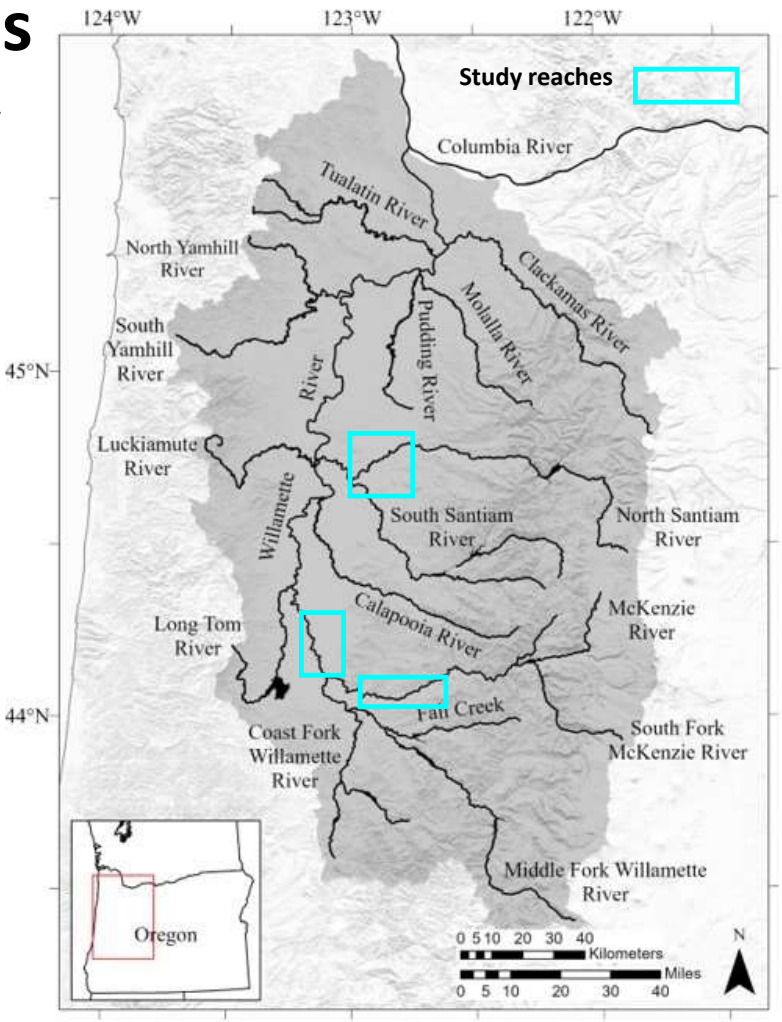
- Select 2-3 reaches with existing 2D hydraulic/temperature models

- Collect invertebrate drift samples and otoliths in 2024-25



- Develop drift-foraging bioenergetics models
- Develop generalized tools so models can be applied more broadly





Basin-wide Mussel and Pacific Lamprey Study

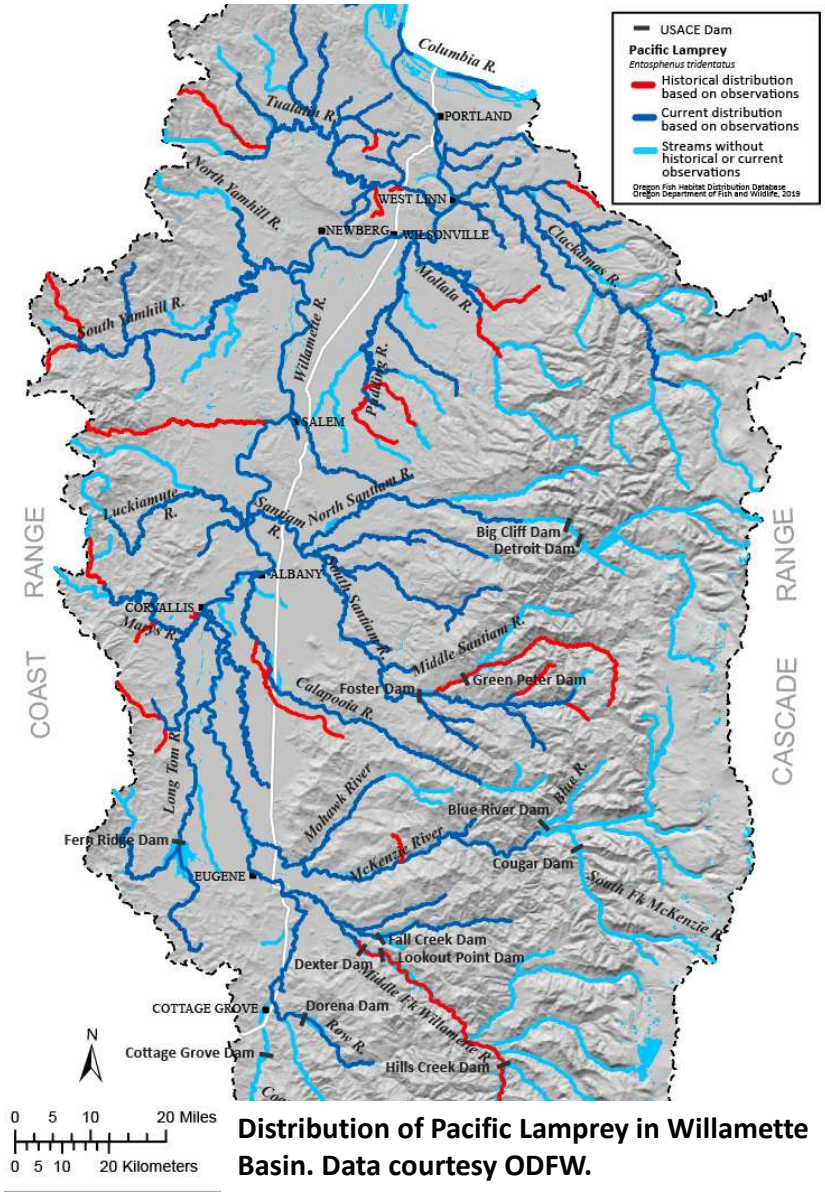
Program name: *EcoFlows Benthics Study*
Goal: *Understand factors driving the occurrence of Pacific Lamprey, western pearlshell mussel, and western ridged mussel in the Willamette River Basin*
PI: *Jason Dunham, Jim Peterson*
Focal area*: Entire Willamette River Basin*

General Approach:

- Compile species observations with basin partners
- Develop basin-wide predictor datasets for physical variables (such as streamflow, water temperature, grain size, and scour potential)
- Build distribution models using predictor datasets
- Develop a transferable framework for other basins in the Pacific Northwest

Photo courtesy of Freshwaters Illustrated

Photo courtesy of Brett Blundon, USFS



Distribution of Pacific Lamprey in Willamette Basin. Data courtesy ODFW.

USGS

Willamette IWS Outreach and Communications

Stakeholder input is informing all aspects of the IWS:

- Understanding of key water management issues, tradeoffs related to people and salmon habitats, and science priorities
- Science syntheses, publications, and websites

Near-term (2024-2026) input needed for water availability studies:

- Focus group to inform modeling scenarios & provide expert review
- Local expertise to ensure accurate characterization of water needs for people and salmon

Multi-faceted communication platforms in development:

- Websites
- Email-list serves and newsletters
- Data visualizations and web-applications

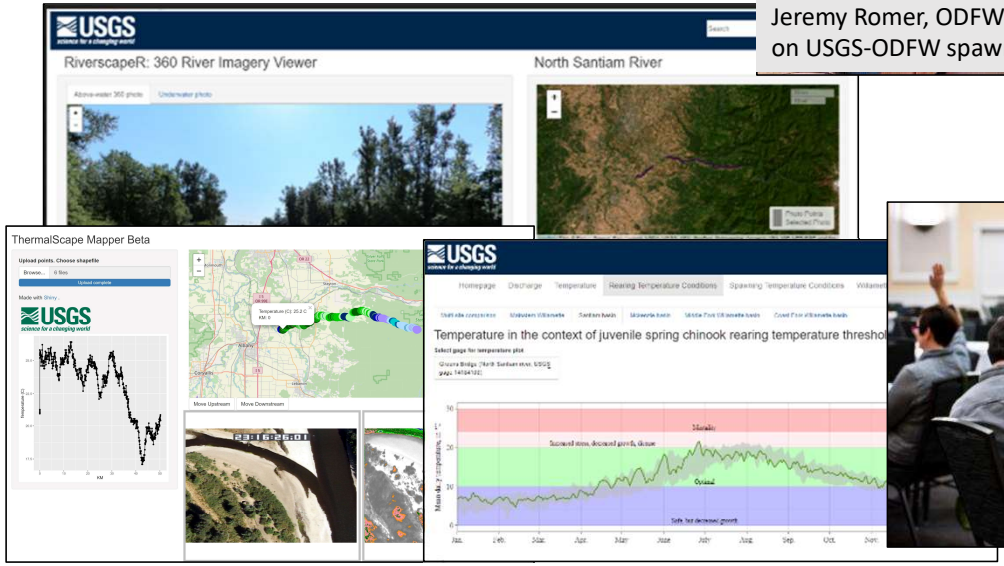
Two-way dialogue and outreach:

- Stakeholder meeting early June 2024
- One-on-one conversations with agencies, stakeholders, researchers, NGOs
- Ongoing dialogue with 'focus groups' and expert panels

Willamette Floodplain Science Symposium

- December 2024 in Corvallis

Jeremy Romer, ODFW (right) and Toby Kock, USGS WFRC (left), on USGS-ODFW spawning trip, McKenzie River 2022



Willamette Basin Web Applications in development: River viewer (top). Thermalscape viewer, and synthesis of flow, temperature and salmon habitat conditions (bottom)

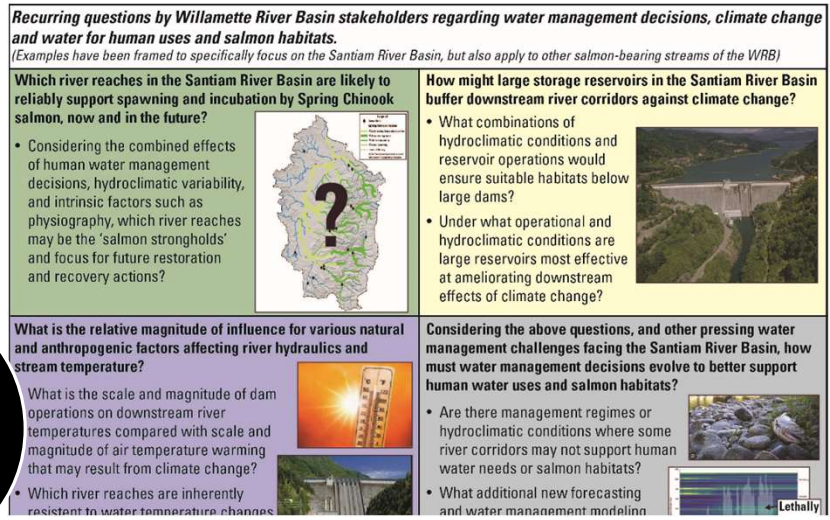
Within Our Reach Workshop, 2018

USGS

Fisheries-focused Willamette IWS Activities 2022-26

Outreach & Stakeholder Partnership:
Knowledge sharing to inform Willamette Basin water management and science plans

Integrated Water Availability Assessments (IWAAs):
Evaluating variability in flow and temperature and implications for people and salmon



EcoFlows:
Predicting consequences of hydrologic variability on ecosystems

Next Generation Water Observing Systems (NGWOS):
Data collection, R&D focused on salmon habitats

USGS

NGWOS, IWAAs and Outreach extend through 2031, but will shift to a basin-wide water availability focus 2027-2031

Questions?

Rose Wallick, Willamette IWS Outreach Coordinator: rosewall@usgs.gov

General inquiries: WillametteIWS@usgs.gov

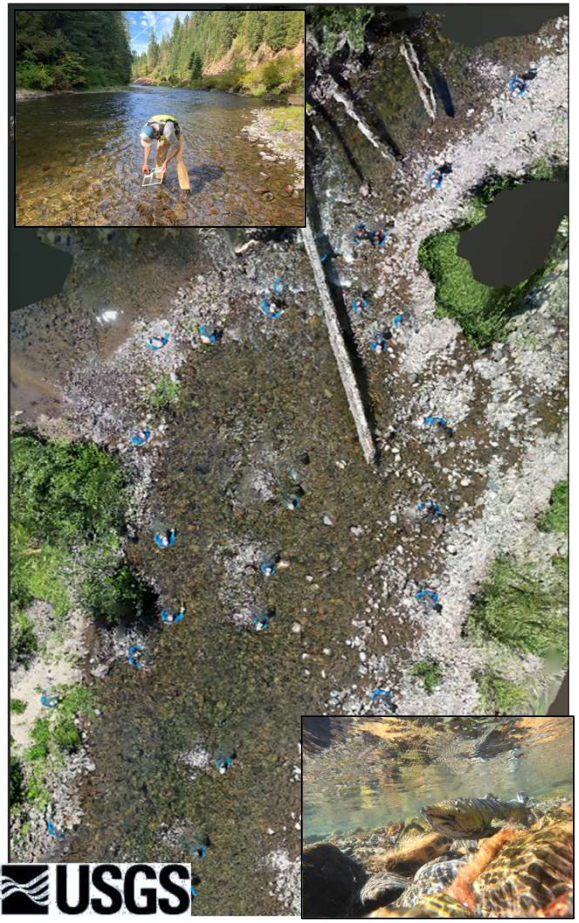
North Santiam River, Photograph courtesy of NOAA Fisheries

Extra Slides

Examples of River Mapping & Equipment Development

Field-based River Surveys

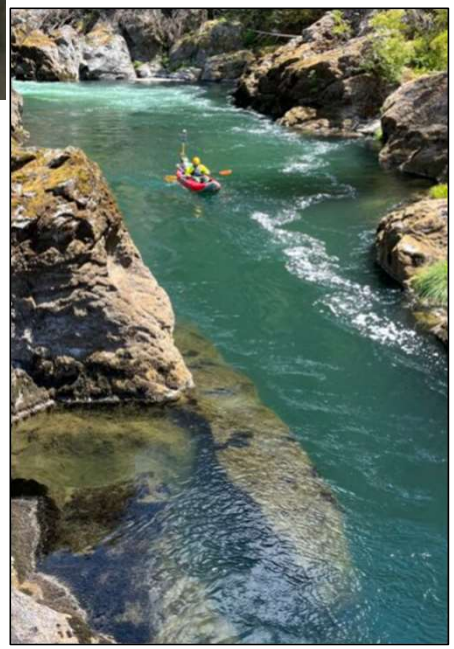
Middle Santiam River, September 2024. Orthophoto and DEM from pole-mounted camera



Boat-Based River Surveys

Sonar- and camera-equipped uncrewed survey vessel, L. North Santiam River, September 2024

Cataraft and kayak surveys across major salmon-bearing rivers.



Crewed Aircraft:

Multi-Sensor payload development facilitates efficient, low-cost hyperspectral and thermal IR image acquisition and processing.

In collaboration with USACE's CRRL and Civil Air Patrol