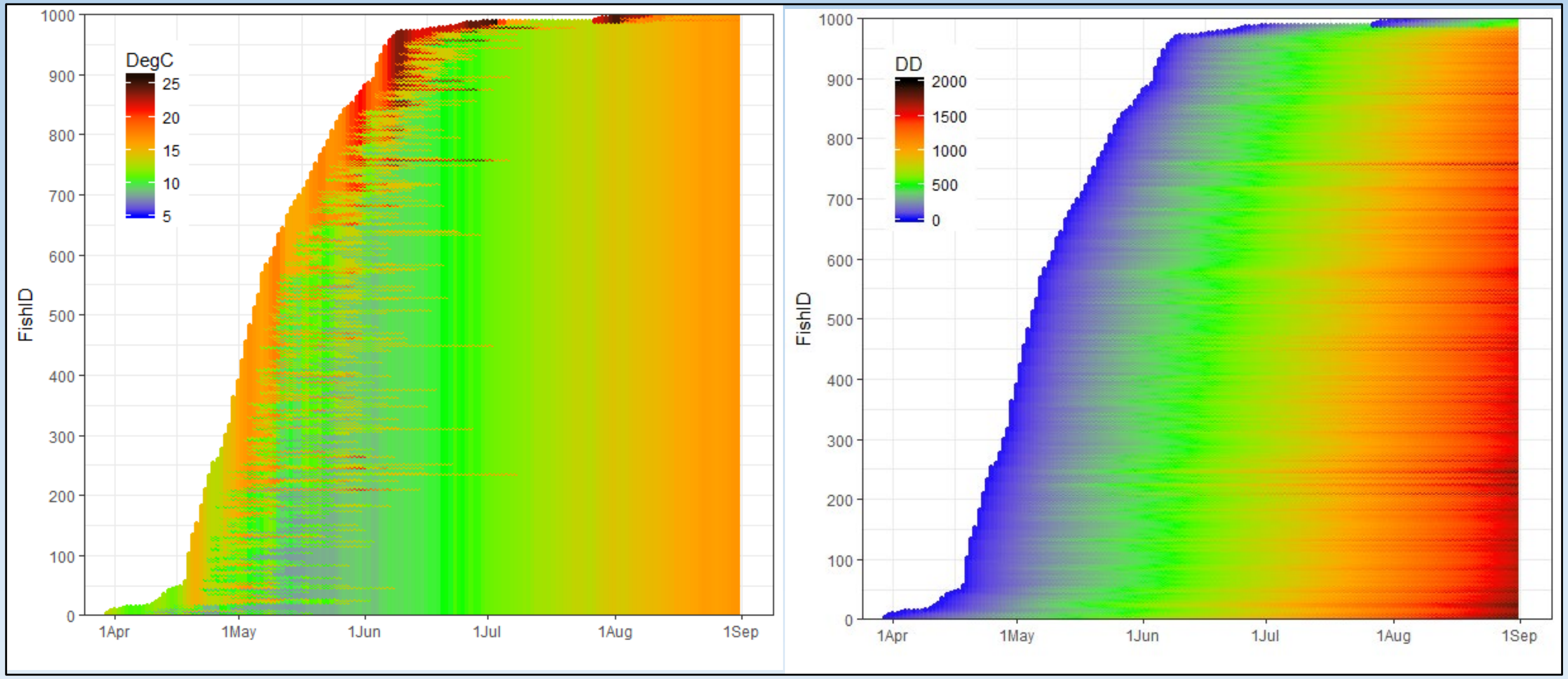
Potential effects of North Santiam River temperature targets on adult Chinook salmon



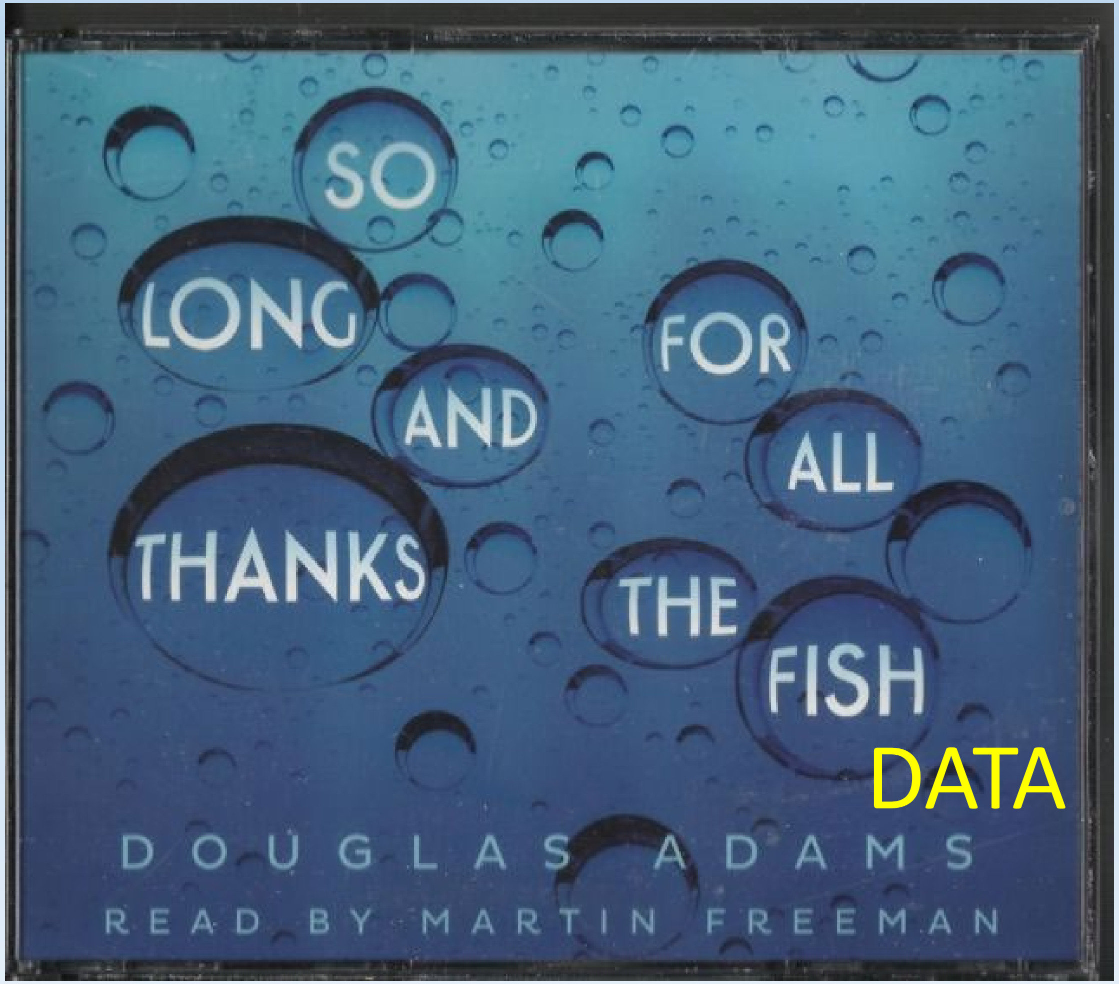
Matthew Keefer[1], Tami Clabough[1], Mike Jepson[1],
Tim Blubaugh[1], Chris Caudill[1], and Norm Buccola[2]

[1] Department of Fish and Wildlife Sciences
University of Idaho

[2] U.S. Army Corps of Engineers

Acknowledgements

- J. Macdonald, R. Walker, R. Piaskowski, F. Khan, S. Hart
- B. DeBow, G. Grenbemer, M. Lewis, L. Whitman, B. Cannon, C. Sharpe
- G. Brink, G. Naughton

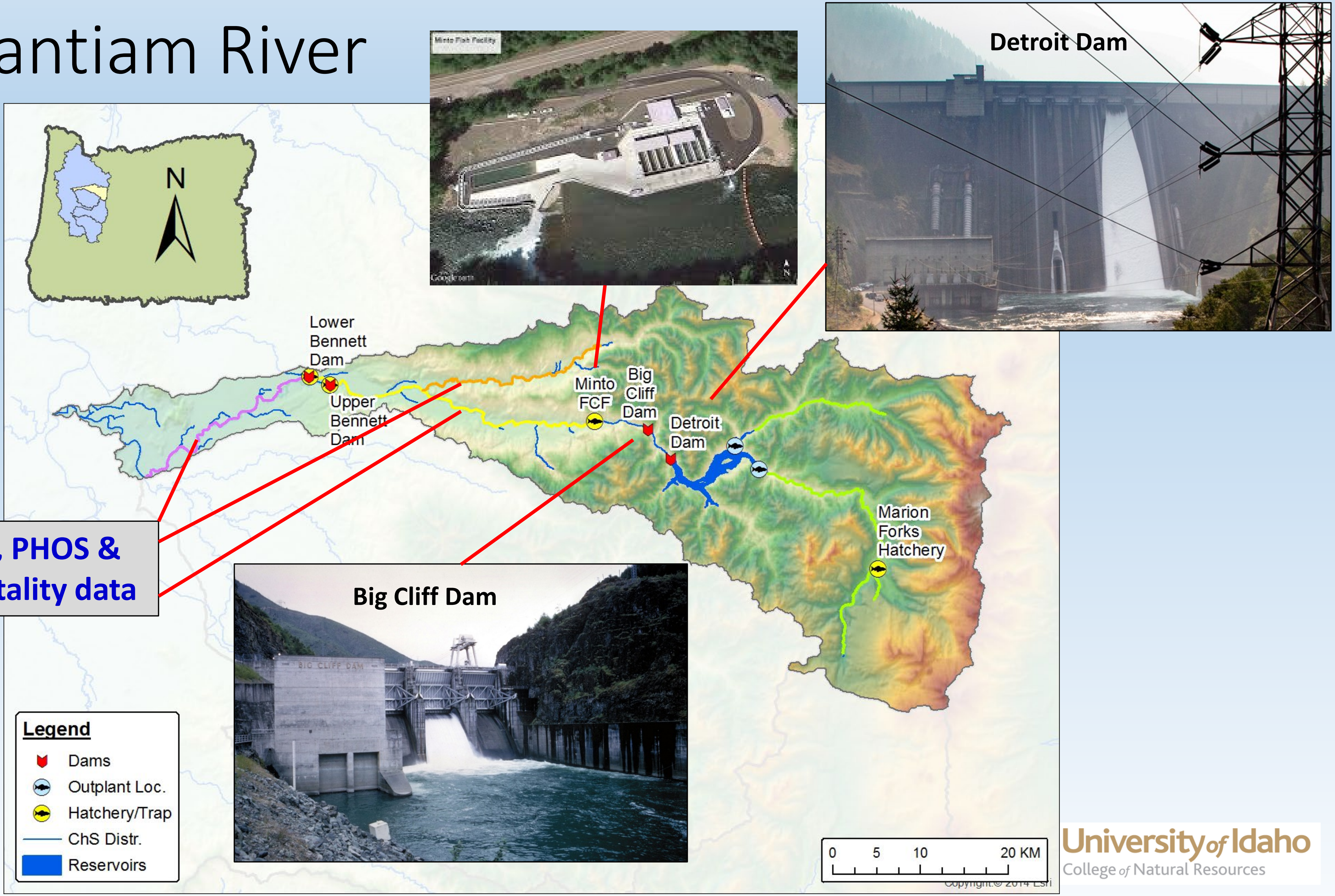


State of OREGON Fish & Wildlife

US Army Corps of Engineers®

University of Idaho
College of Natural Resources

North Santiam River

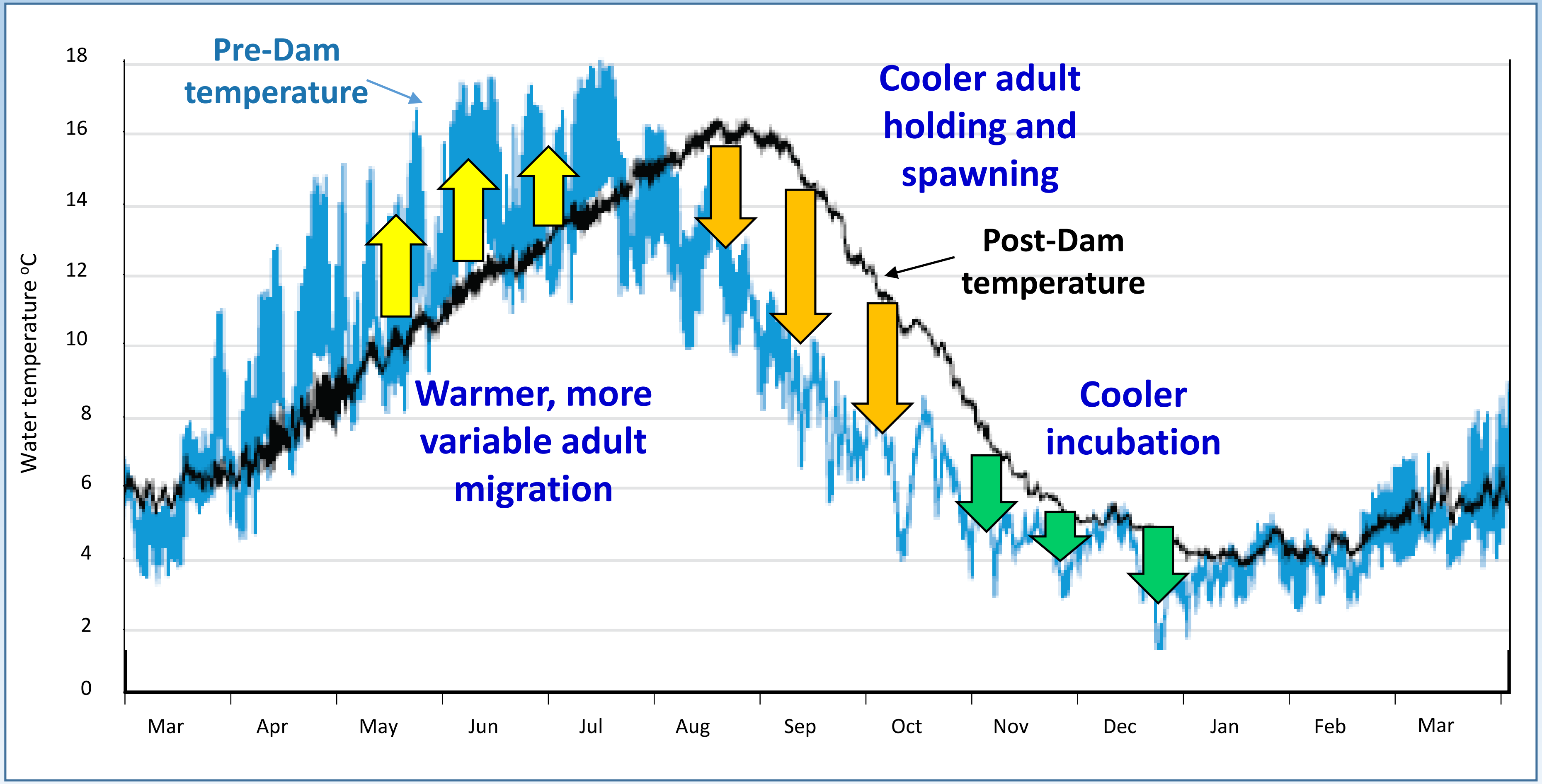


Redd, carcass, PHOS & prespawn mortality data

Map: C. Sharpe

University of Idaho
College of Natural Resources

A ‘normative’ regime for N. Santiam Chinook

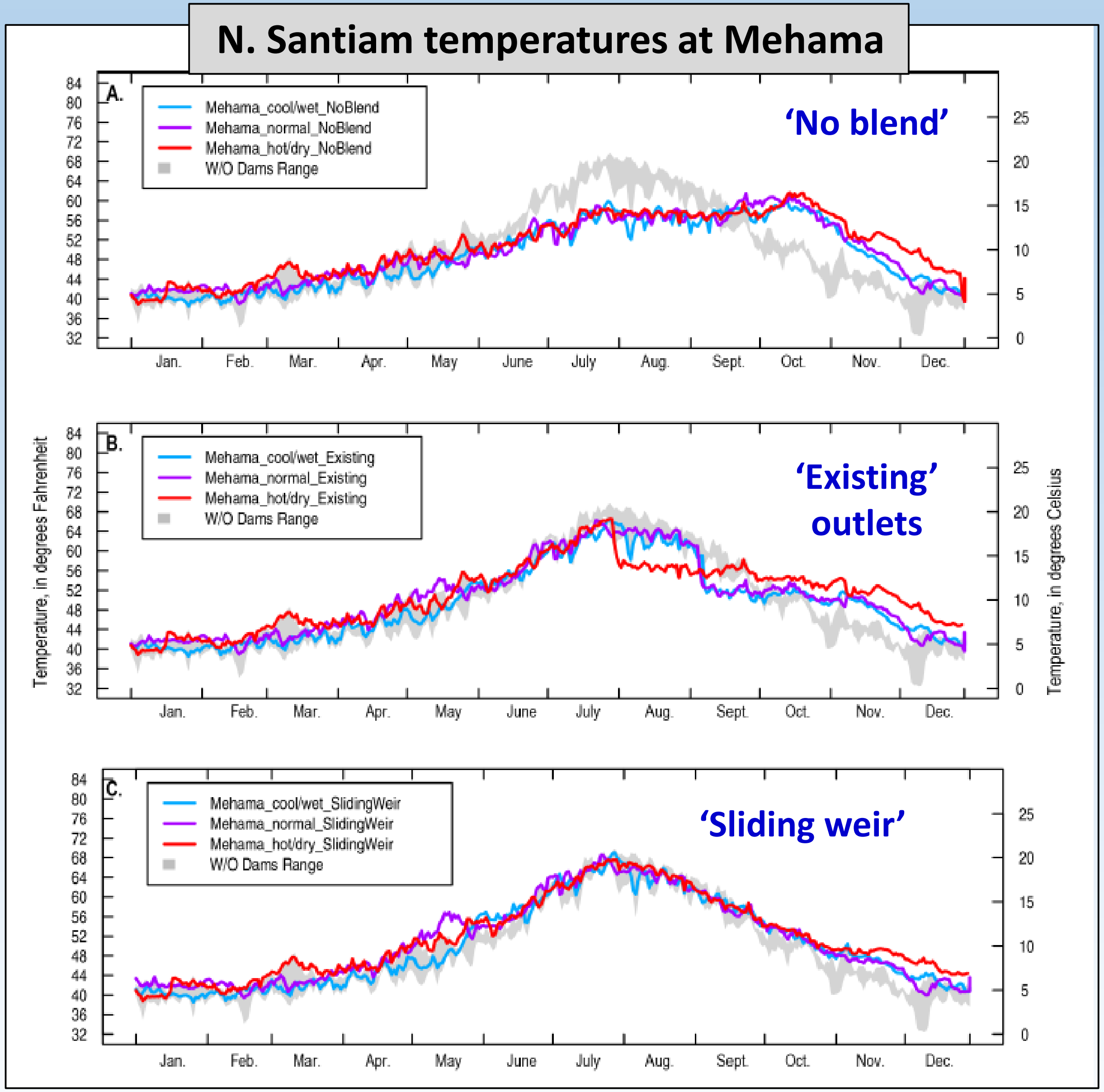


Temperature graph: Rounds (2010, modified)

University of Idaho
College of Natural Resources

Temperature management scenarios

- Water temperature models of Detroit and Big Cliff lakes and N. Santiam River (CE-QUAL-W2)
- Simulations for a variety of water years and operational scenarios



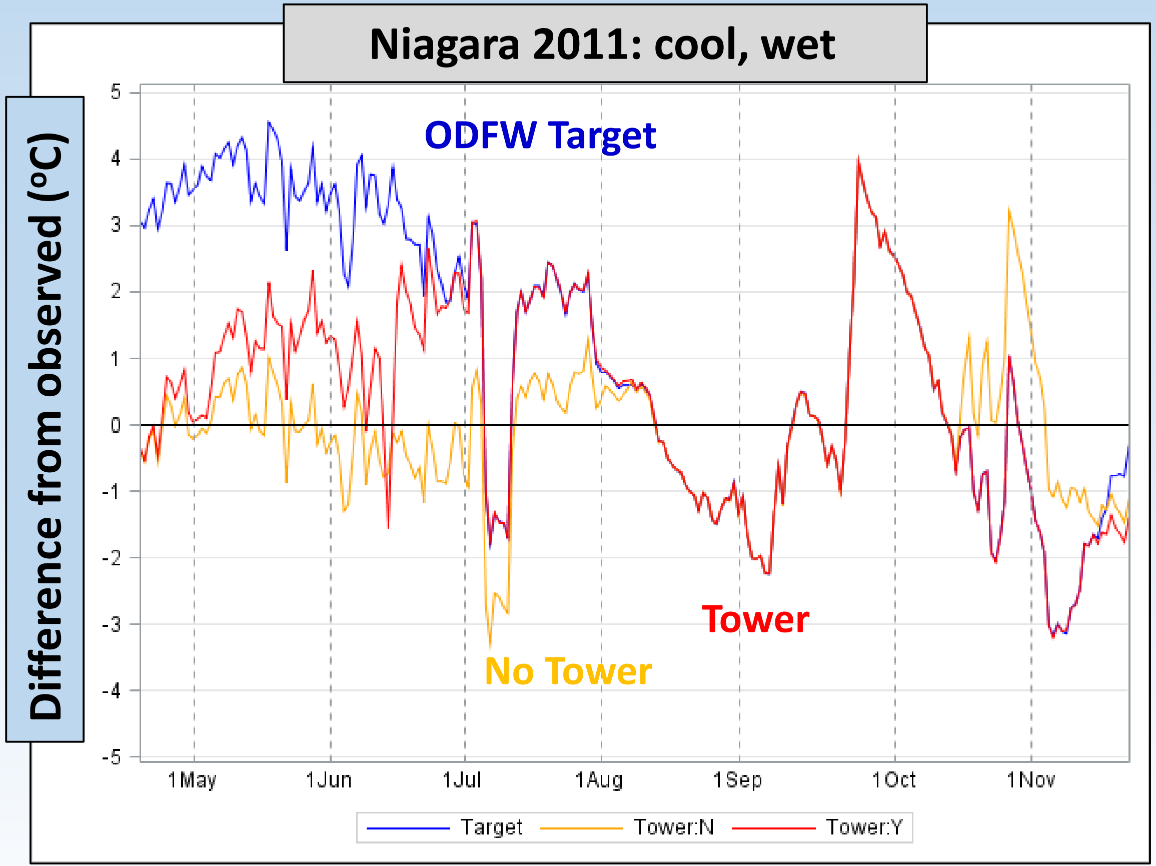
Buccola et al. (2015)

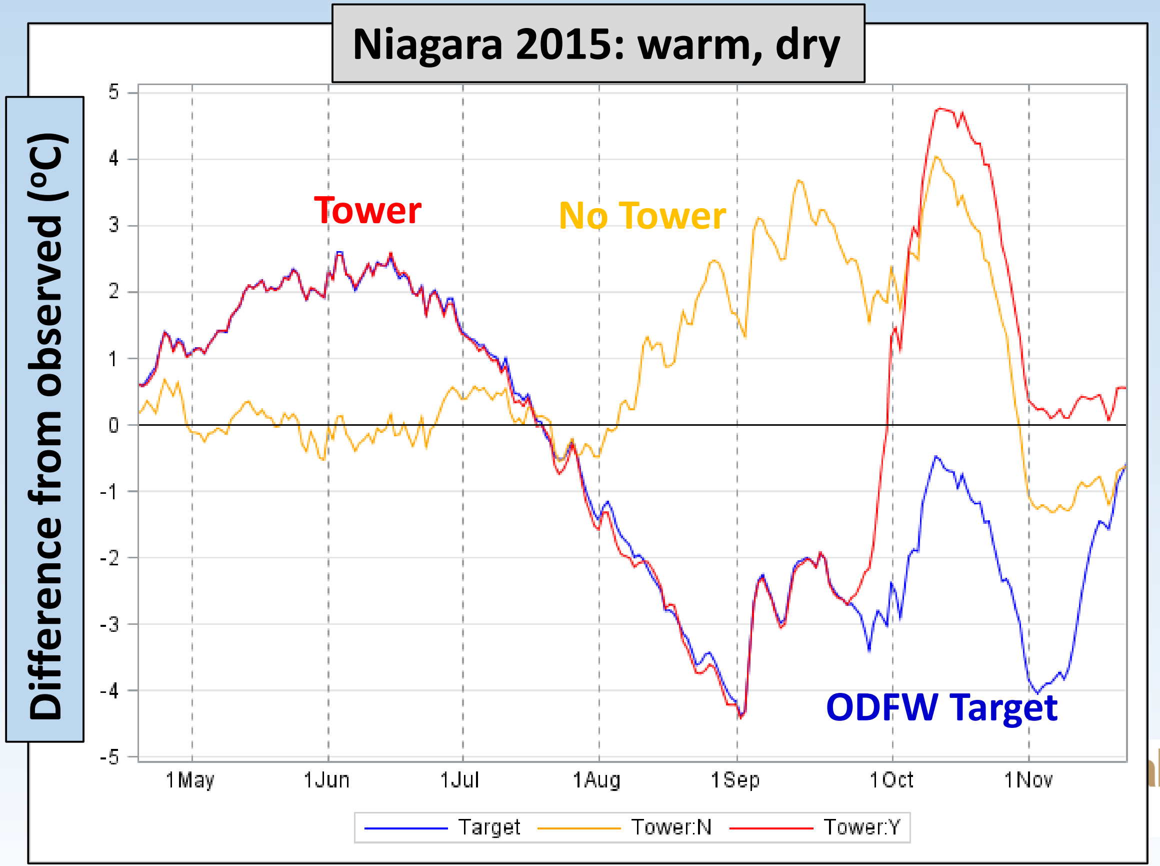
Temperature management scenarios

- 'ODFW Target' – based on recommendations made in 2017

1: With Temperature Control structure at Detroit ('Tower')

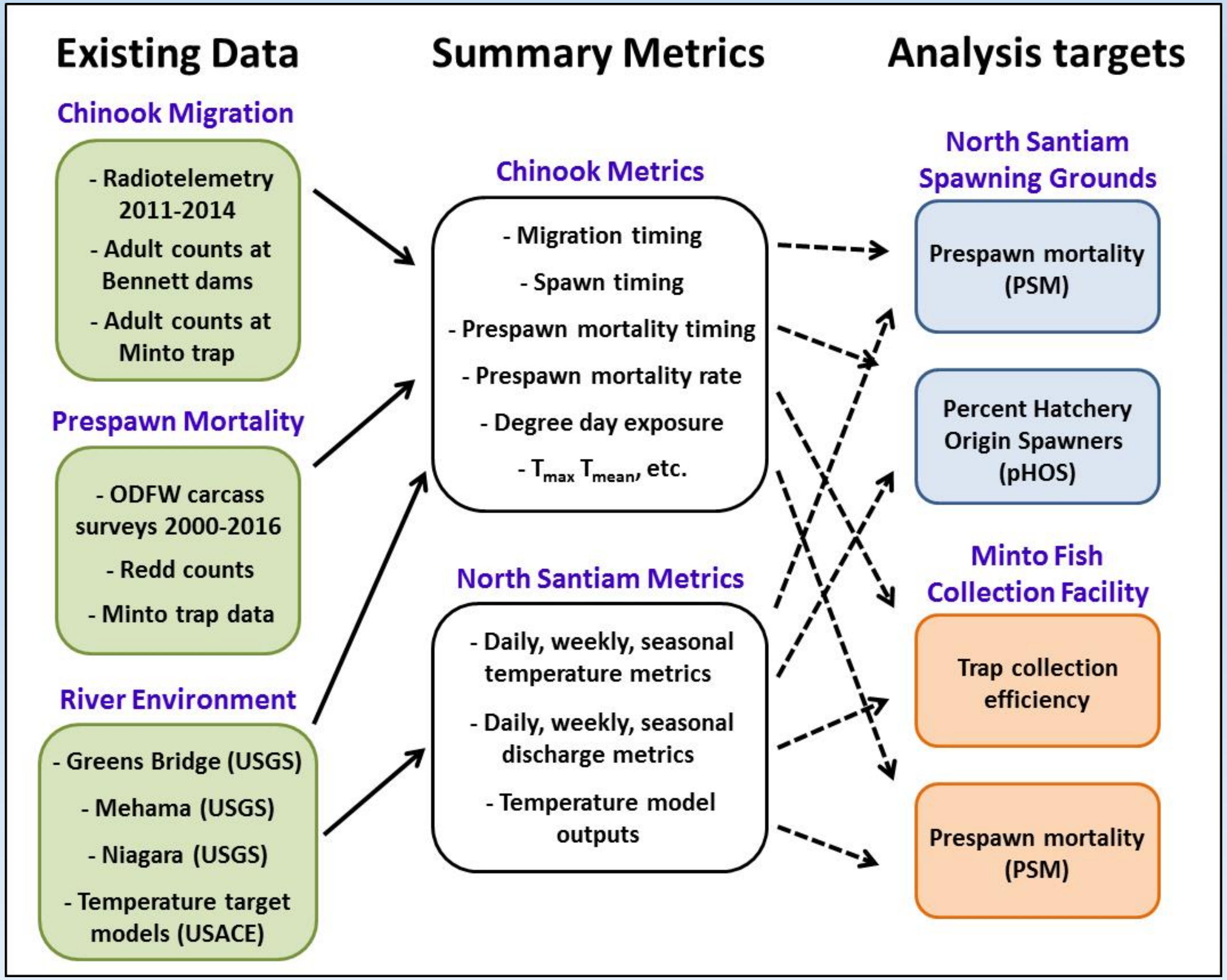
2: Without Temperature Control structure at Detroit ('No Tower')

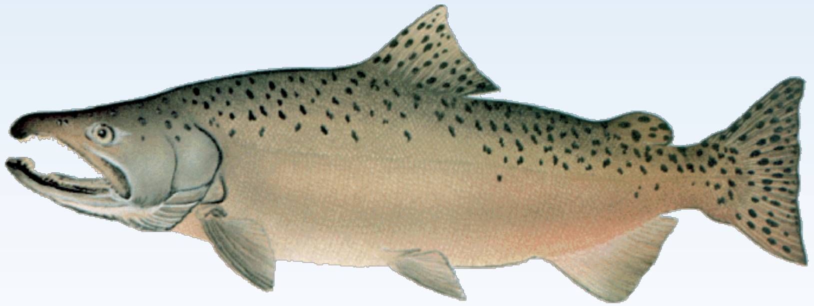




Research objectives

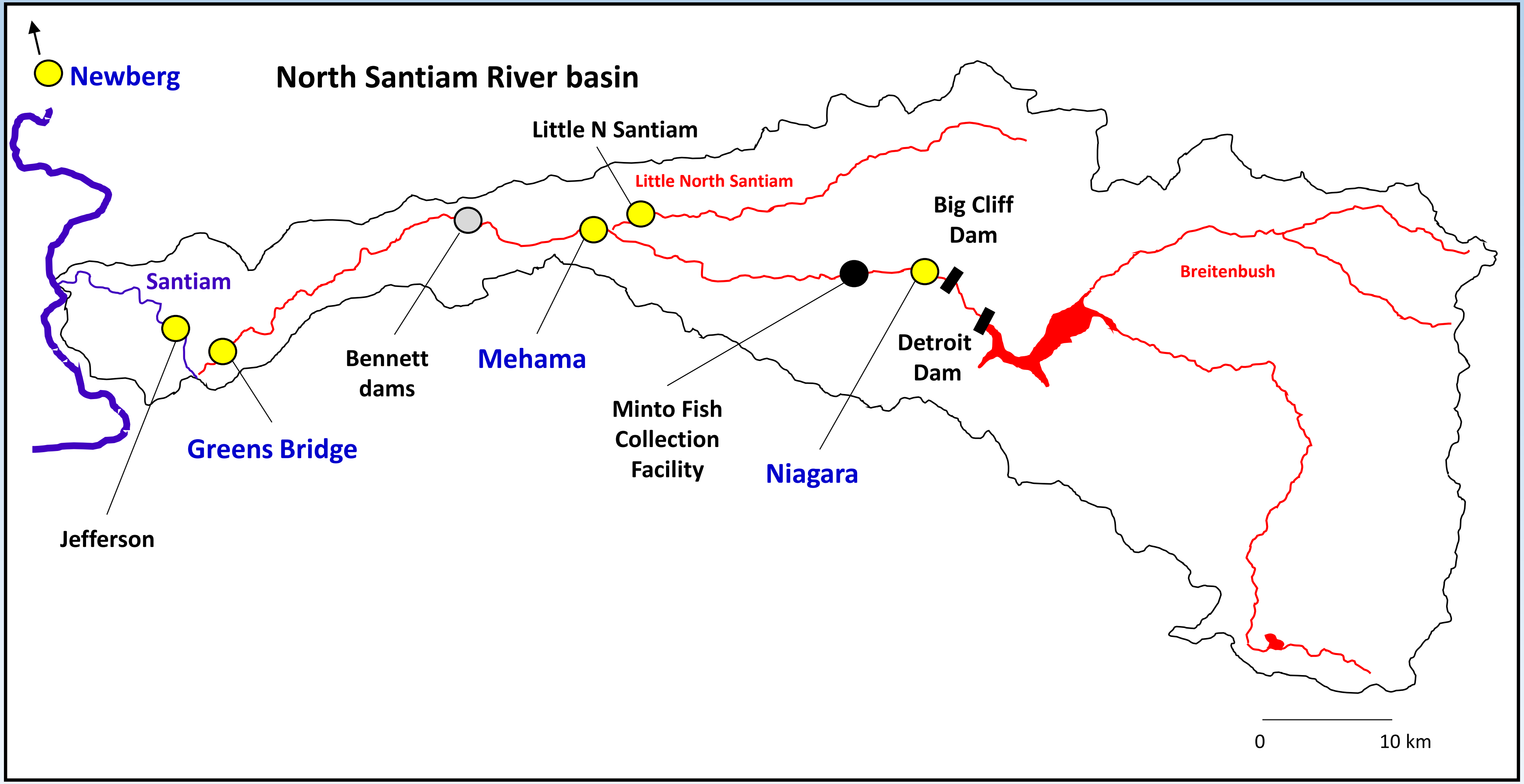
- Integrate existing data
  - River environment
  - Migration, holding behaviors
  - Prespawn mortality, PHOS
- Models to evaluate temperature management effects
  - Thermal exposure
  - *Emergence timing*
  - *Bioenergetics*





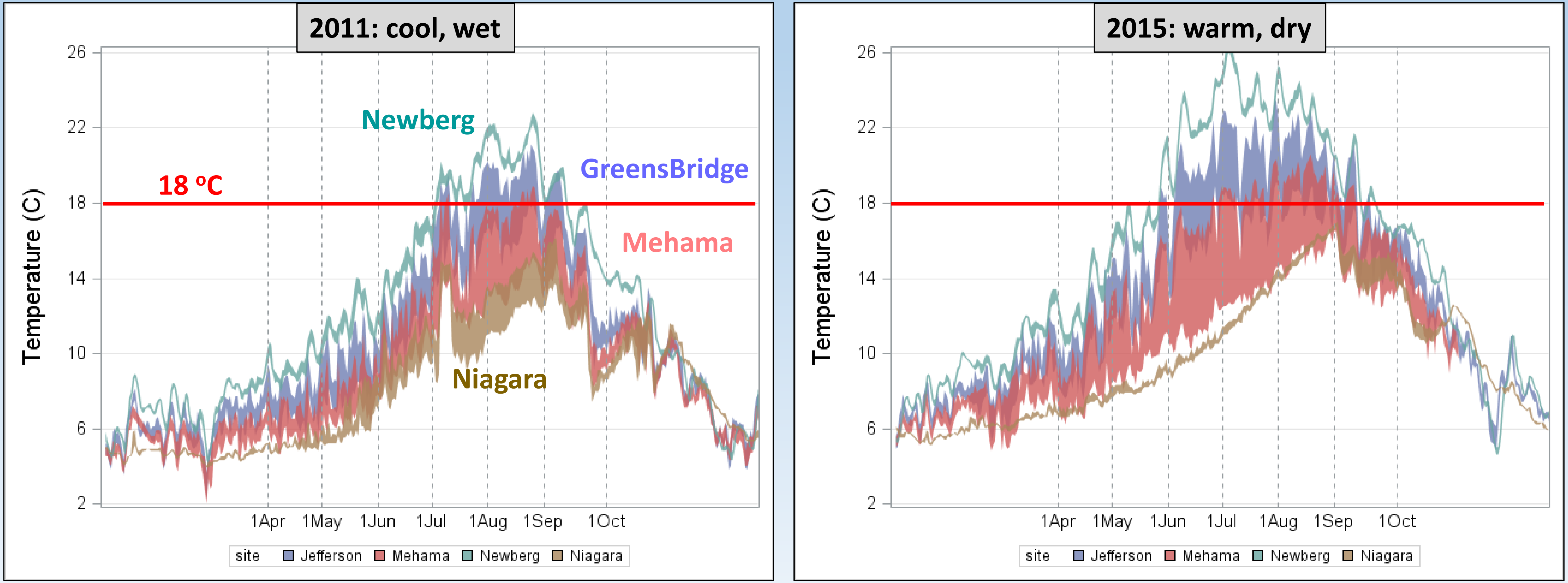
University of Idaho
College of Natural Resources

River environment: USGS gage sites



University of Idaho
College of Natural Resources

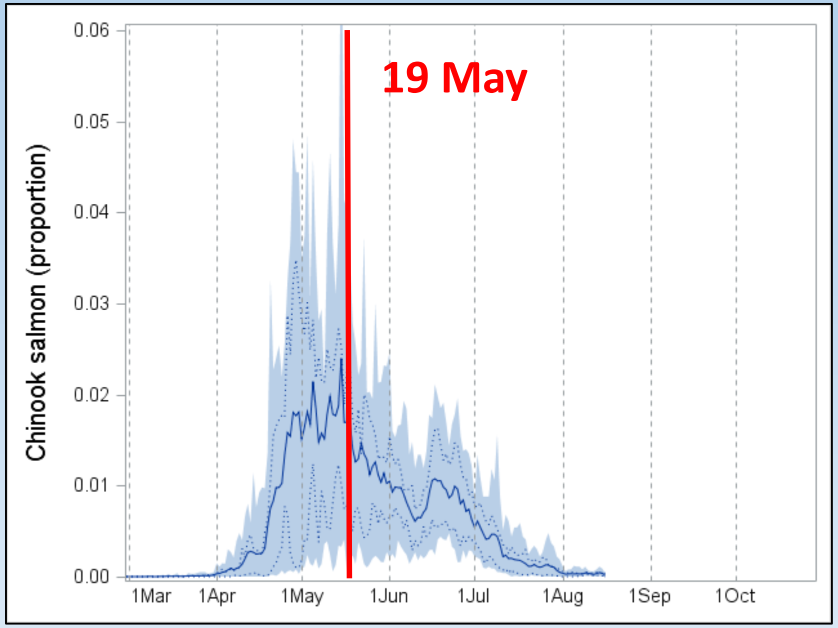
Thermal environment



University of Idaho
College of Natural Resources

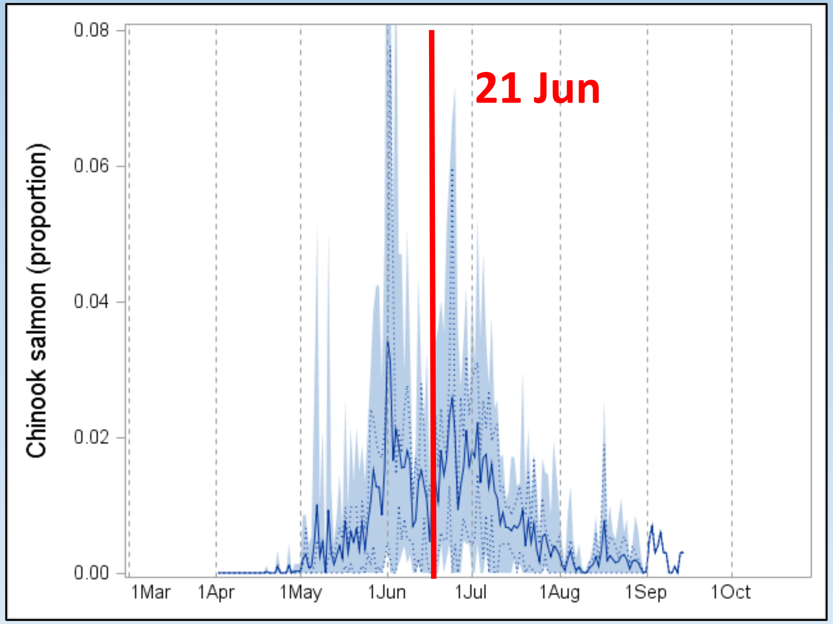
Chinook salmon: Migration timing

Willamette Falls (2001-2018)



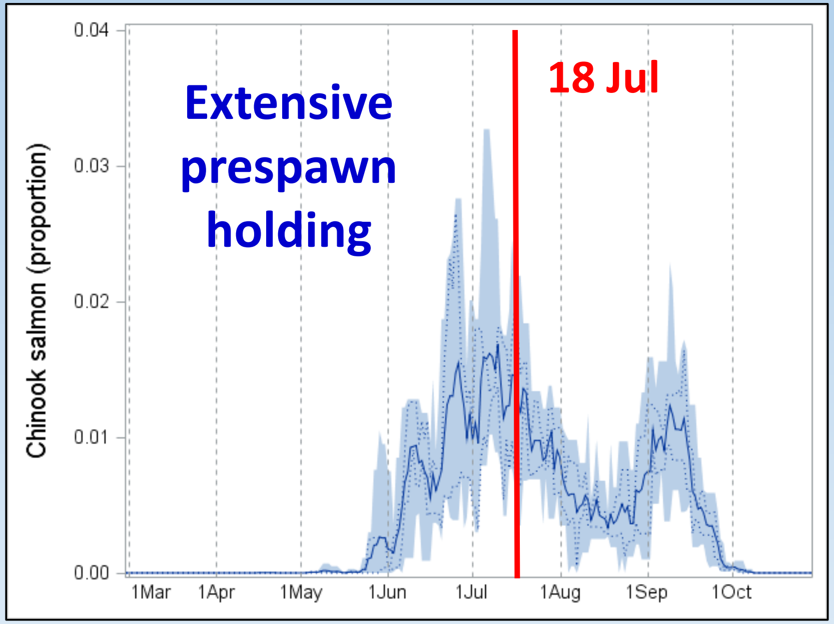
Data source: ODFW daily counts

Upper Bennett (2010, 2014-2017)



Data source: B. DeBow daily counts

Minto (2013-2017, *smoothed*)



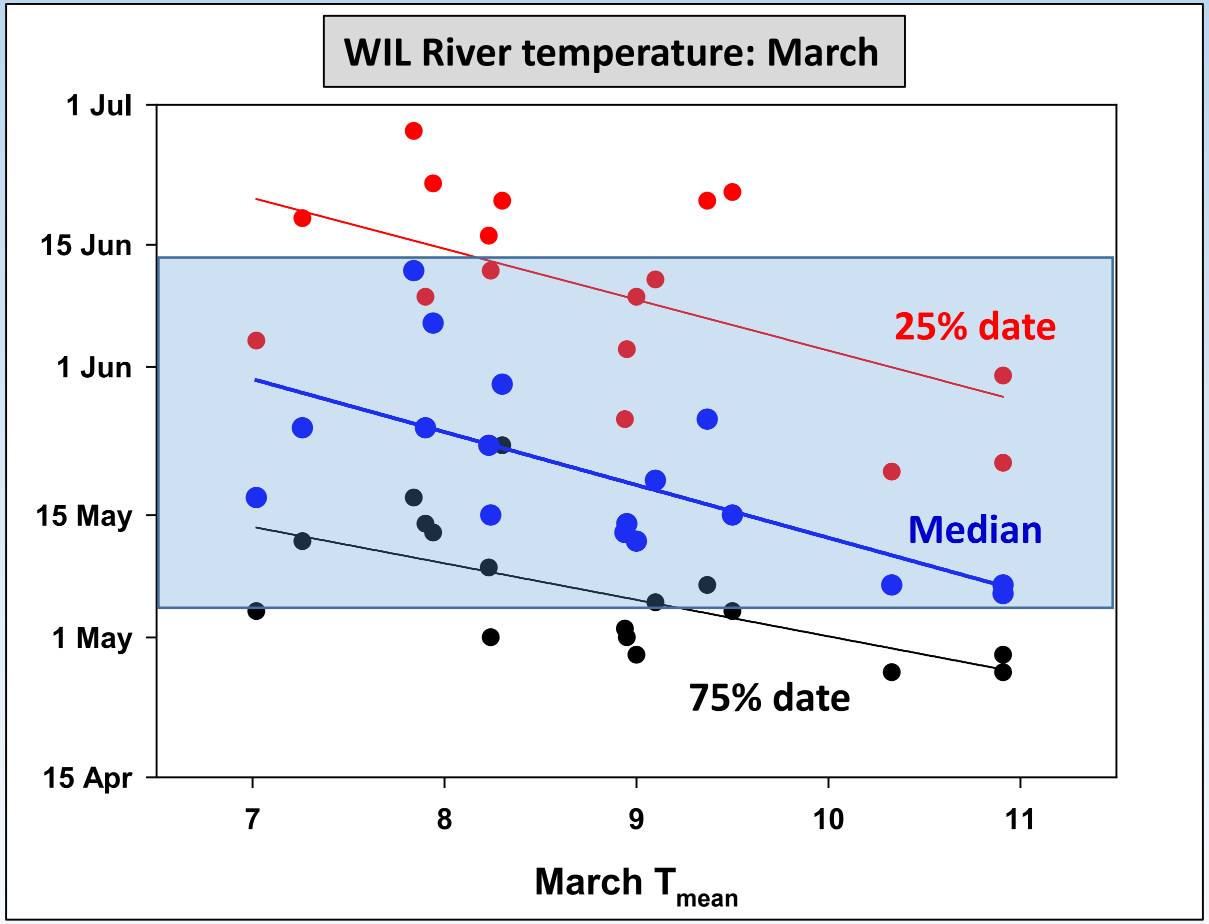
Data source: G. Grenbemer daily counts

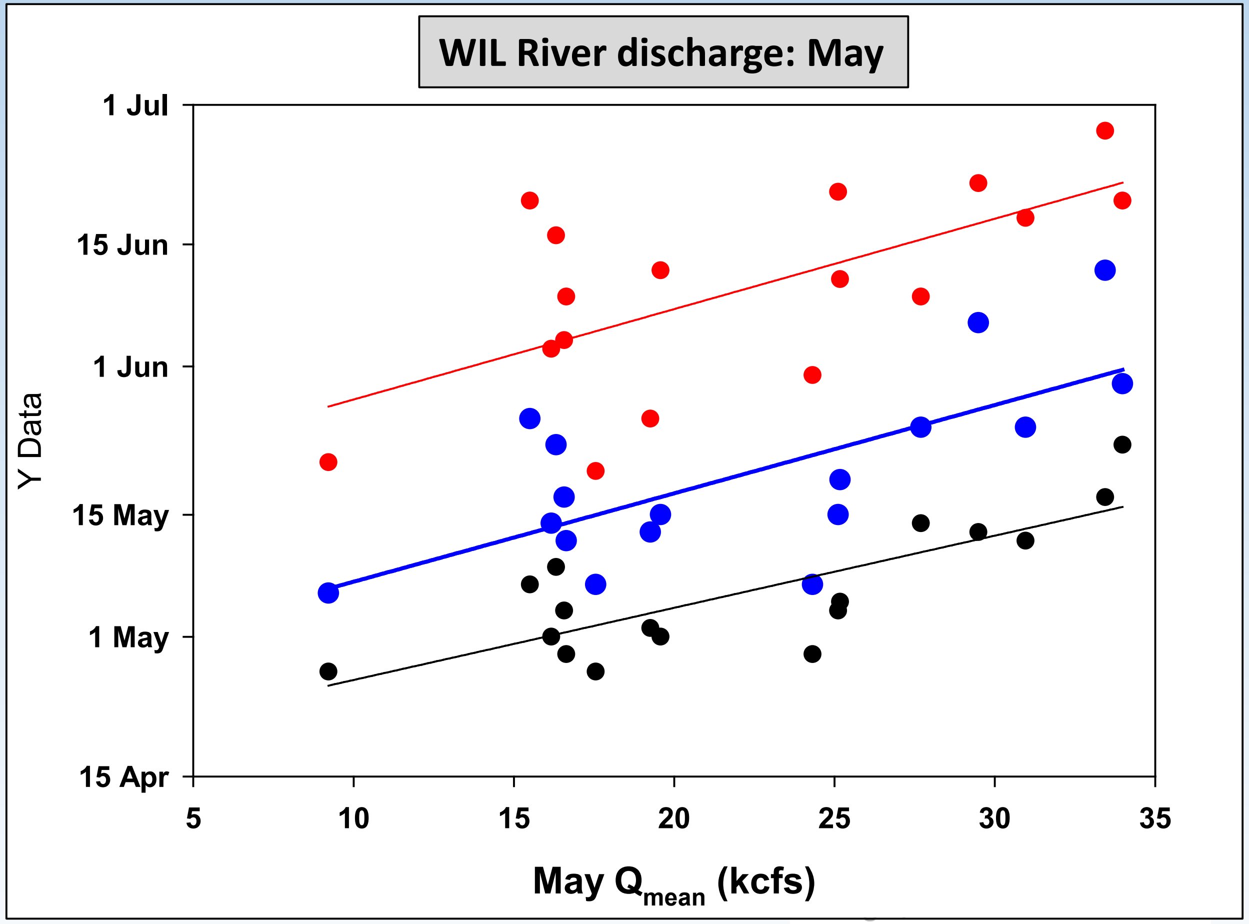
~183 rkm

~35 rkm

Migration timing

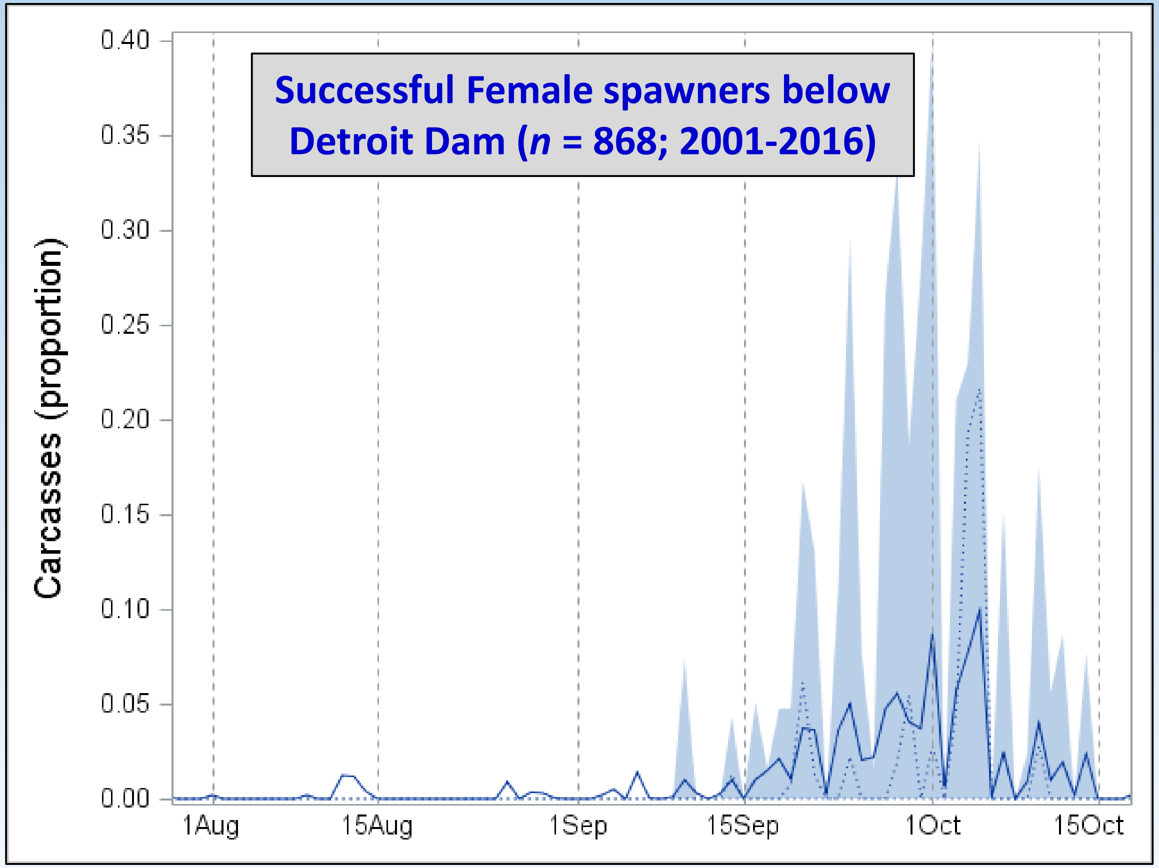
- Early in warm, low-flow years
- Run timing at Willamette Falls varies by >30 d

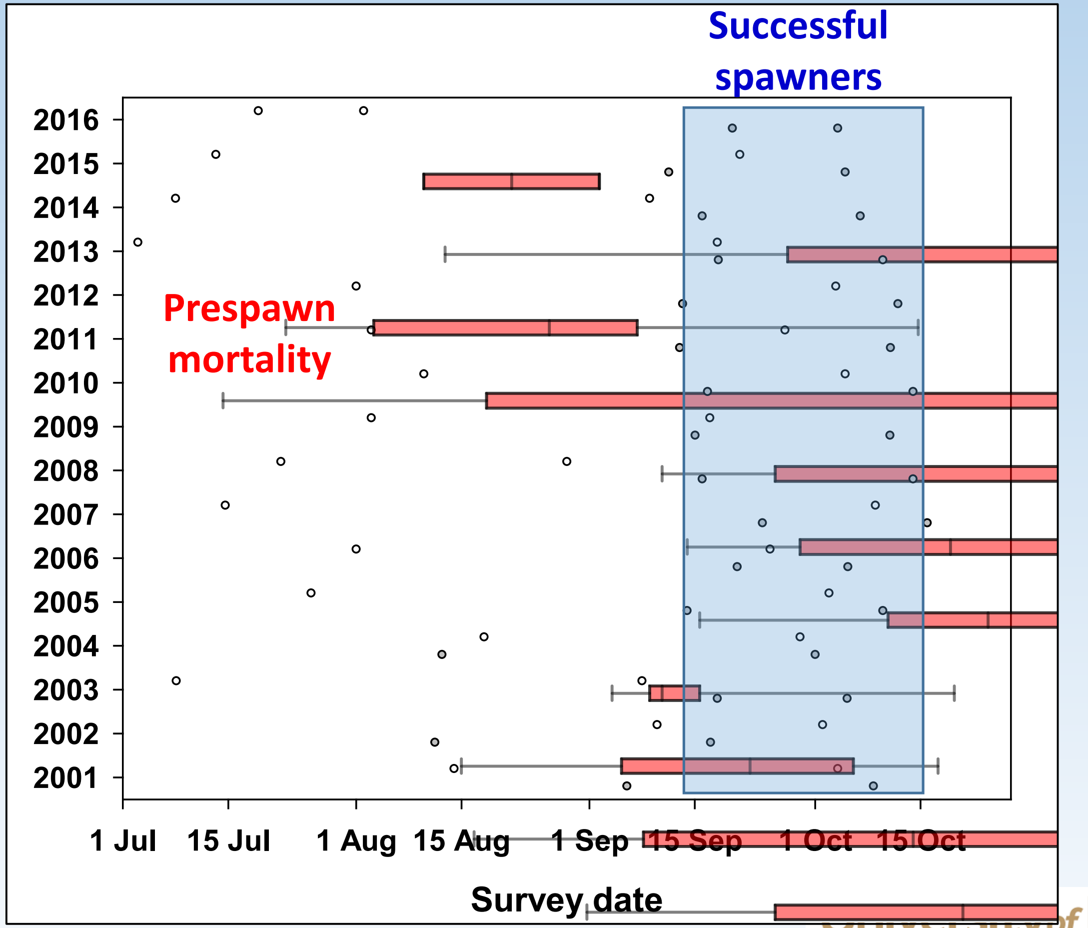




Spawn timing

- Less inter-annual variation and less evidence for environment effects

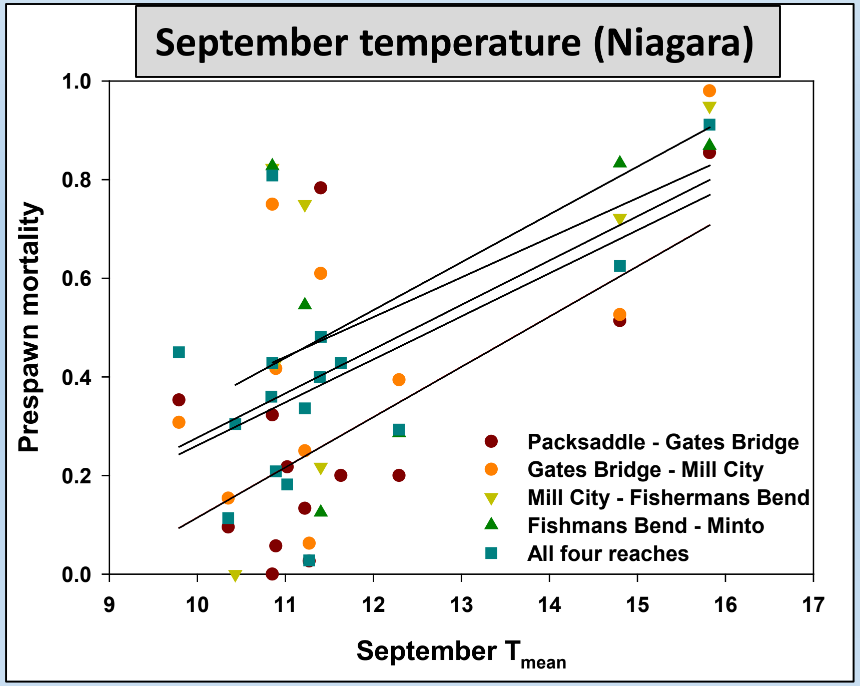


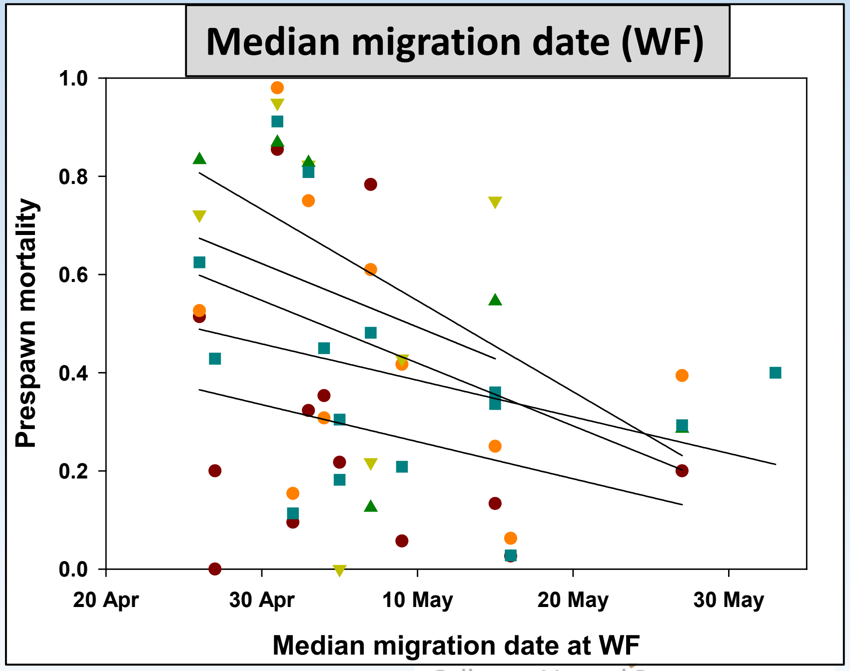


Data source: ODFW_OWCS

Prespawn mortality

- Warm, low-flow years = Early migration
- Early migration = Long residence times
- Long residence times = Many risk factors
  - Pathogen / Parasite proliferation
  - Senescent processes
  - Energetic exhaustion



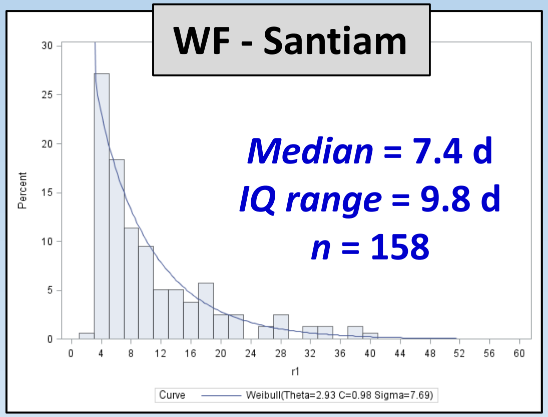


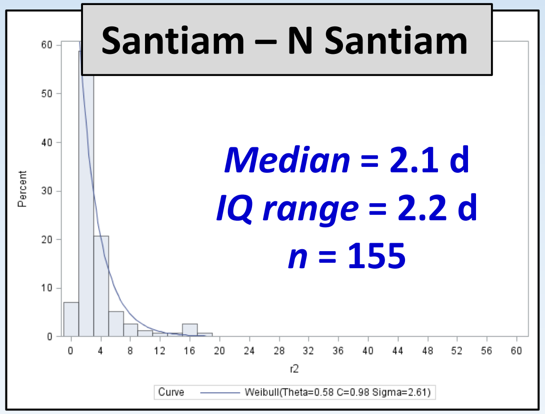
Data source: ODFW_OWCS

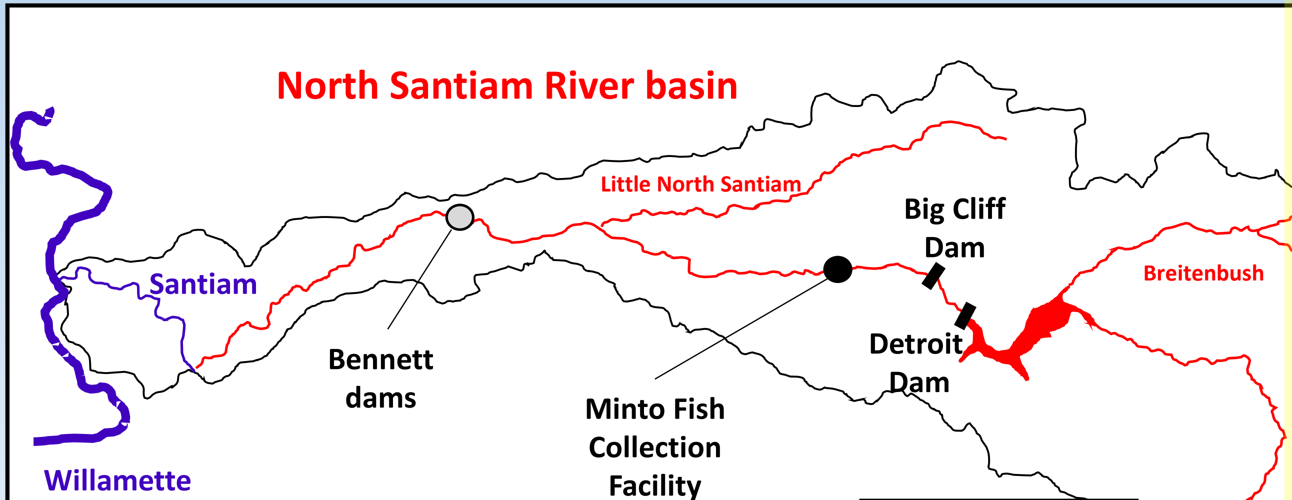
What about individuals?

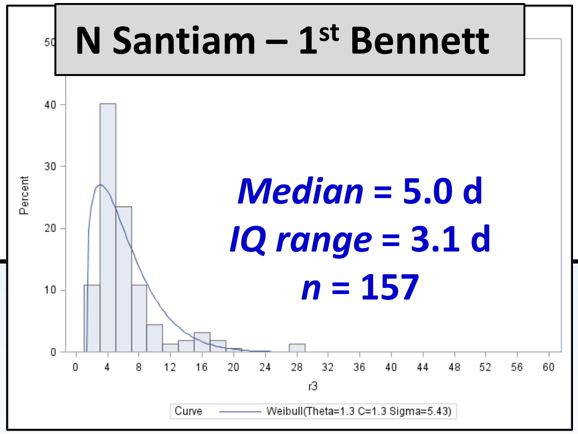
- Radiotelemetry: adults tagged at WF in 2011-2014

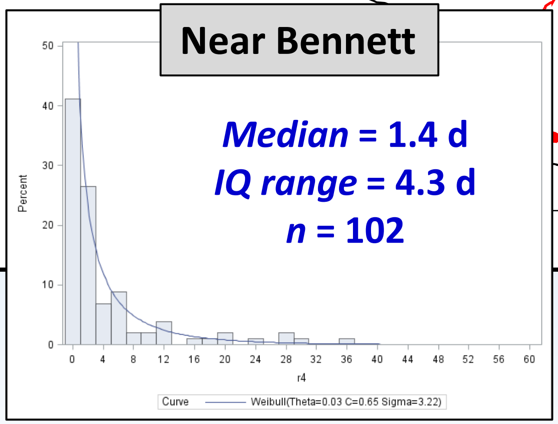
Warmer water = Faster migration

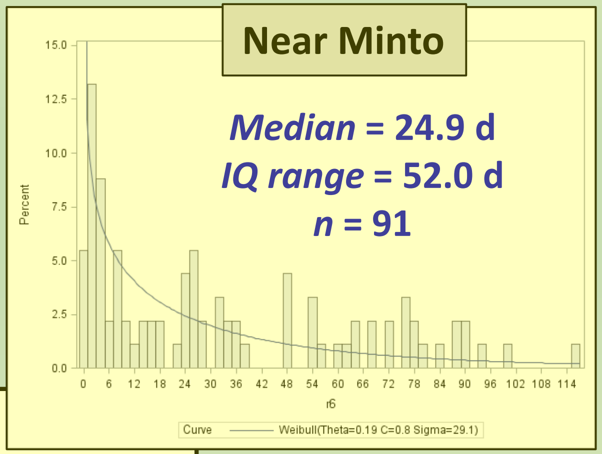


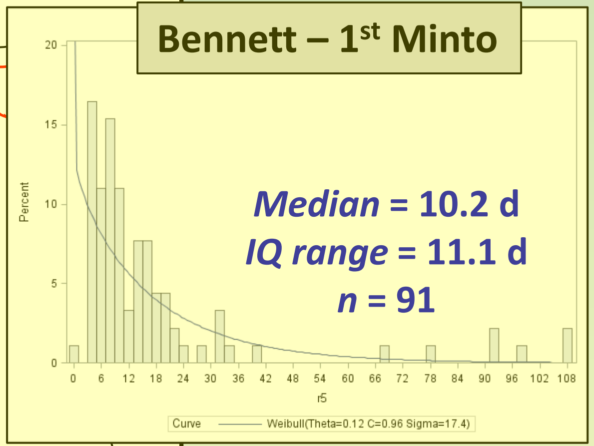








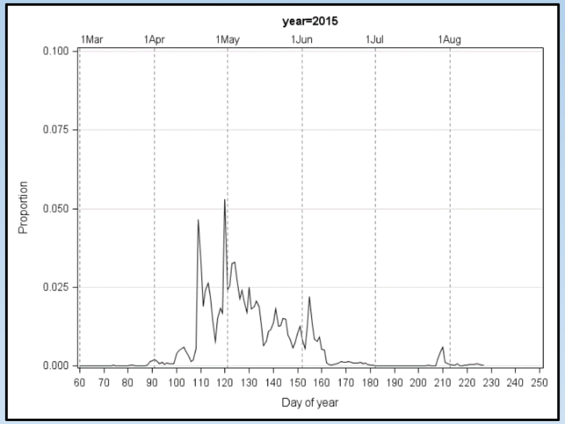




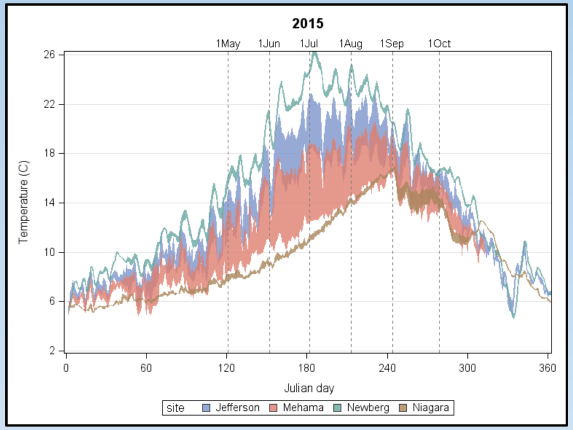
University of Idaho
College of Natural Resources

Adult Chinook: thermal exposure model

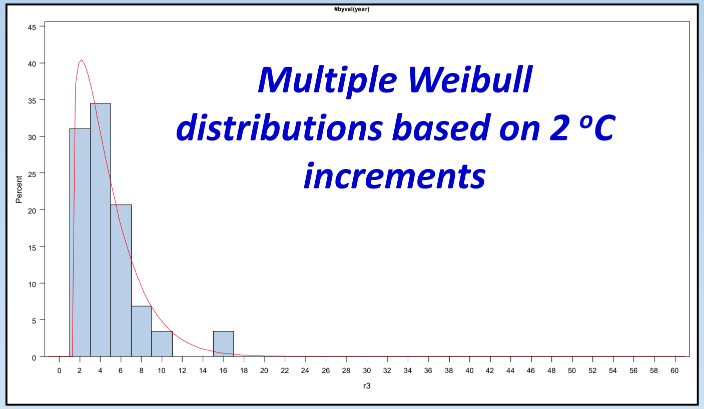
1. Random Chinook sample from passage distribution at WF



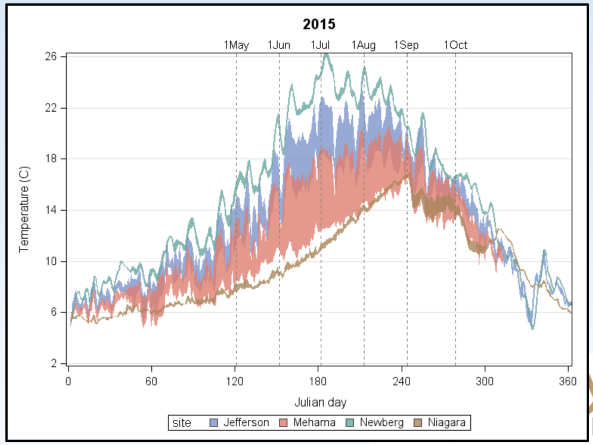
2. Match fish to WIL River temperature on start date



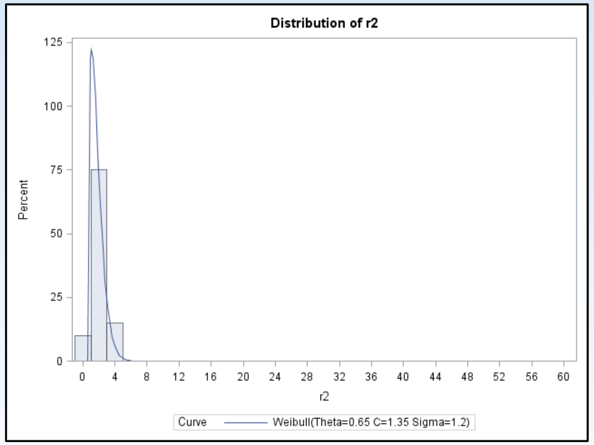
3. Random draw from passage time distributions (telemetry)

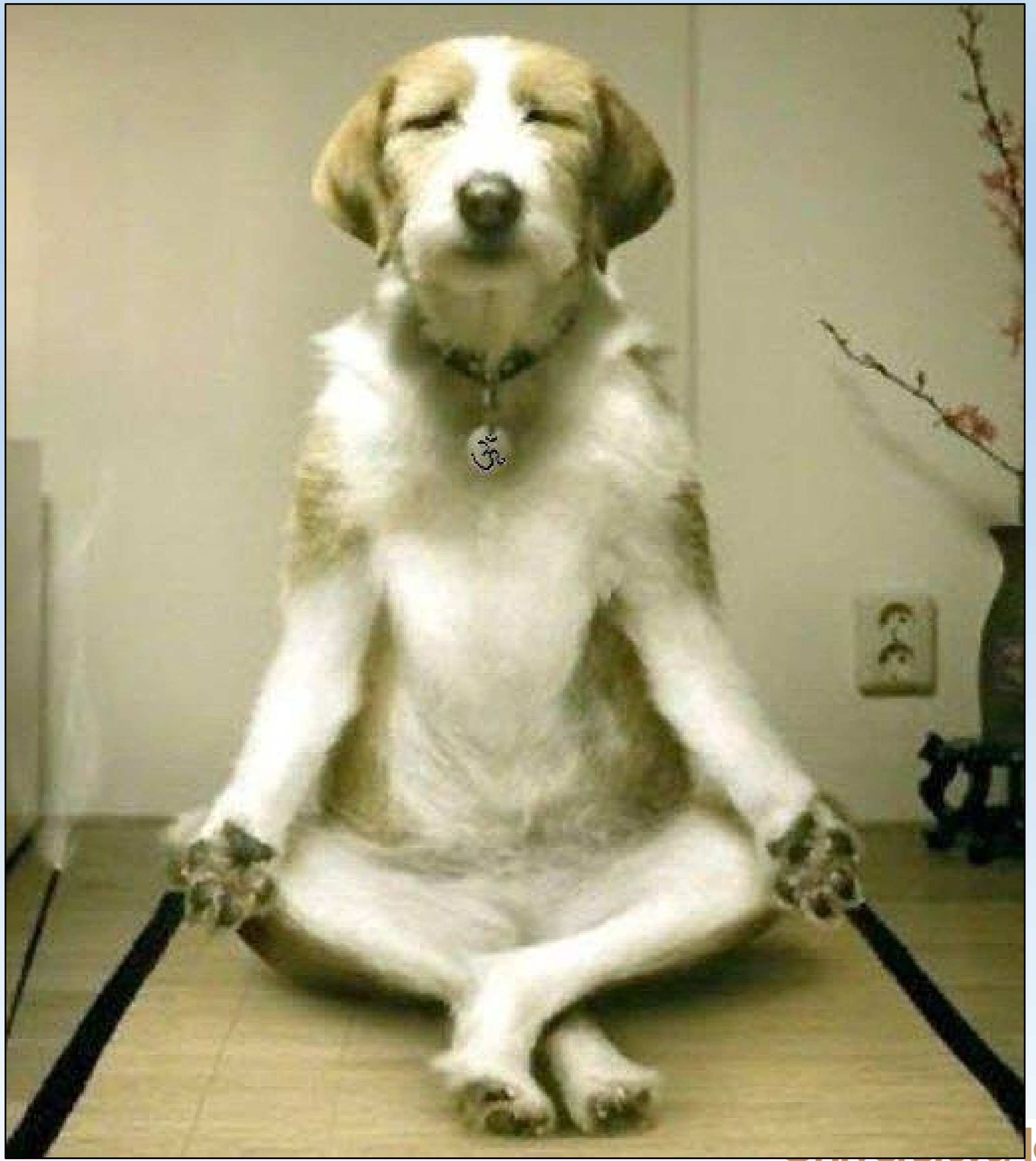


4. Use output to seed next upstream reach, matching fish & date to temperature at nearest gage site



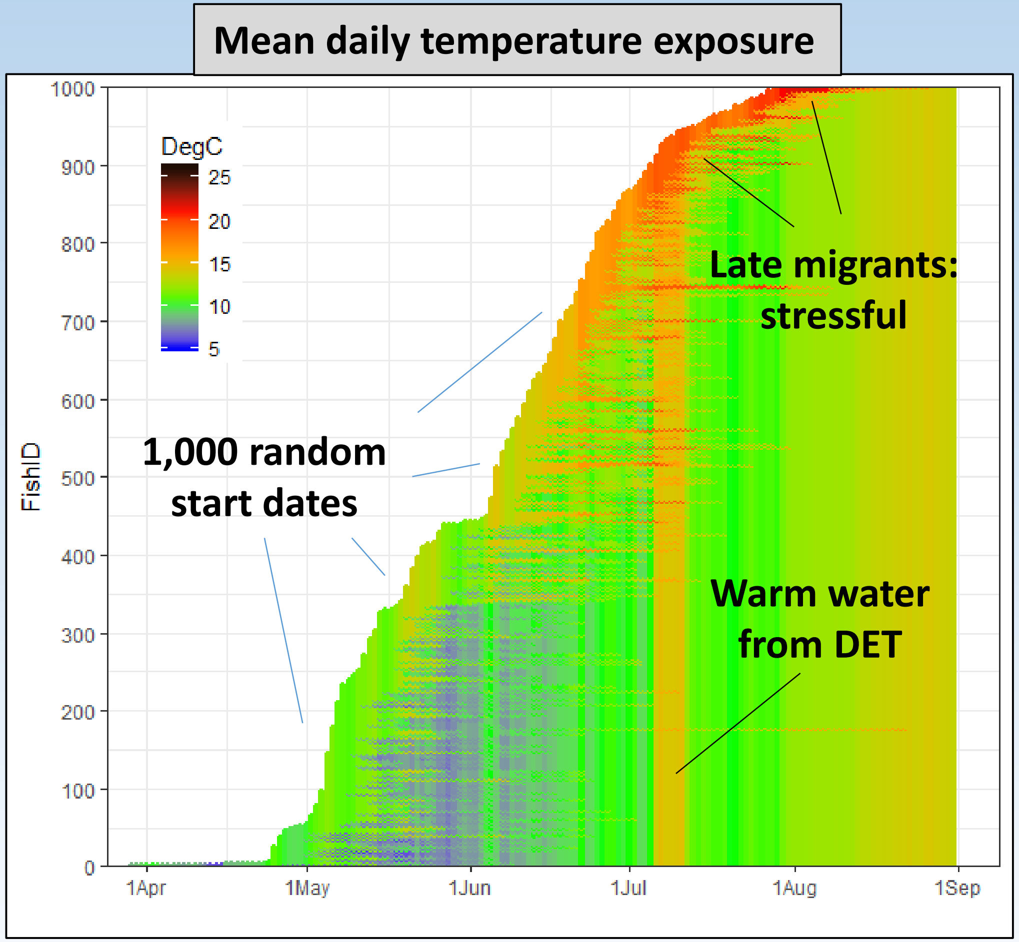
5. REPEAT through 6 reaches

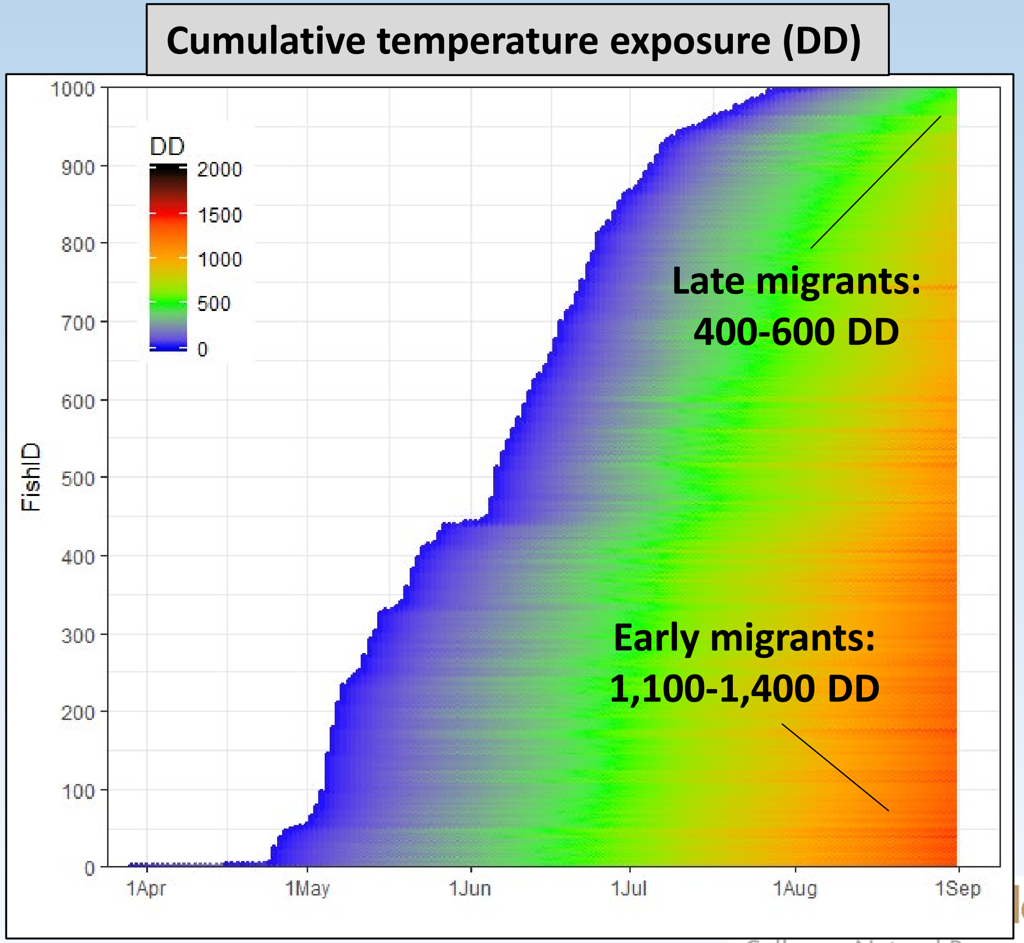




Thermal exposure model

- Model: 1,000 Chinook at WF
- Observed temperatures (2011, cool)



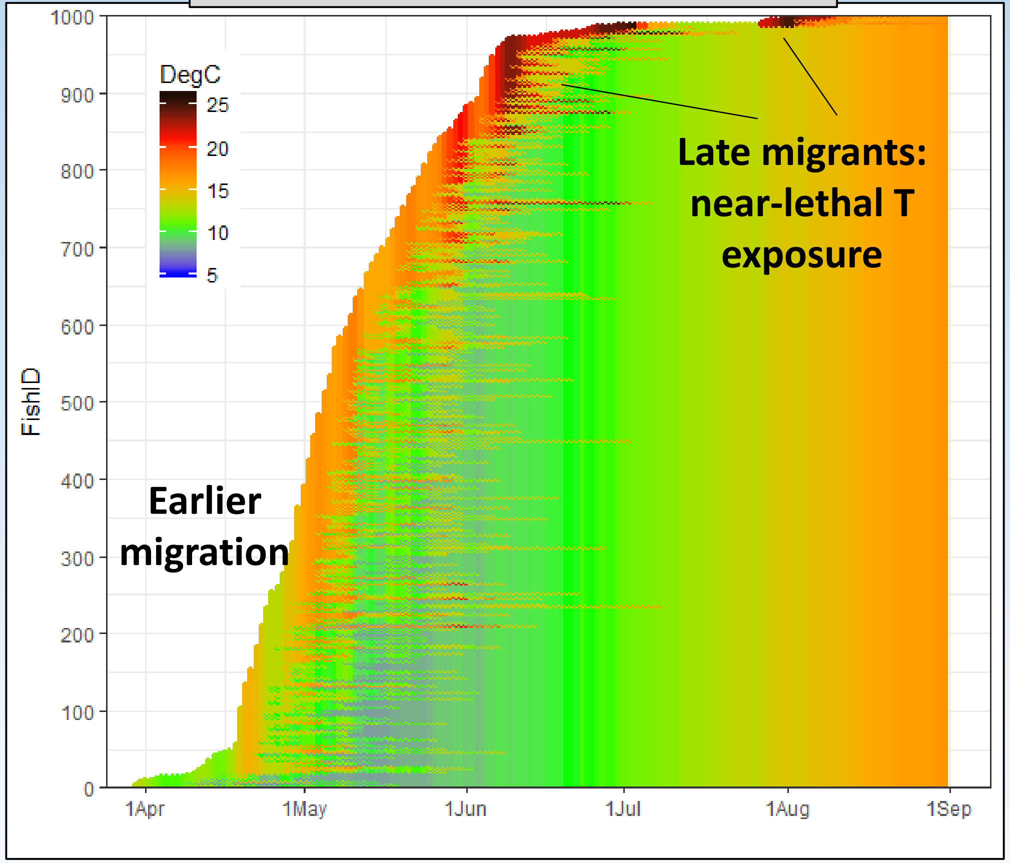


Thermal exposure model

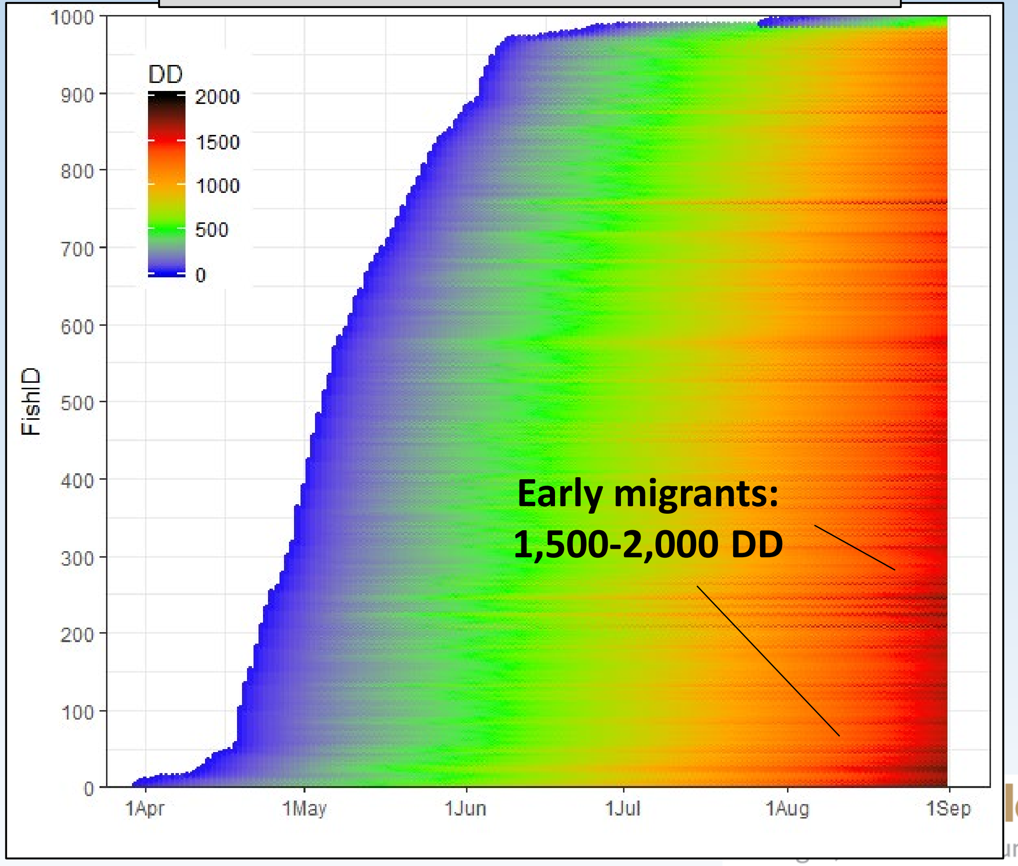
- Model: 1,000 Chinook at WF
- Observed temperatures (2015, warm)

A continuum of thermal experiences and risk factors within this population

Mean daily temperature exposure



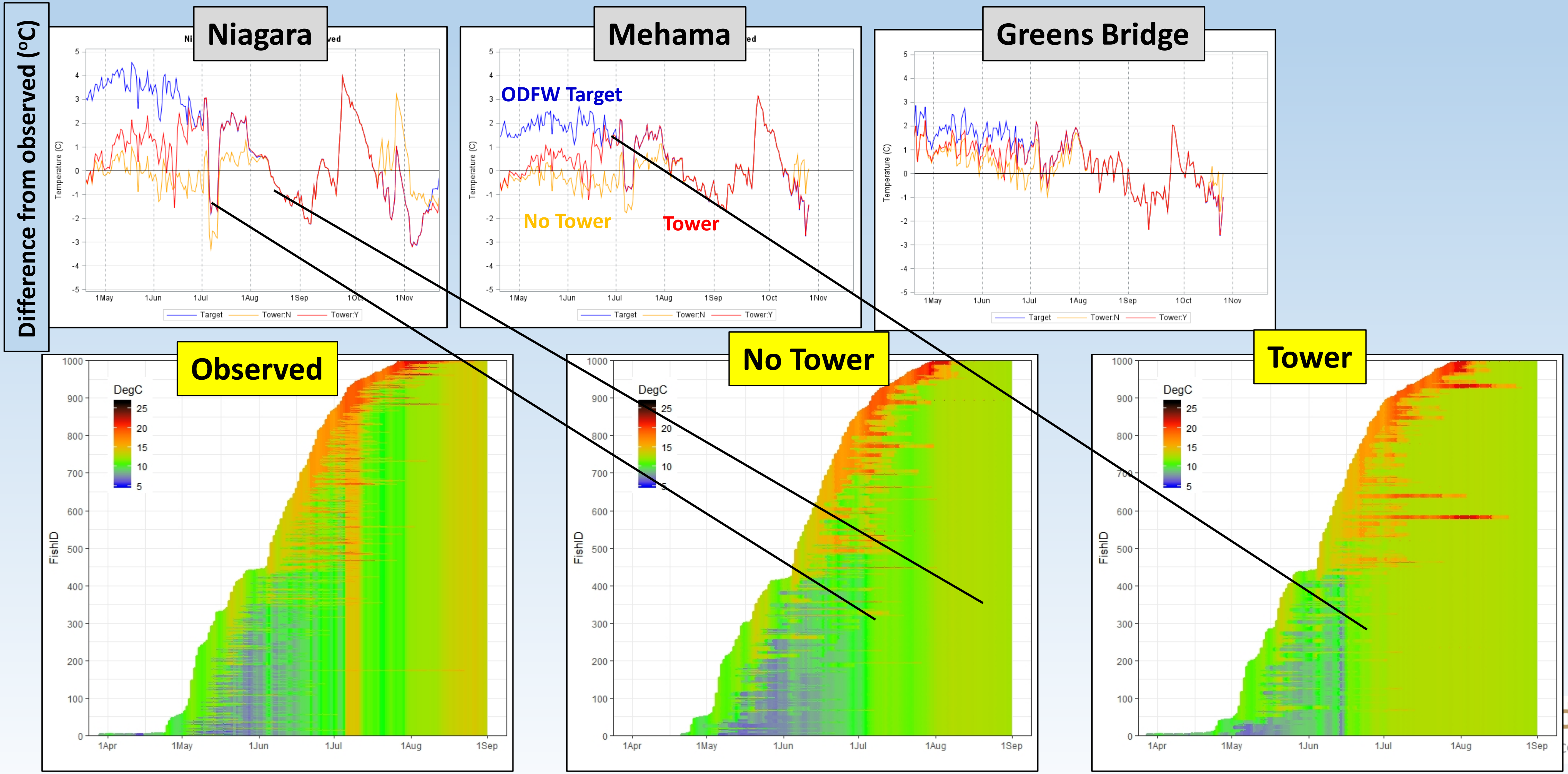
Cumulative temperature exposure (DD)



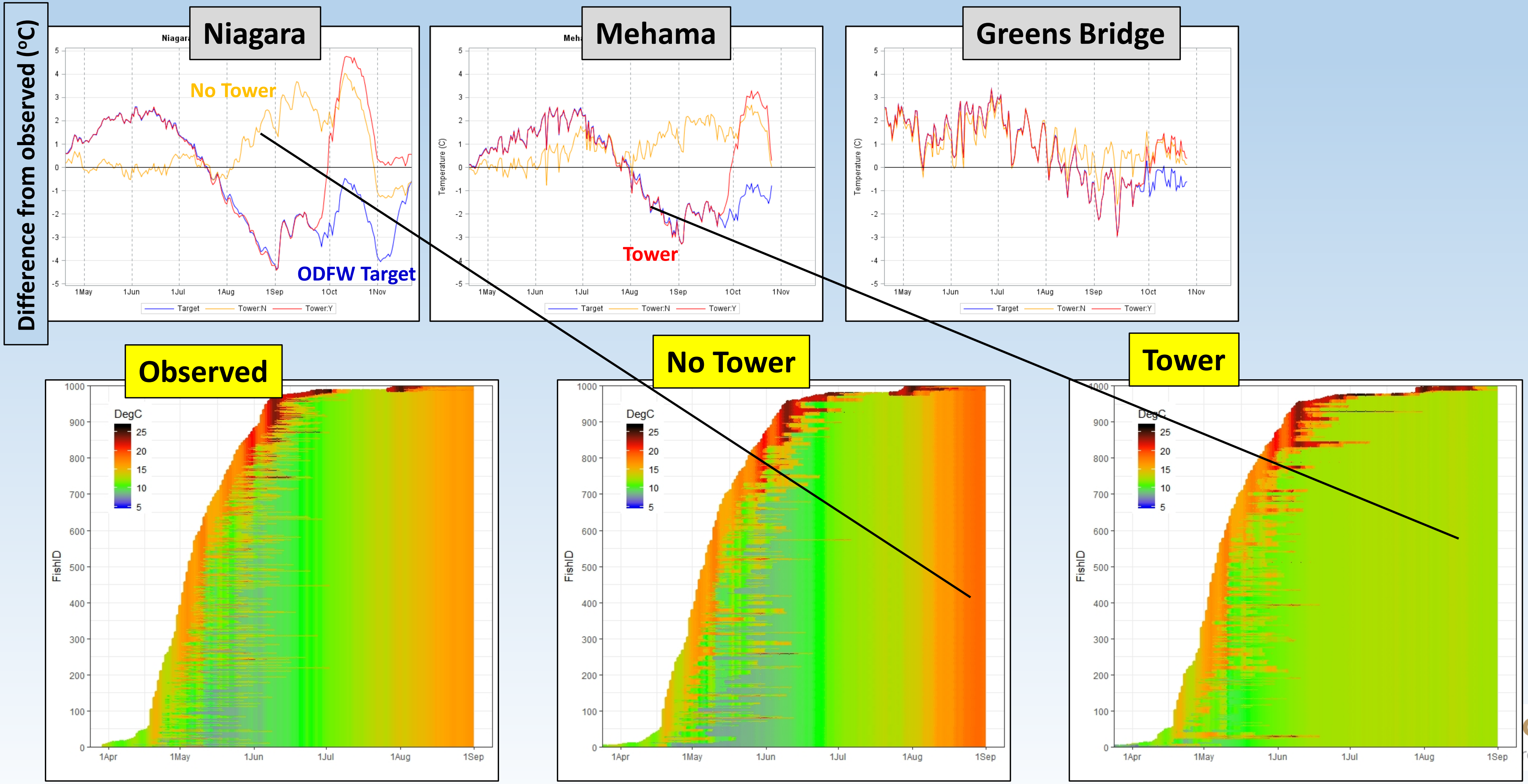
Idaho

Temperature management scenarios (2011)

- Use scenario temperature data within the Chinook exposure model



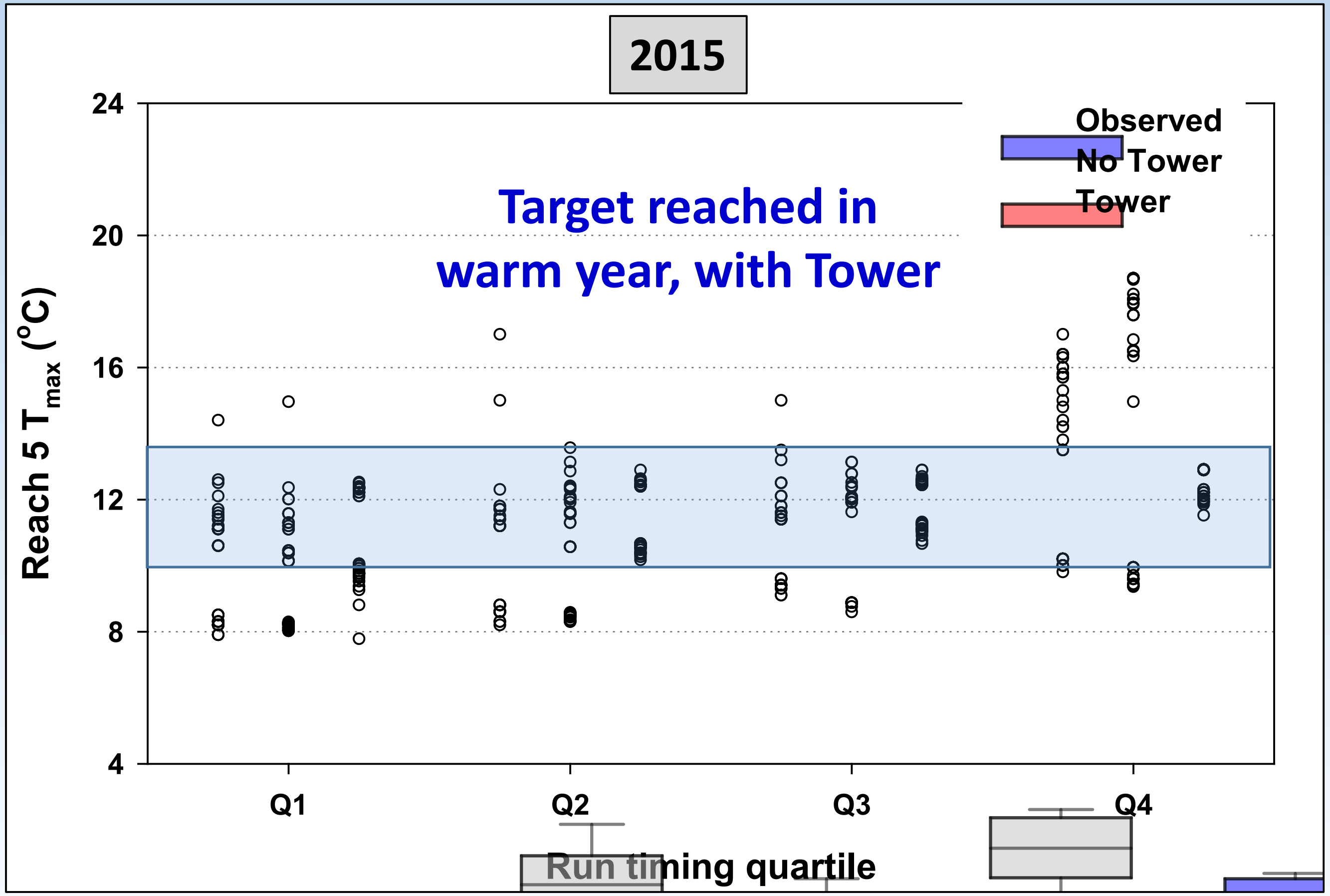
Temperature management scenarios (2015)



How to assess effects?

- Maximum T in Reach 5 (Bennett – 1st Minto)
  - Most enter reach in mid-summer
  - Median residency = ~10 d

Objective = Warmer migration

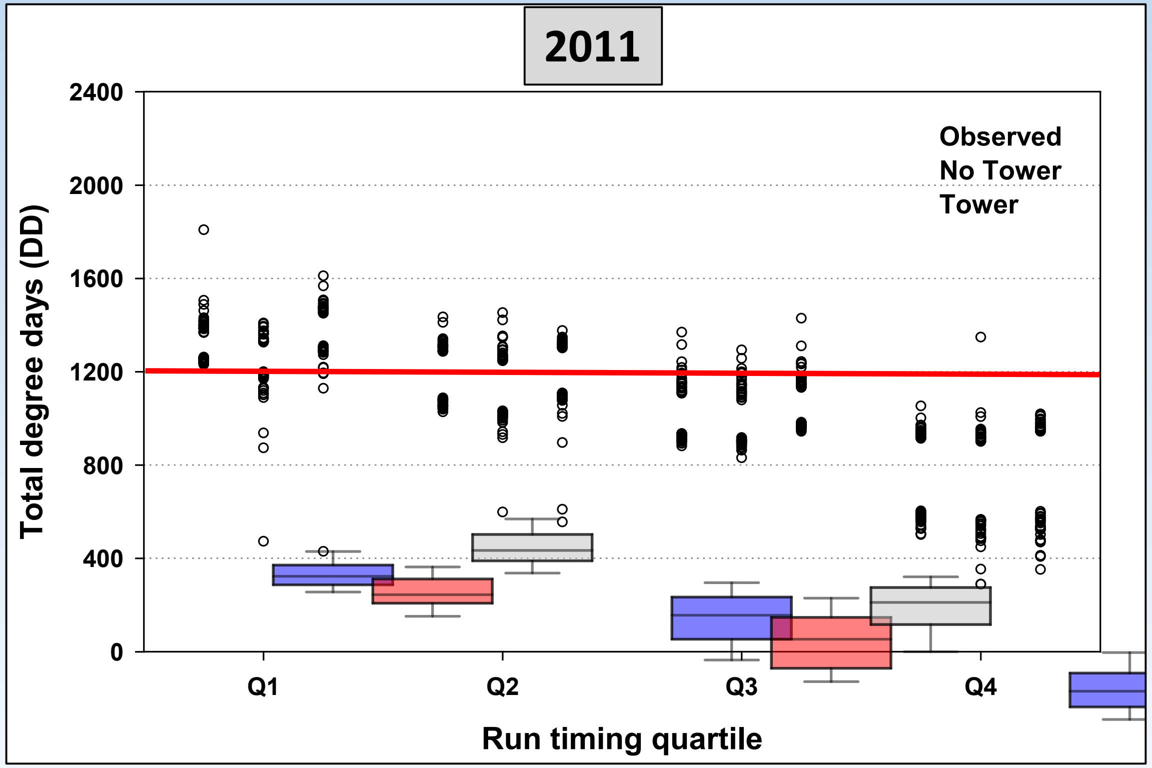


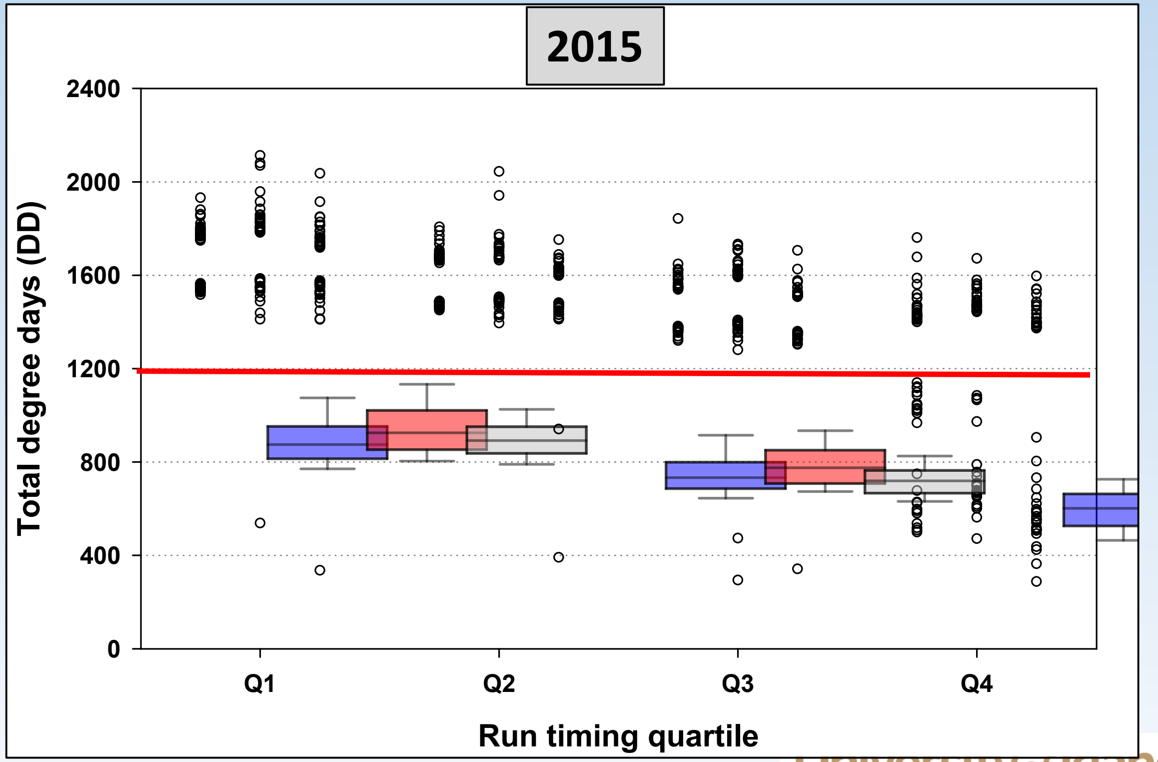
How to assess effects?

- Cumulative degree days
  - Full migration from Willamette Falls to Minto

Cooler holding mostly offset by warmer migration

Objective = Reduce total DD





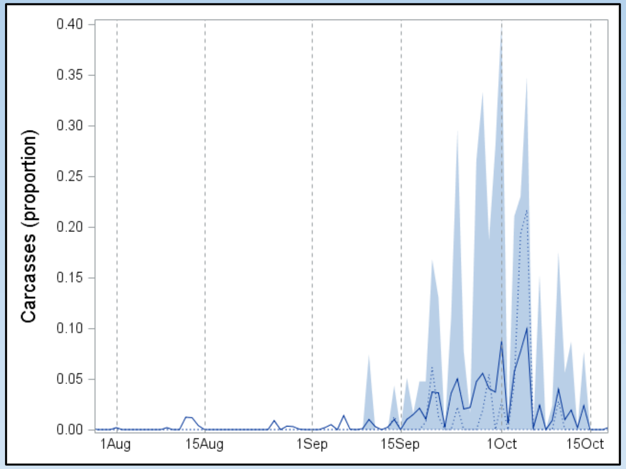
University of Idaho
College of Natural Resources

Summary

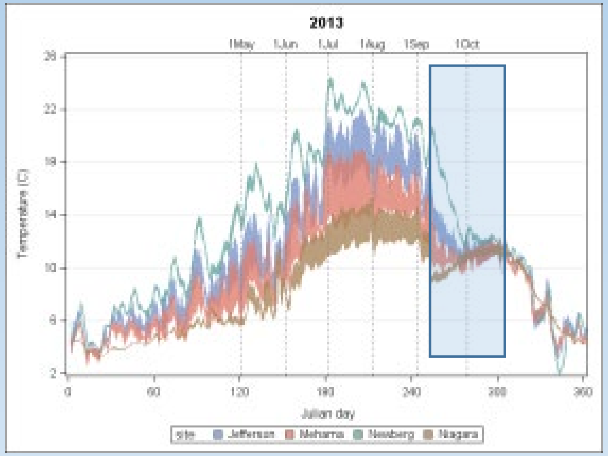
- Water temperature is a key biological driver for NSAN Chinook
  - Phenology, behavior, physiology, mortality
- Current thermal regime is a poor evolutionary match for Chinook
- Temperature management at Detroit can provide benefits
  - Within operational and environmental constraints
- Models indicate likely biological tradeoffs
  - Adult ‘sub-populations’
  - Migration vs Holding
  - Adults vs early life history stages

Fry emergence model

1. Random sample from spawn timing distribution

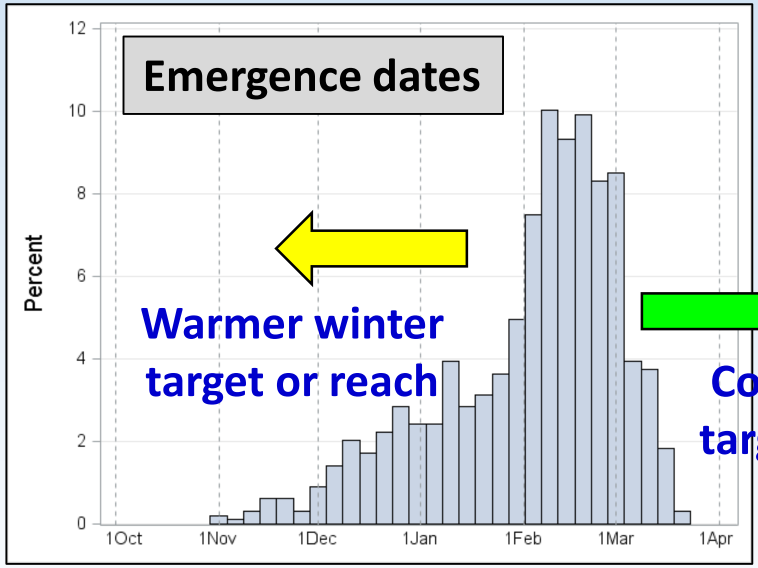


2. Match eggs to N Santiam River temperature on spawn date



3. Use scenario data to calculate cumulative DD

Chinook emergence at 1,650 -1,850 DD



Warmer winter target or reach

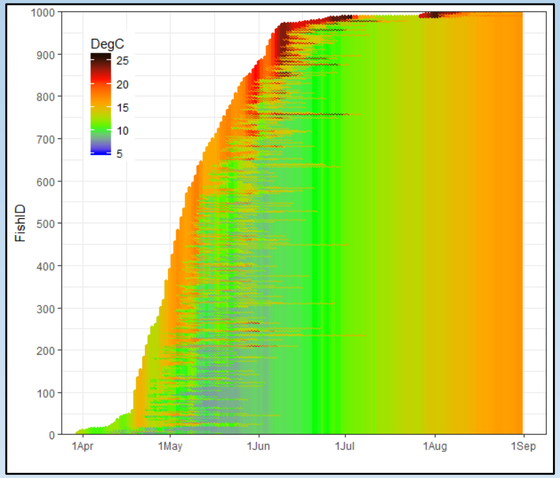
Cooler winter target or reach

University of Idaho
College of Natural Resources

How to assess effects: Bioenergetics model

1. Select initial Chinook weight and energy density

2. Use thermal exposure histories



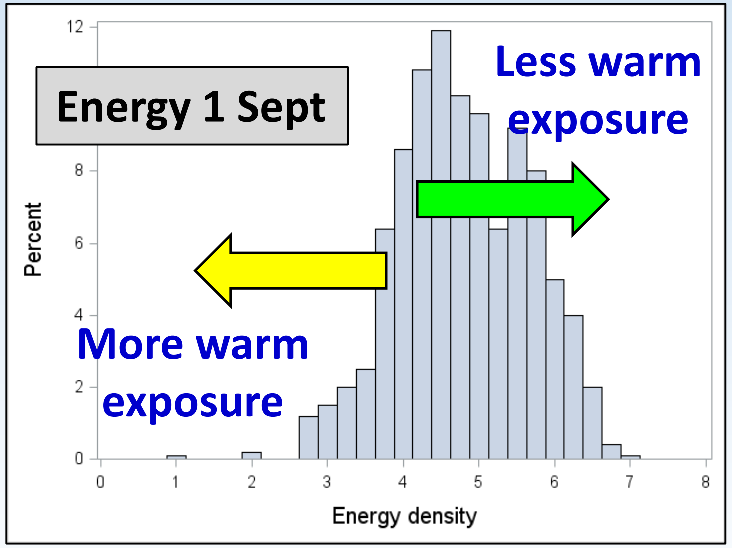
3. Run histories through Wisconsin bioenergetics model

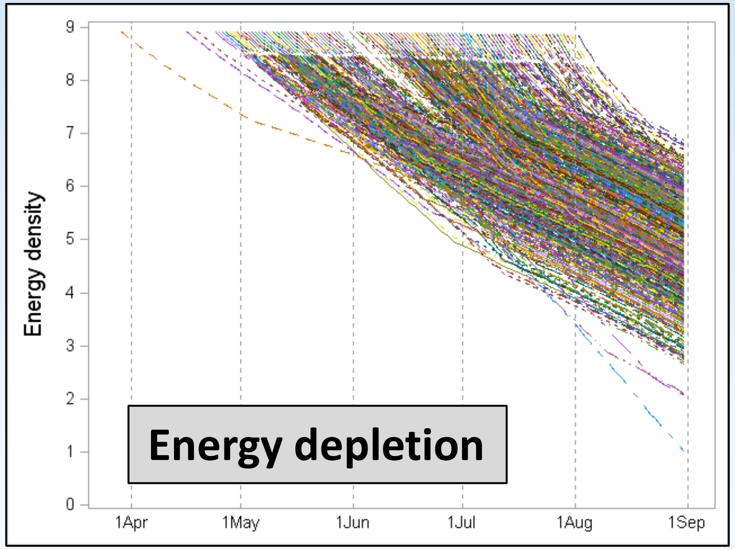
Metabolism

Respiration

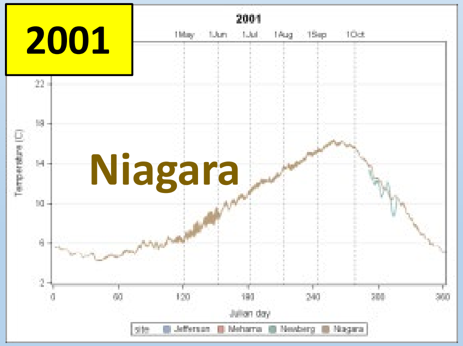
Mass

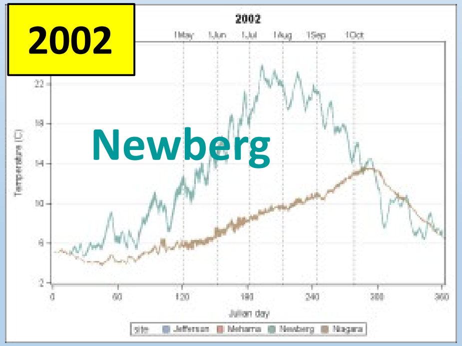
Swim speeds

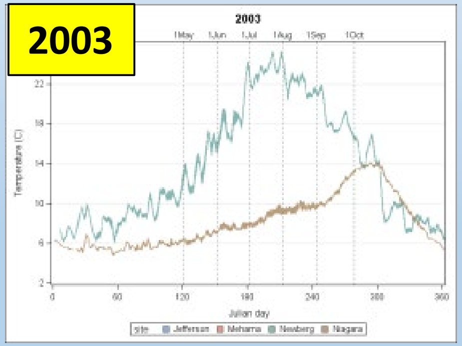


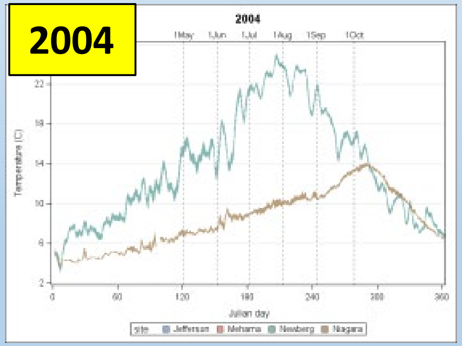


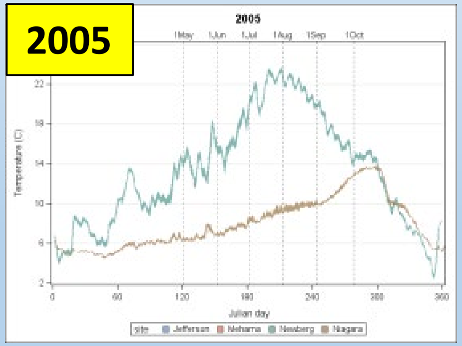
University of Idaho
College of Natural Resources

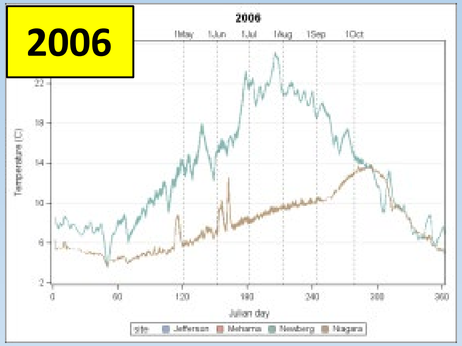


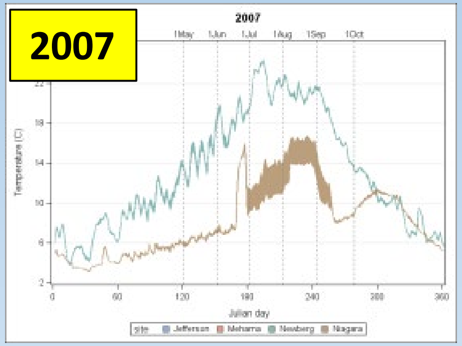


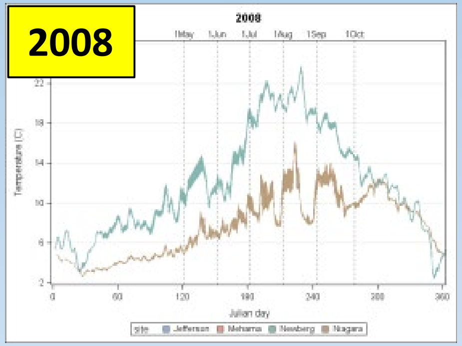


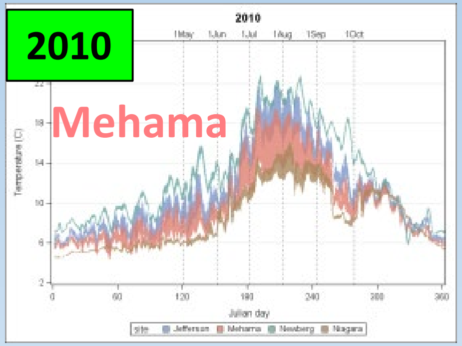


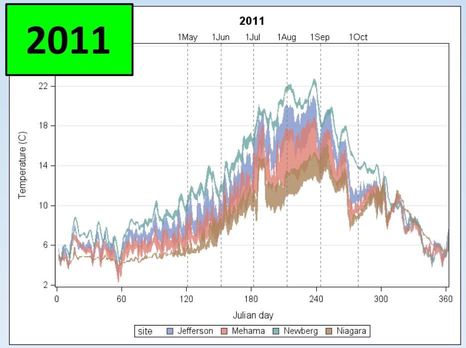


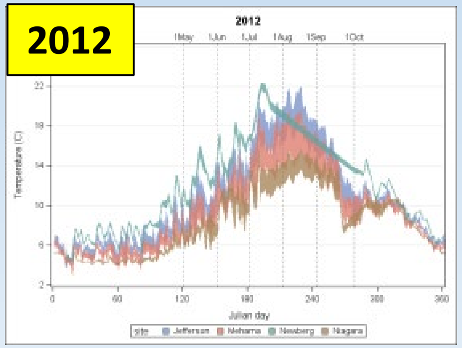


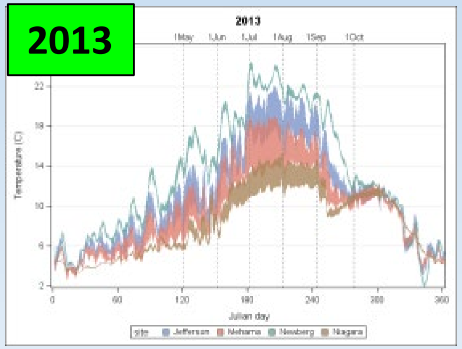


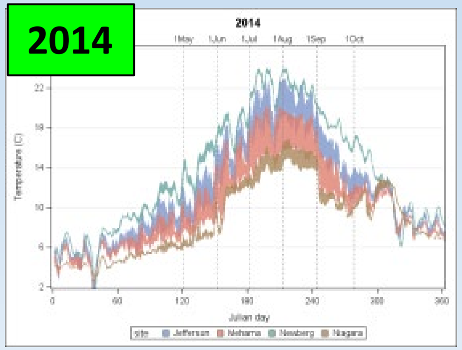


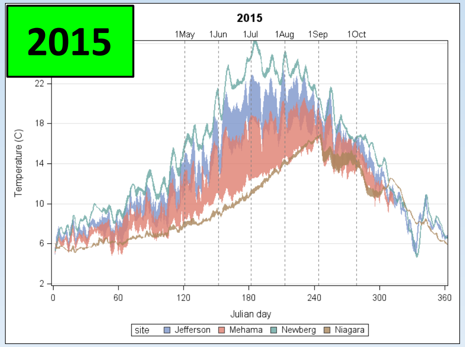


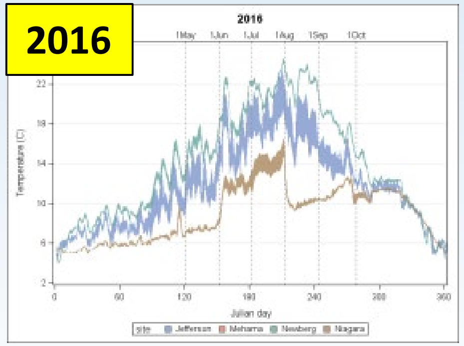


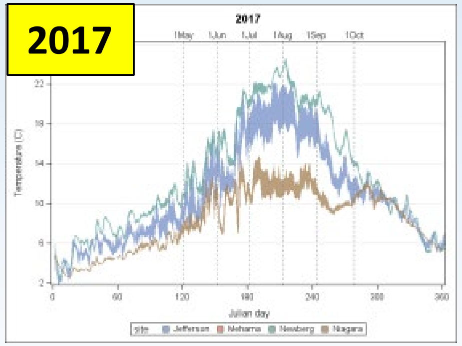


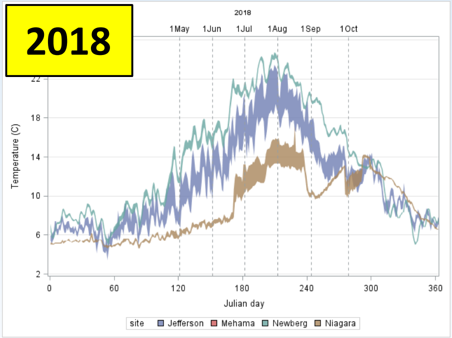






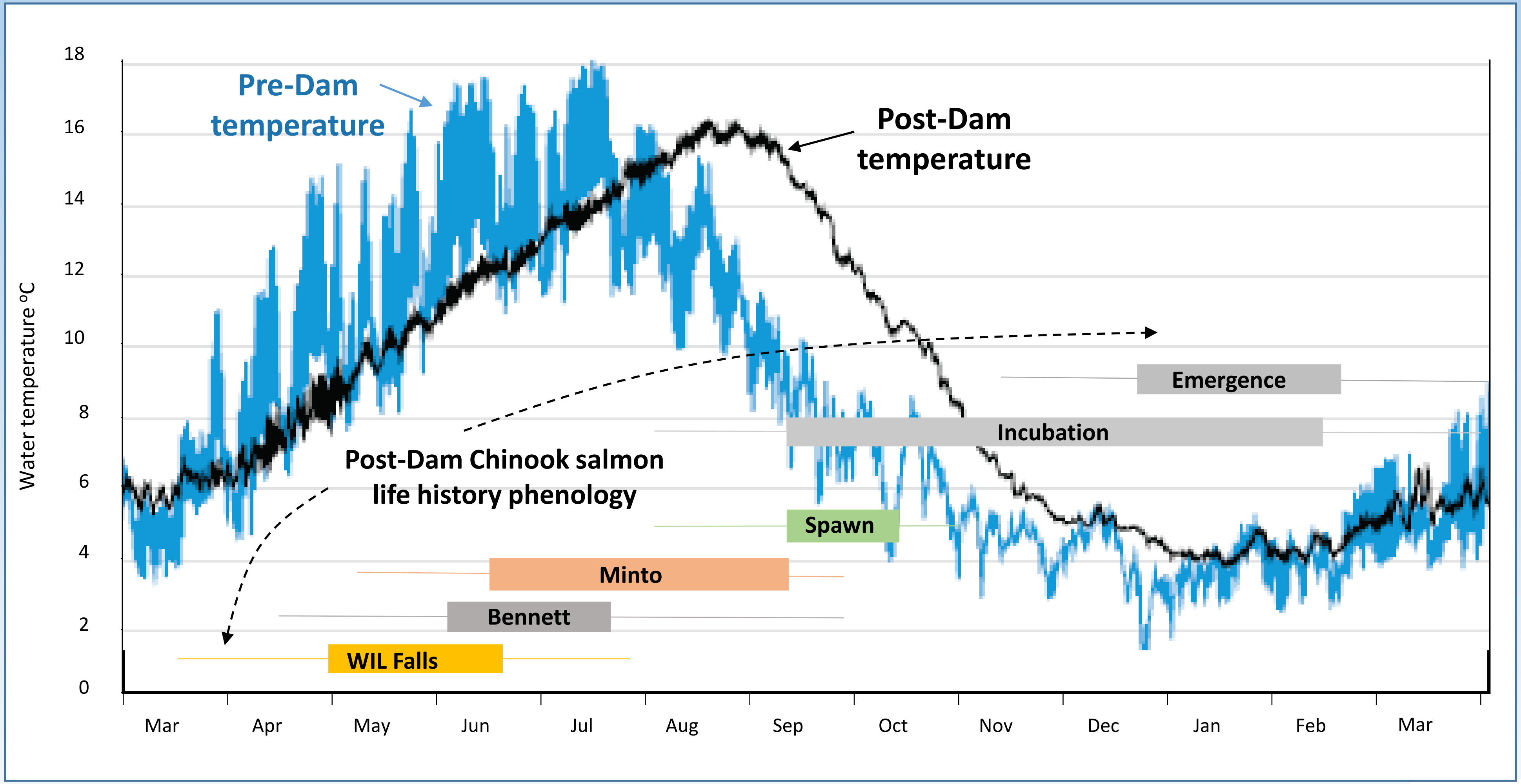






Never step in the same river twice. . . .

N. Santiam temperature + Chinook life history



Temperature graph: Rounds (2010, modified)

University of Idaho
College of Natural Resources