

Pacific salmon heat stress in Alaska

VANESSA R. VON BIELA, LIZABETH BOWEN, STEPHEN D. MCCORMICK, MICHAEL P. CAREY, DANIEL DONNELLY, AMY M. REGISH, SHANNON WATERS, SARAH M. LASKE, RANDY J. BROWN, SEAN LARSON, STAN ZURAY, AND CHRISTIAN E. ZIMMERMAN



Yukon River

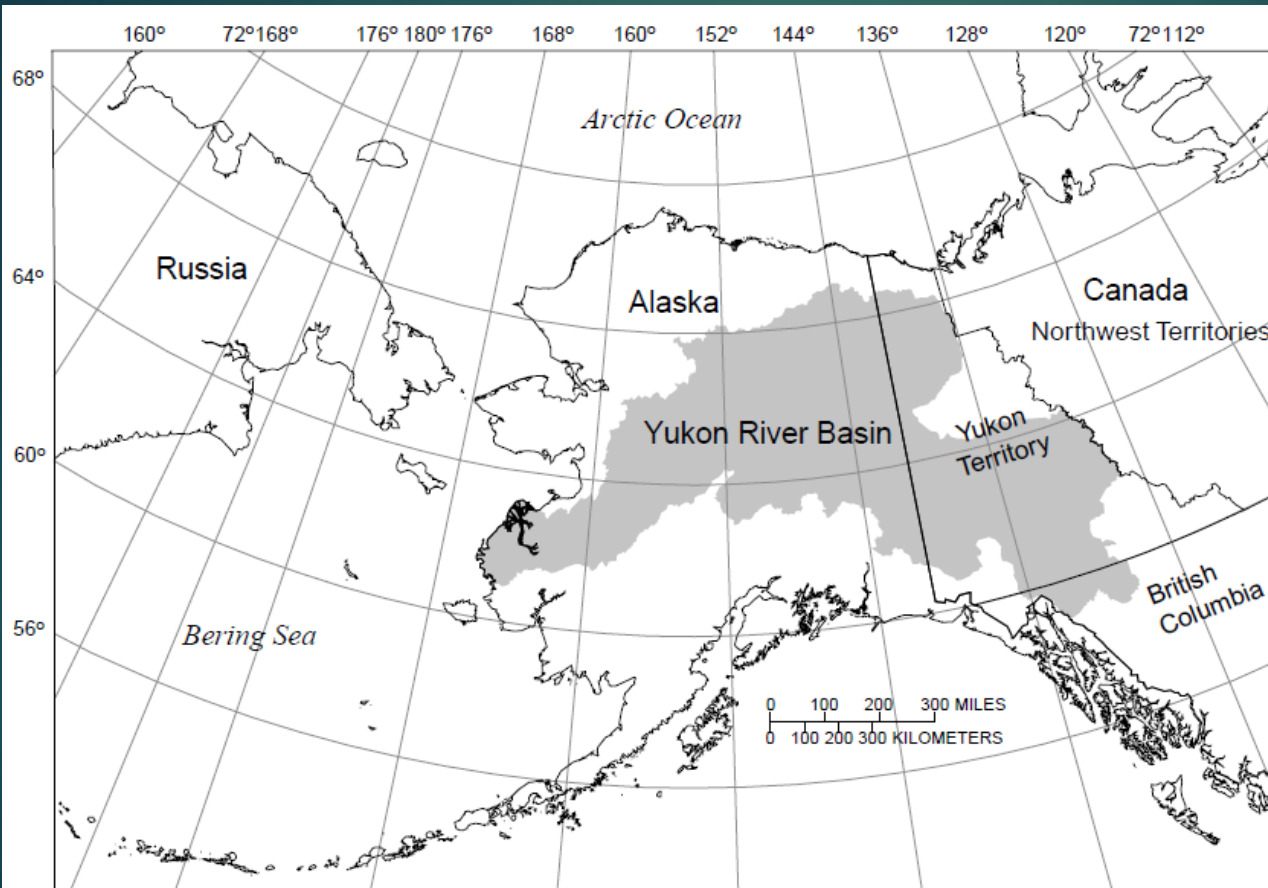


Figure 1. Location of the Yukon River Basin in Canada and Alaska.

Chinook salmon declined in the 1990s and haven't recovered

Why study Pacific salmon...

Food security



Economic driver



Ecosystem



health

Culture



Physical & mental health

Zuray/Rapids Research



Pacific salmon are cold-water fish



Cold lethal
limit
32 °F
0 °C

Warming water temperatures

Alaska
winters

-----Alaska's summer maximum range-----
Big differences across rivers/streams,
smaller year to year differences within a place

Pacific salmon are cold-water fish



**Lethal limit
adults
~70 to 75 °F
~21 to 24 °C**

Cold lethal
limit
32 °F
0 °C



Alaska
winters

-----Alaska's summer maximum range-----
Big differences across rivers/streams,
smaller year to year differences within a place



Pacific salmon are cold-water fish



Cold lethal limit
32 °F
0 °C

Best for spawning
~50°F
~10 °C

Best for juveniles
~55 °F
~13 °C

Best for adults
~59 °F
~15 °C

Lethal limit adults
~70 to 75 °F
~21 to 24 °C

Warming water temperatures

Alaska winters

-----Alaska's summer maximum range-----
Big differences across rivers/streams,
smaller year to year differences within a place

Pacific salmon are cold-water fish



Cold lethal limit
32 °F
0 °C

Best for spawning
~50°F
~10 °C

Best for juveniles
~55 °F
~13 °C

Best for adults
~59 °F
~15 °C

Stress for adults
~65 °F
~18 °C

Lethal limit adults
~70 to 75 °F
~21 to 24 °C

Warming water temperatures

Alaska winters

-----Alaska's summer maximum range-----
Big differences across rivers/streams,
smaller year to year differences within a place

More than half a salmon run can die in
the river before spawning

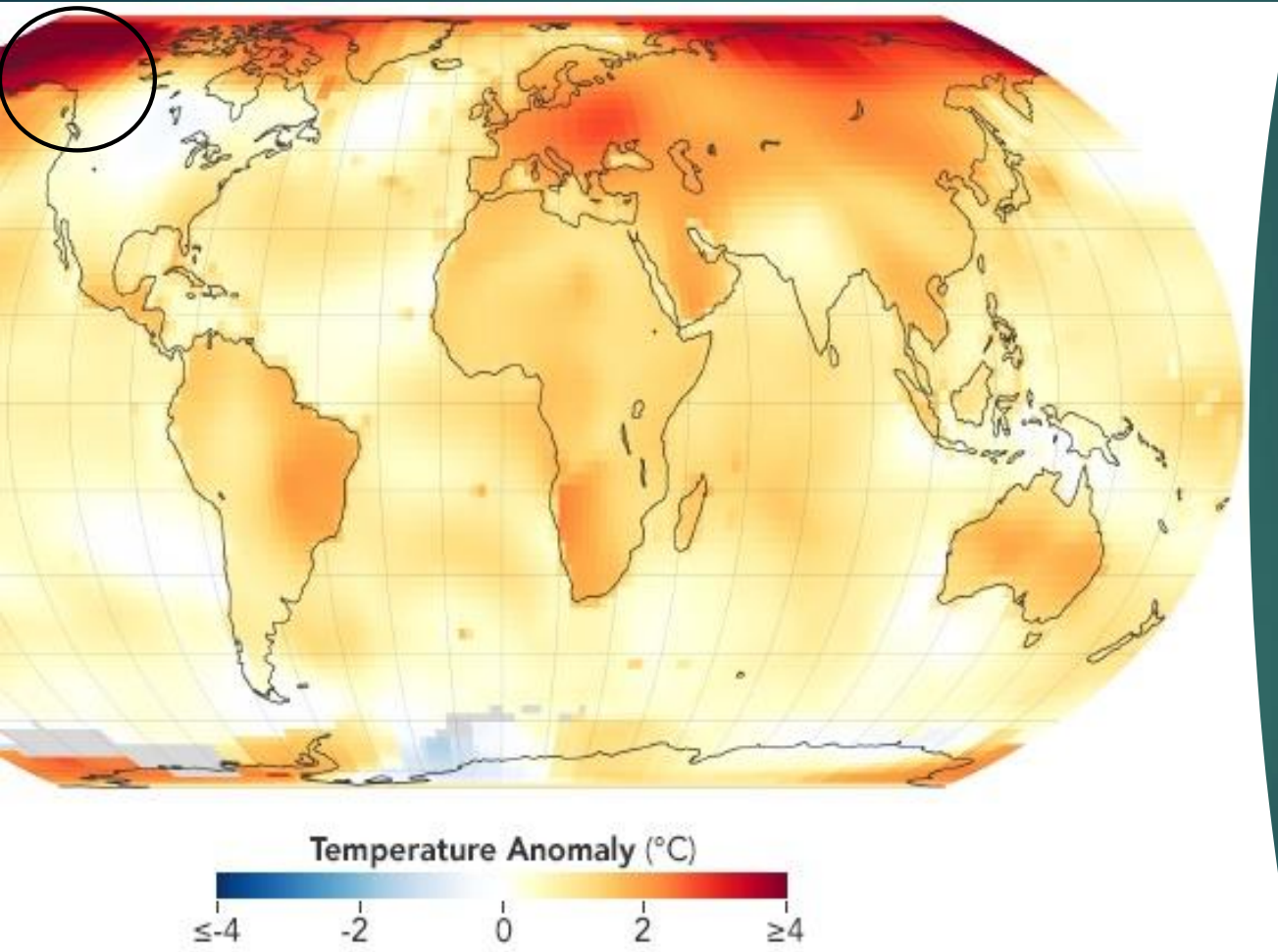


Even a week above 18 °C / 65 °F has big consequences for
Fraser River Sockeye Salmon

Heat stress linked to death

- ▶ Run out of oxygen/air
- ▶ Run out of energy/fat/fuel
- ▶ Pathogens can do more damage and cause disease



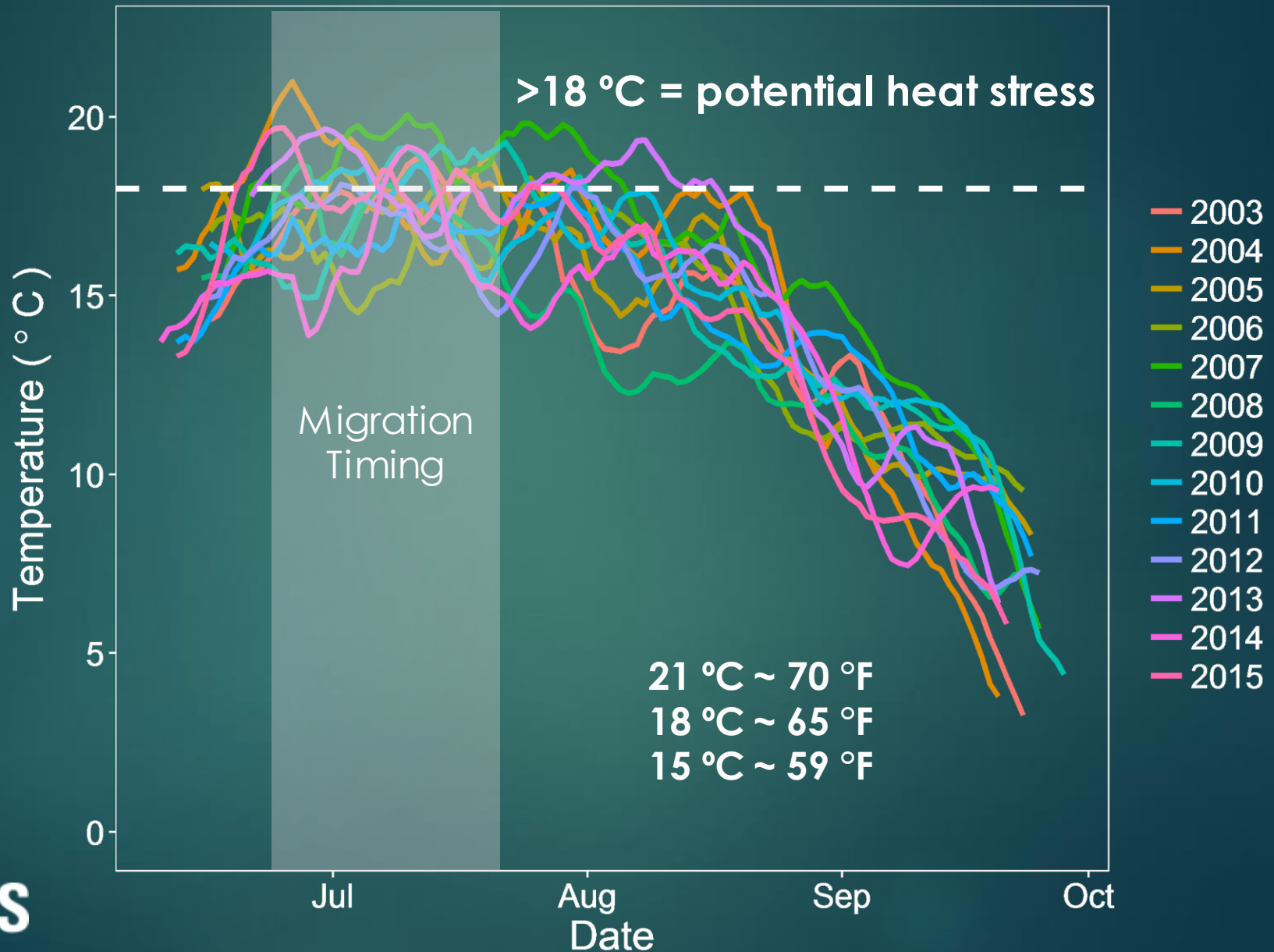


The past 5 years are the warmest of the 140 year record globally

Alaska is warming fast!

NASA: <https://earthobservatory.nasa.gov/images/146154/2019-was-the-second-warmest-year-on-record>

Yukon River Temperatures



**Hypothesis: Warm Water temperatures are
inducing heat stress among
Pacific salmon *in Alaska***



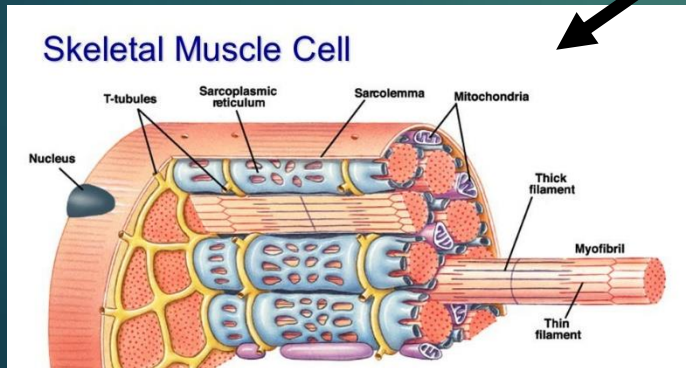
How do we study heat stress?



We measure biomarkers in muscle cells with lab tests

Gene transcription (mRNA)

→ Shows which parts of the DNA an animal is using

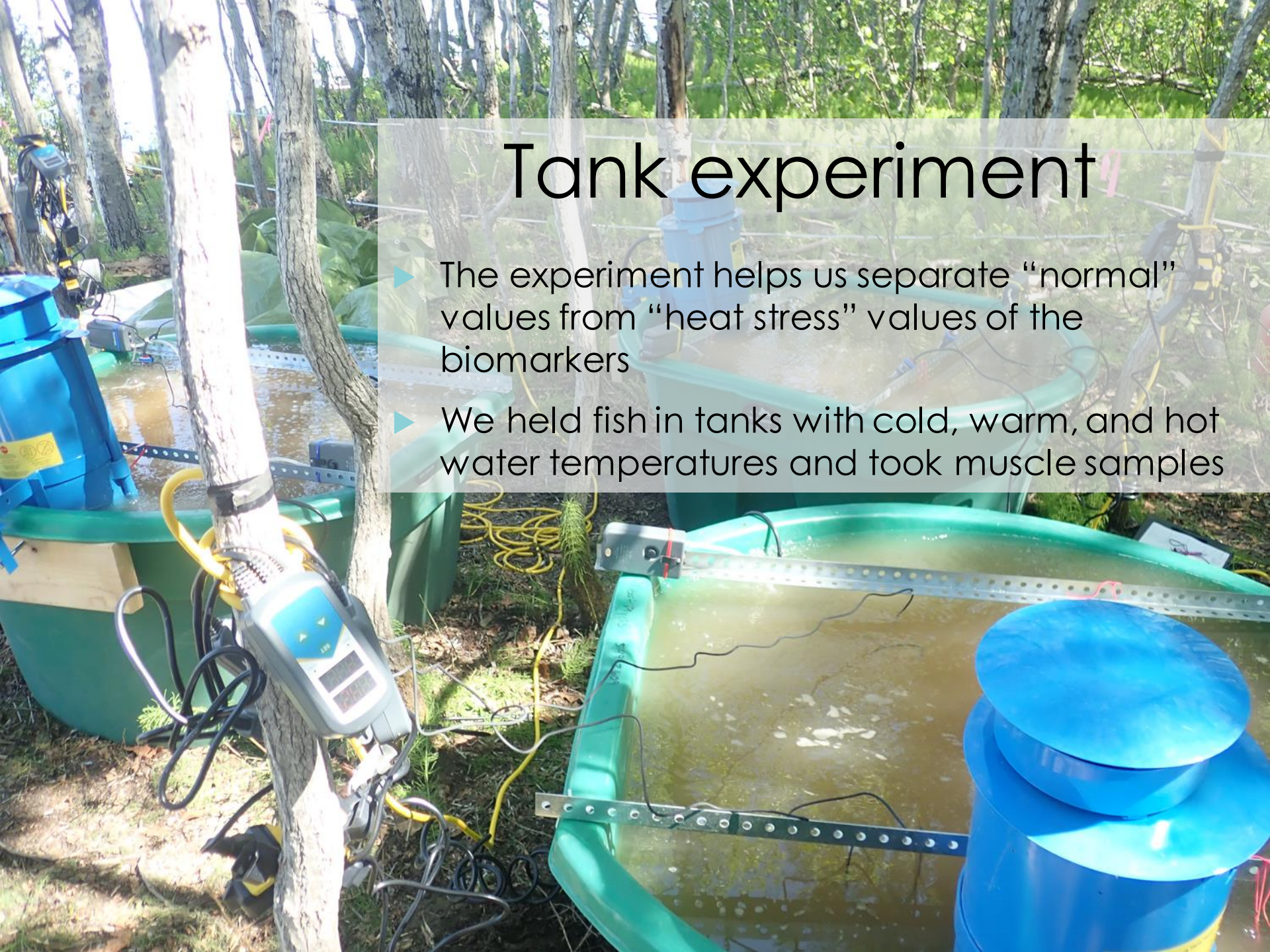


Heat shock protein 70 (HSP70)

→ A special helper protein animals make in their cells when it is too warm

Tank experiment

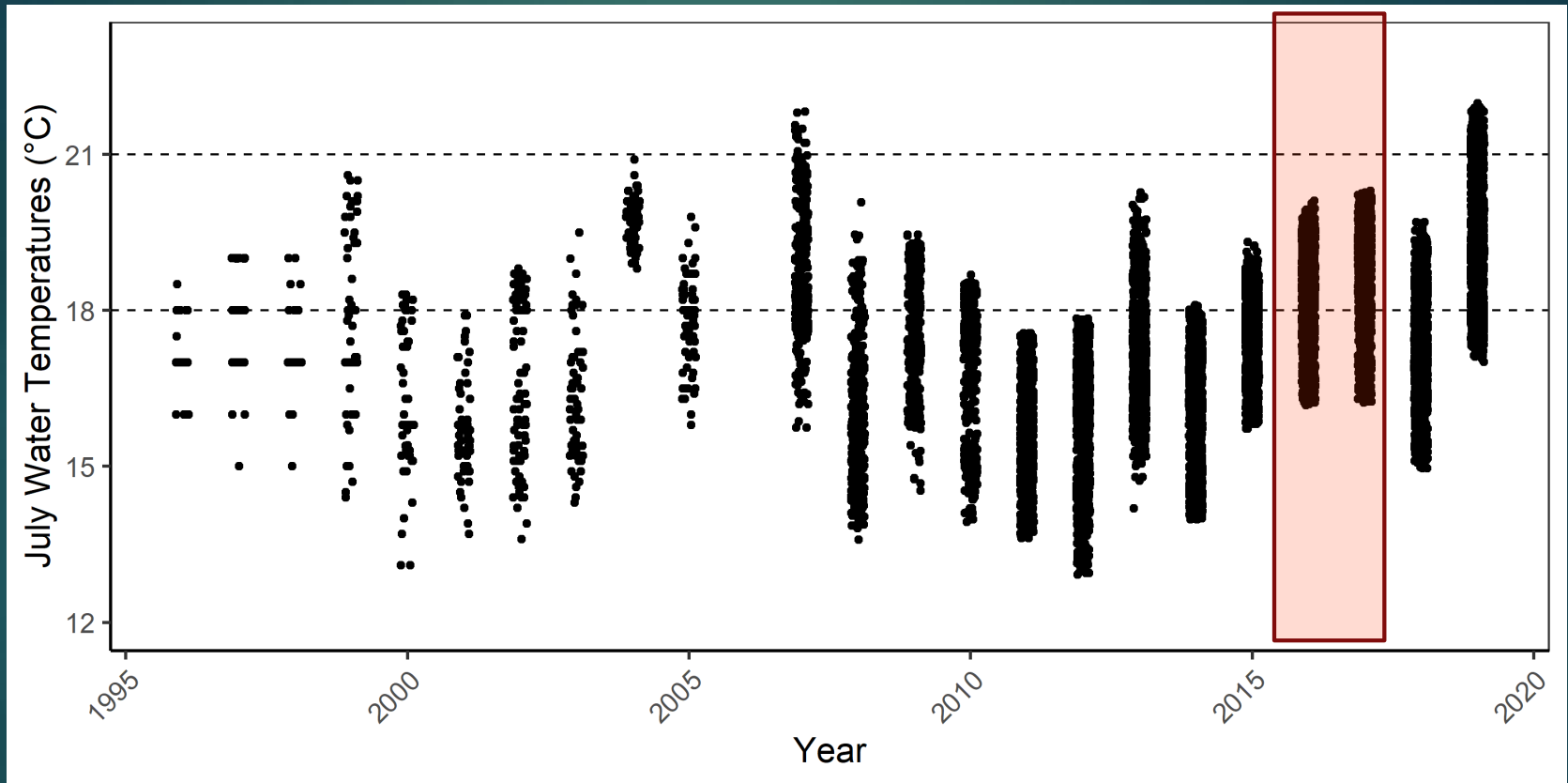
- ▶ The experiment helps us separate “normal” values from “heat stress” values of the biomarkers
- ▶ We held fish in tanks with cold, warm, and hot water temperatures and took muscle samples



Muscle biopsy & live release of 500 fish in 2016 and 2017 across the watershed

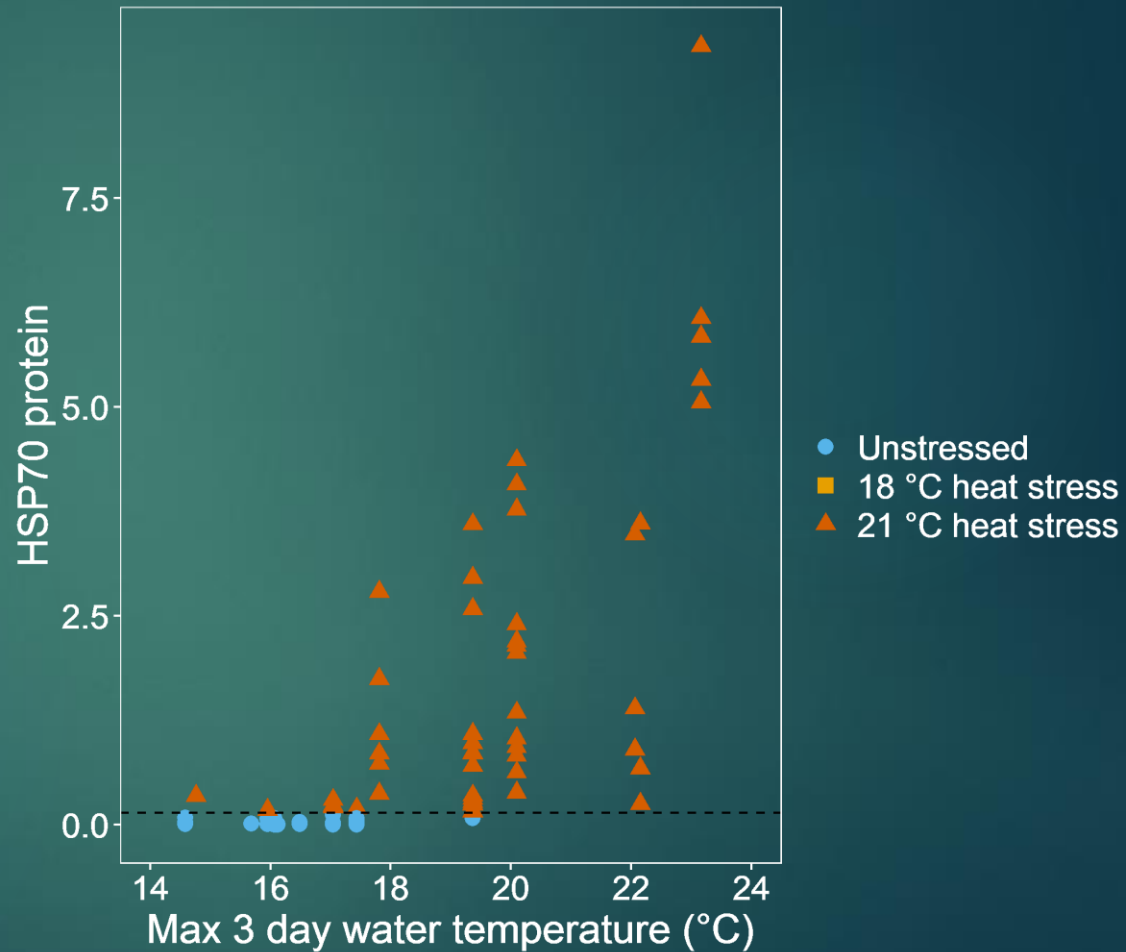
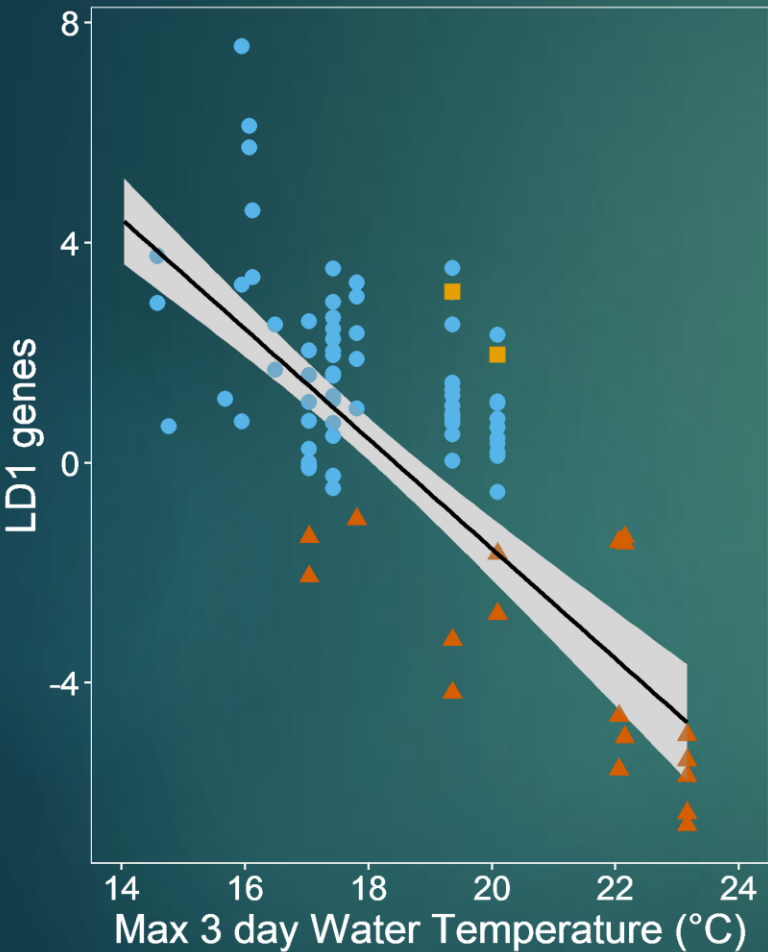


Yukon River Water Temperatures

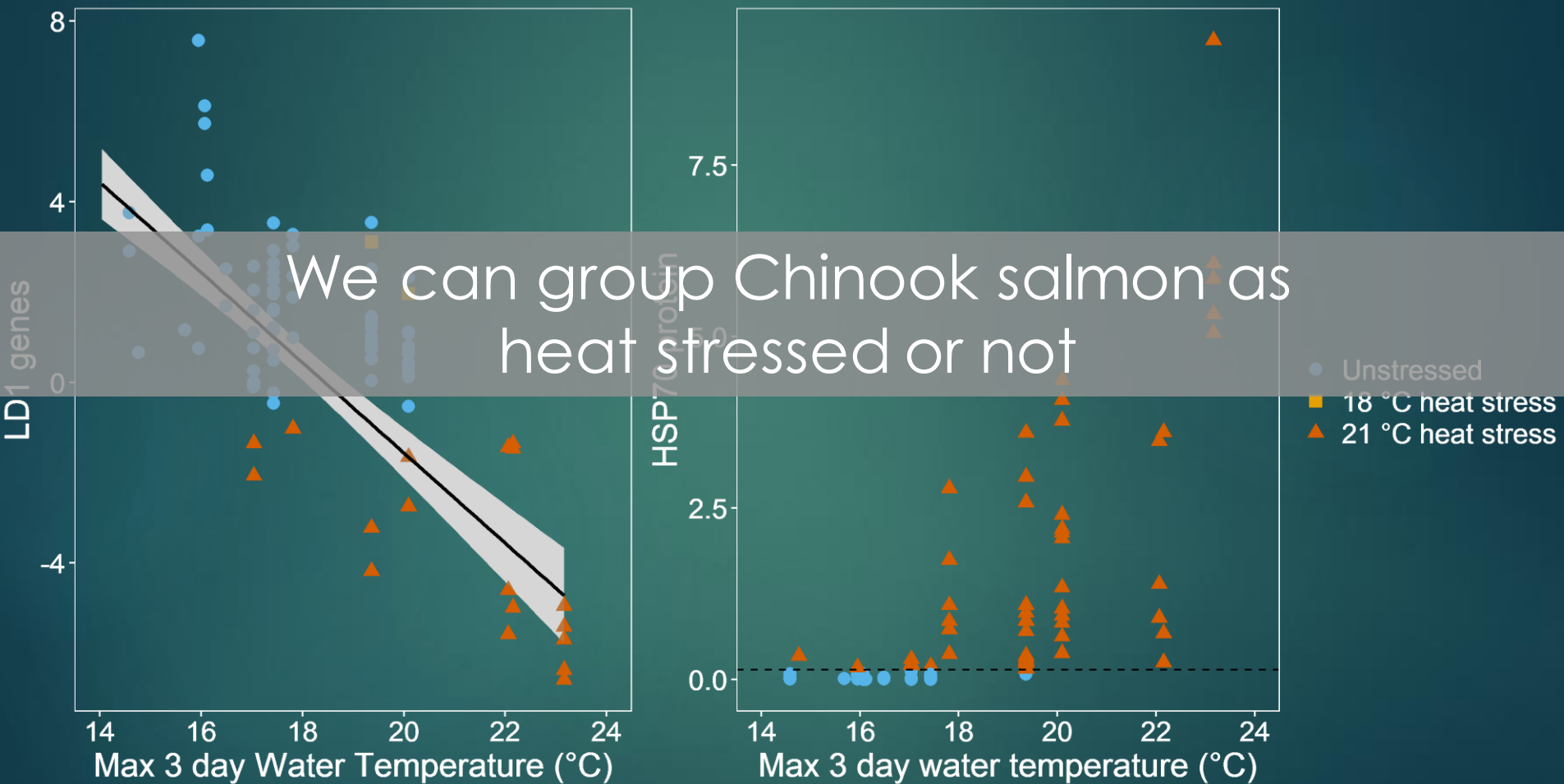


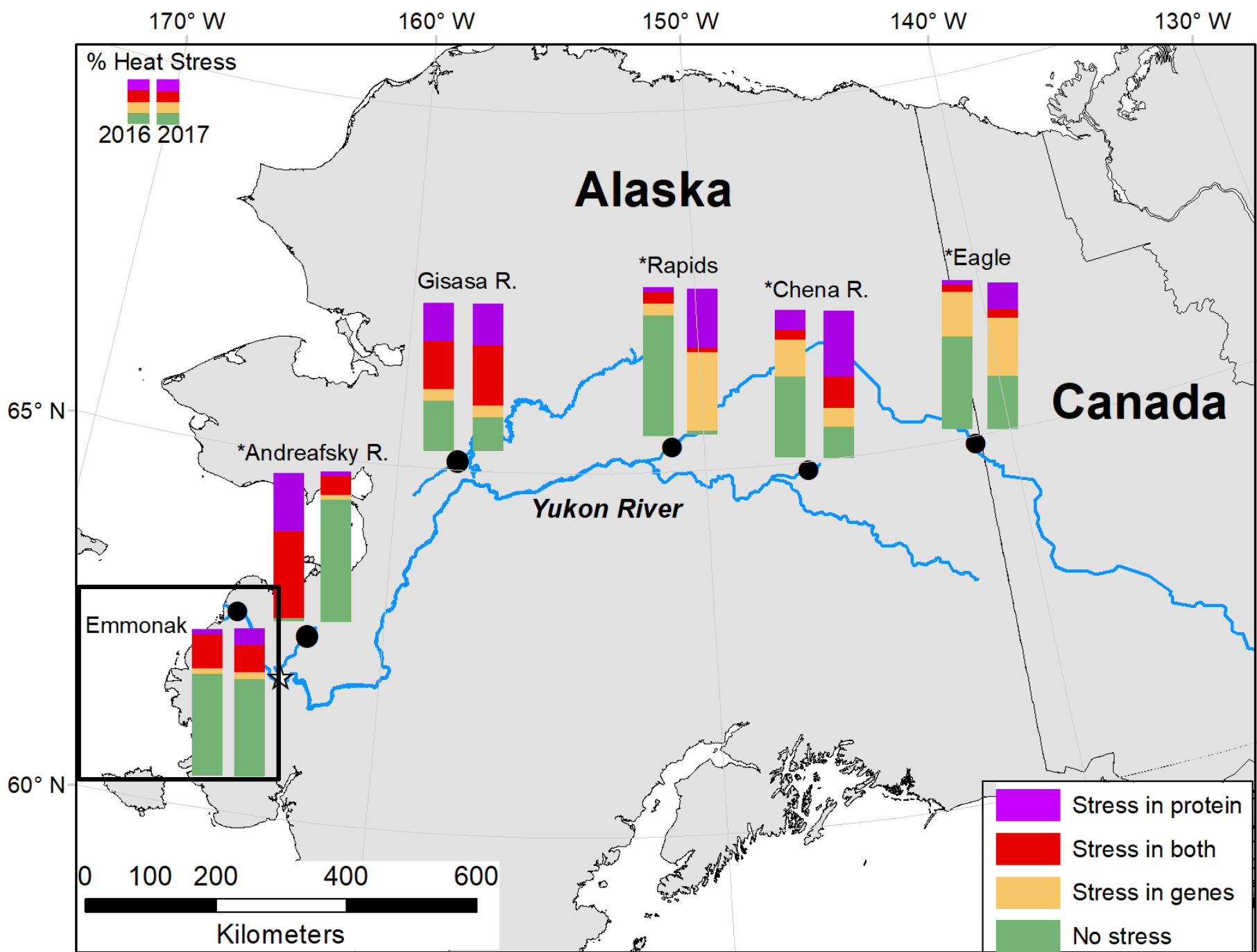
Our study years were warm, but not outside of the normal range

Are the biomarkers working? YES!



Are the biomarkers working? YES!





170° W

160° W

150° W

140° W

130° W

% Heat Stress



2016 2017

Alaska

Canada

65° N

*Andreafsky R.

Gisasa R.

*Rapids

*Chena R.

*Eagle

Yukon River

Emmonak

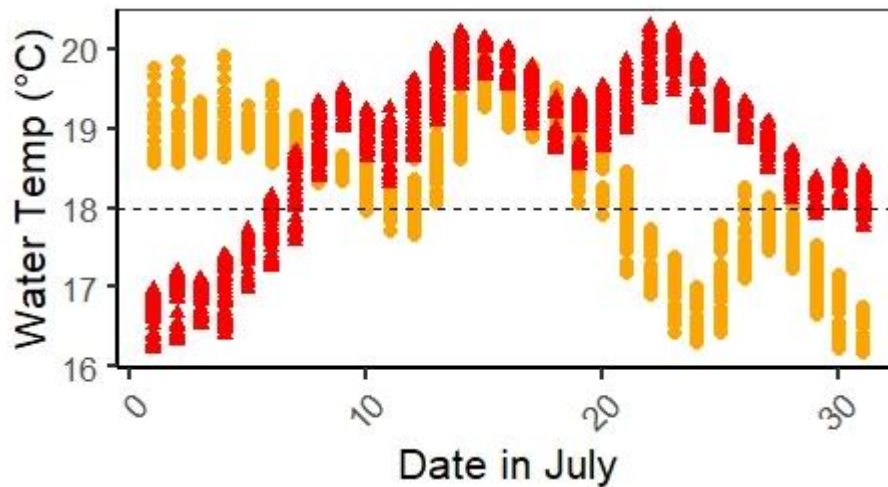
2016: Warm

2017: Warmer

60° N

0 100 200 400 600

Kilometers



protein
both
genes

No stress

170° W

160° W

150° W

140° W

130° W

% Heat Stress



2016 2017

Alaska

2016: Warmer

2017: Warm

65° N

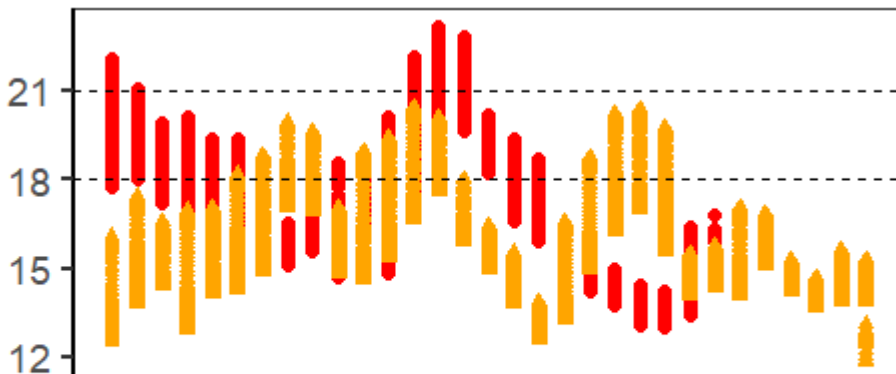
Canada

*Andreafsky R.

Emmonak

60° N

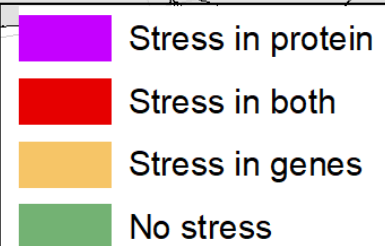
Water Temp (°C)



Date in July

0 100 200 400 600

Kilometers



Implications of this work

- ▶ Management
 - ▶ Heat stress can occur near the northern range extent of Pacific salmon
 - ▶ Escapement counts may no longer indicate a successful spawner

Implications of this work

- ▶ Management
 - ▶ Heat stress can occur near the northern range extent of Pacific salmon
 - ▶ Escapement counts may no longer indicate a successful spawner
- ▶ Research priorities
 - ▶ Expand water temperature monitoring in northern watersheds
 - ▶ Expand heat stress monitoring
 - ▶ Estimate *en route* and prespawn mortality
 - ▶ Identify important temperature and dissolved oxygen thresholds for northern Pacific salmon populations

Questions?

vvonbiela@usgs.gov / 907-786-7073

Thanks to...



- ▶ Arctic Yukon Kuskokwim Sustainable Salmon Initiative
- ▶ Rampart Rapids subsistence fishing community
- ▶ Community of Pilot Station
- ▶ ADF&G Test fishery crews and FWS weir crews in 2016 and 2017
- ▶ 2018 Pilot Station Sonar Crew
- ▶ NSEDC Pilgrim River weir crews 2014-2016



Part 2: Pacific salmon die-off in 2019



In partnership with...

- ▶ LEO Network contributors and Erica Lujan and Michael Brubaker
- ▶ Citizen scientists that shared reports with ADF&G
- ▶ Yukon River Inter-tribal Fish Commission: Stephanie Quinn-Davidson
- ▶ ADF&G: Zach Liller, Charles Russell
- ▶ Prince William Sound Science Center: Pete Rand
- ▶ Chris Sergeant
- ▶ University of Alaska: Peter Westley



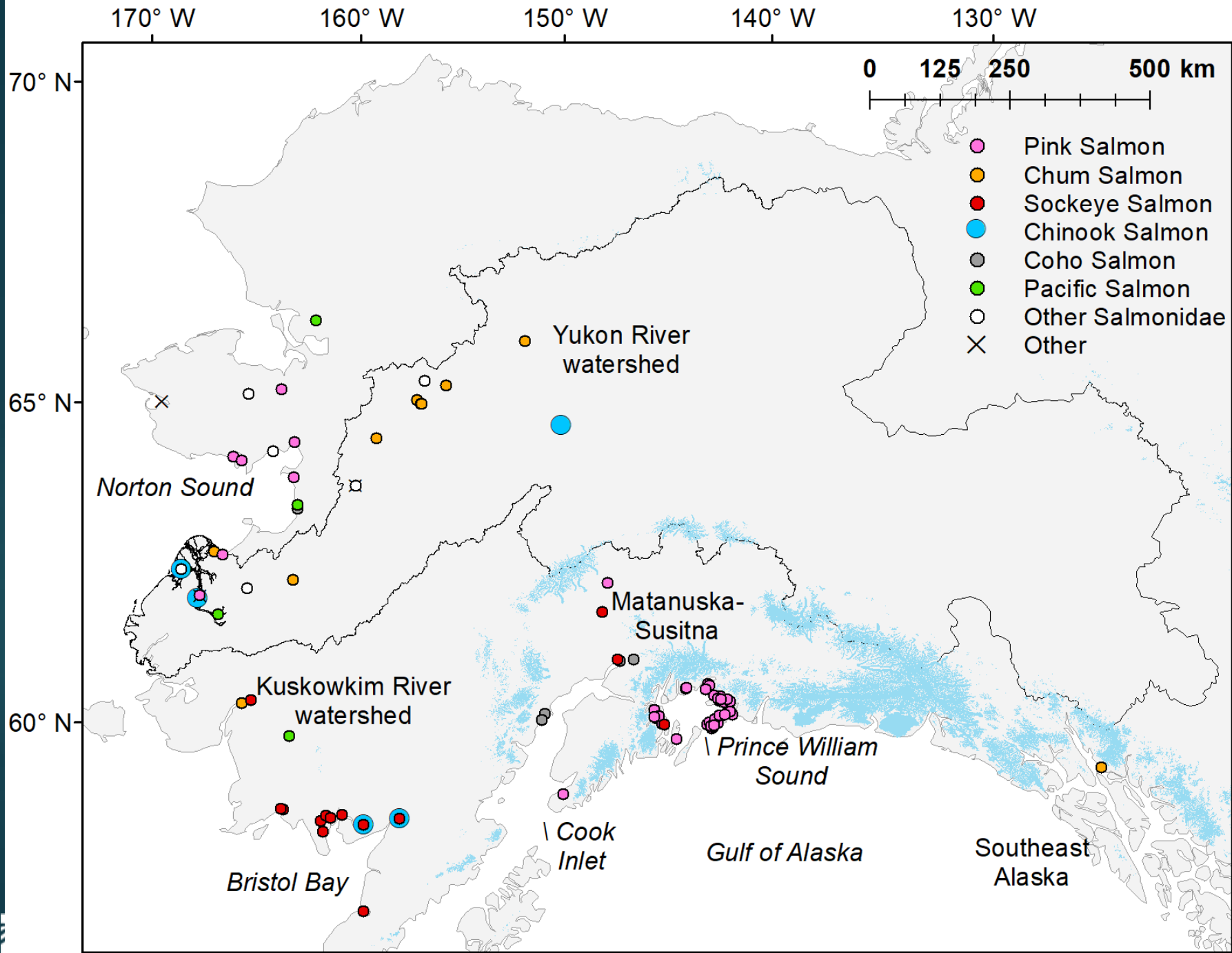
2019 Pacific salmon mortality

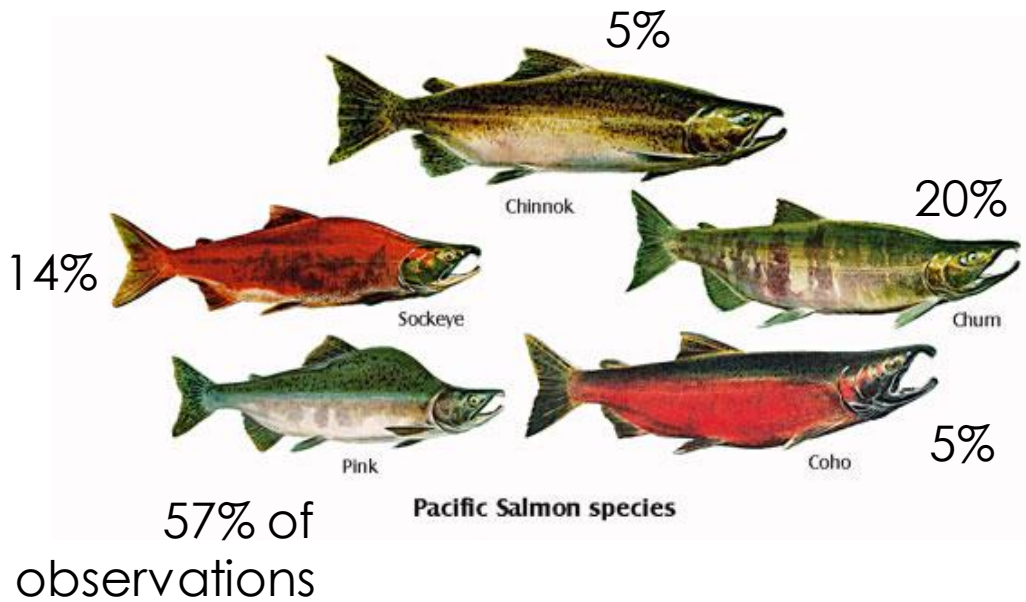
Can we use observations collected by citizens and biologists to answer these basic questions...

- ▶ Who? Which species?
- ▶ What? How many?
- ▶ When?
- ▶ Where?
- ▶ Why?

Observations

- ▶ Collected 109 observations from across Alaska
 - ▶ LEO Network
 - ▶ Alaska Department of Fish and Game
 - ▶ Social media reports and news stories
 - ▶ Directed emails to selected individuals to assess geographic gaps





The % each species contributes to the observations generally lines up with their abundance in Alaska

Who:

All 5 Pacific salmon species

What:

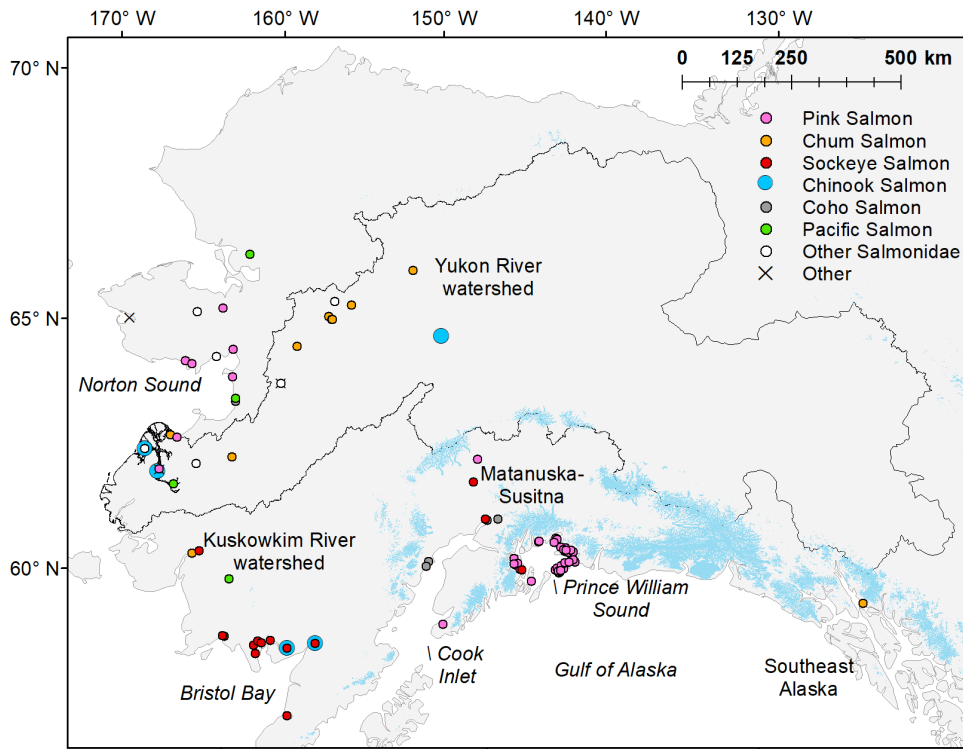
Observations range from 1 to 1,000s of carcasses along migration routes

47% are $\geq 1,000$

24% are ≥ 100 and $< 1,000$

18% are < 100





When:
July to
September 2019

Where:
Western and
southcentral
Alaska

Why

Circumstantial evidence suggests two causes of death

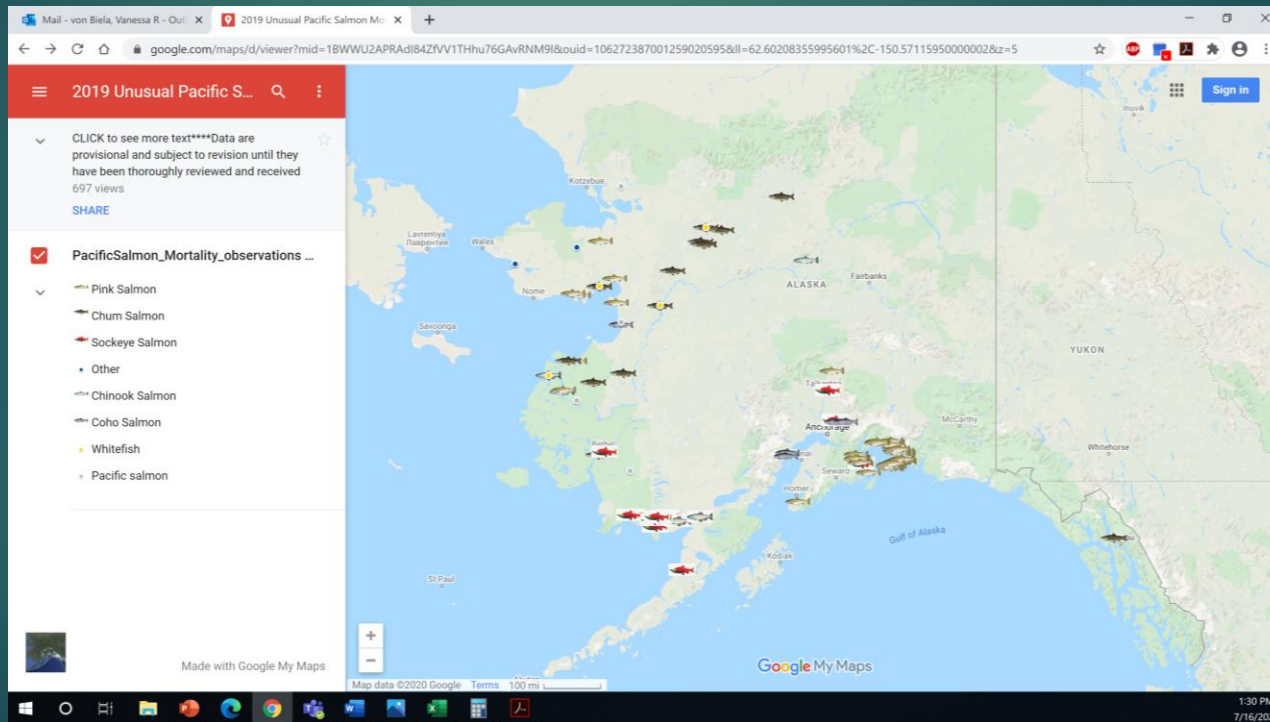
- ▶ Western Alaska mortalities were primarily associated with warm temperatures
- ▶ Southcentral Alaska mortalities were primarily drought with streams drying and stranding 1,000s of fish
- ▶ Low oxygen may play an important role in both cases
- ▶ Little evidence of disease noted



Stephanie Quinn-Davidson,
YRITFC

Explore the map yourself!

- ▶ <https://drive.google.com/open?id=1BWWU2APRADl84ZfVV1THhu76GAvRNM9I&usp=sharing>



Is there good news for Pacific salmon?



Streams with large groundwater or glacier input are cooler and have lower risk of high temperature or drought



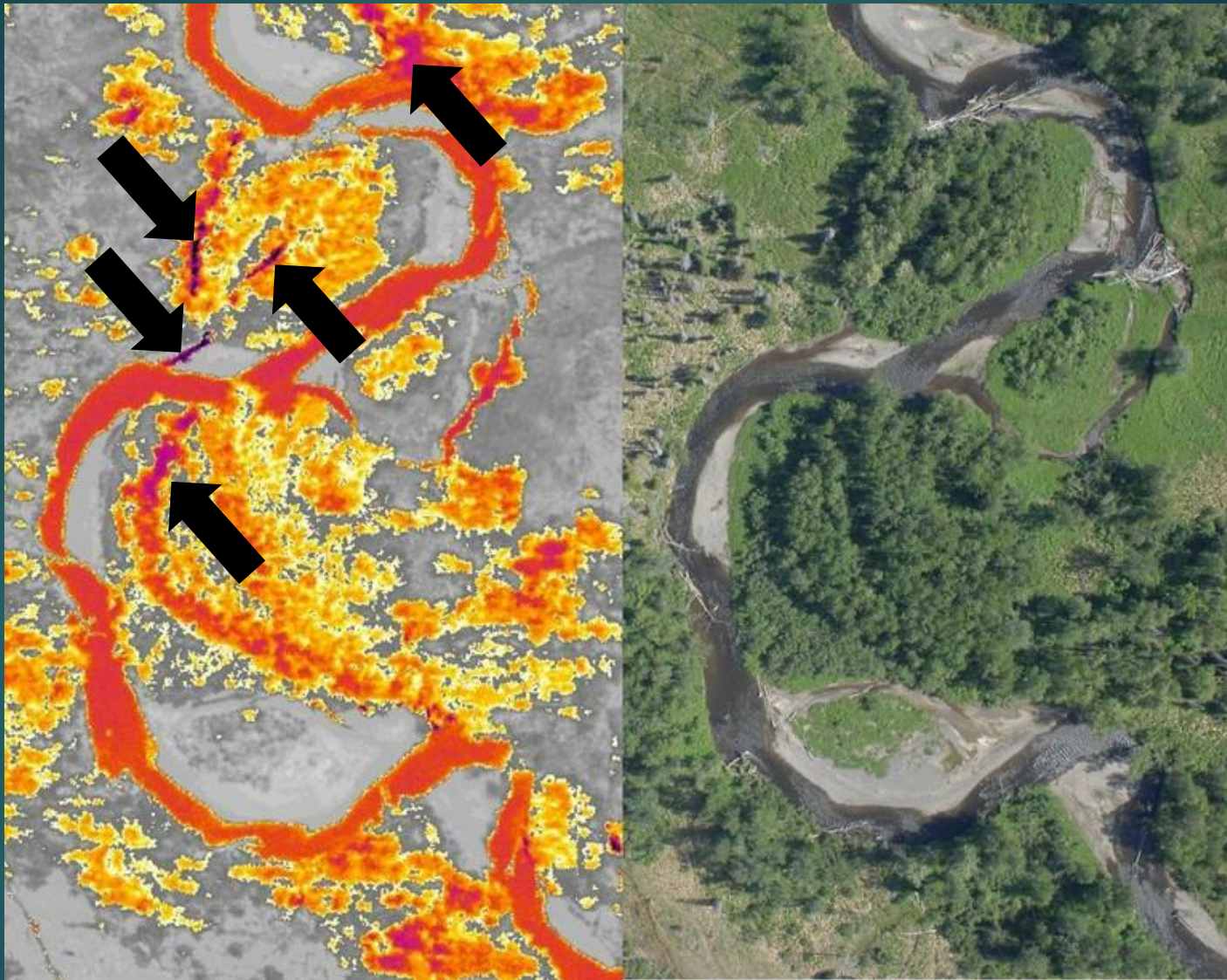
These cooler systems may even benefit in warm years because water temperatures are below ideal levels for Pacific salmon

Example: Chena River juvenile salmon grew fast in 2019 (UAF study)



Some warm systems have cool water pockets that helped Pacific salmon cope with warm temperatures

Example: Anchor River



Future of Pacific salmon in Alaska



The map of Alaskan rivers and streams that produce the most Pacific salmon may shift



Streams that have historically been near ideal water temperatures might be too warm to maintain high Pacific salmon production



Streams that have historically been too cold might warm enough to increase Pacific salmon production

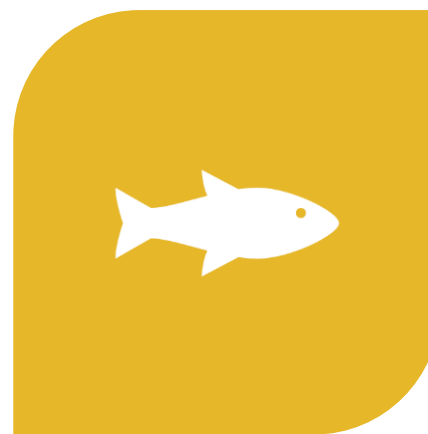


Redistributing Pacific salmon across Alaska would be a challenge for people and communities that depend on the resource

Share your thoughts



DO YOUR RIVERS AND STREAMS
SEEM WARMER IN RECENT
SUMMERS?



DO YOU HAVE CONCERNS
ABOUT WATER TEMPERATURE
AND FISH IN YOUR AREA?