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Identifying heat stress in Pacific salmon using muscle

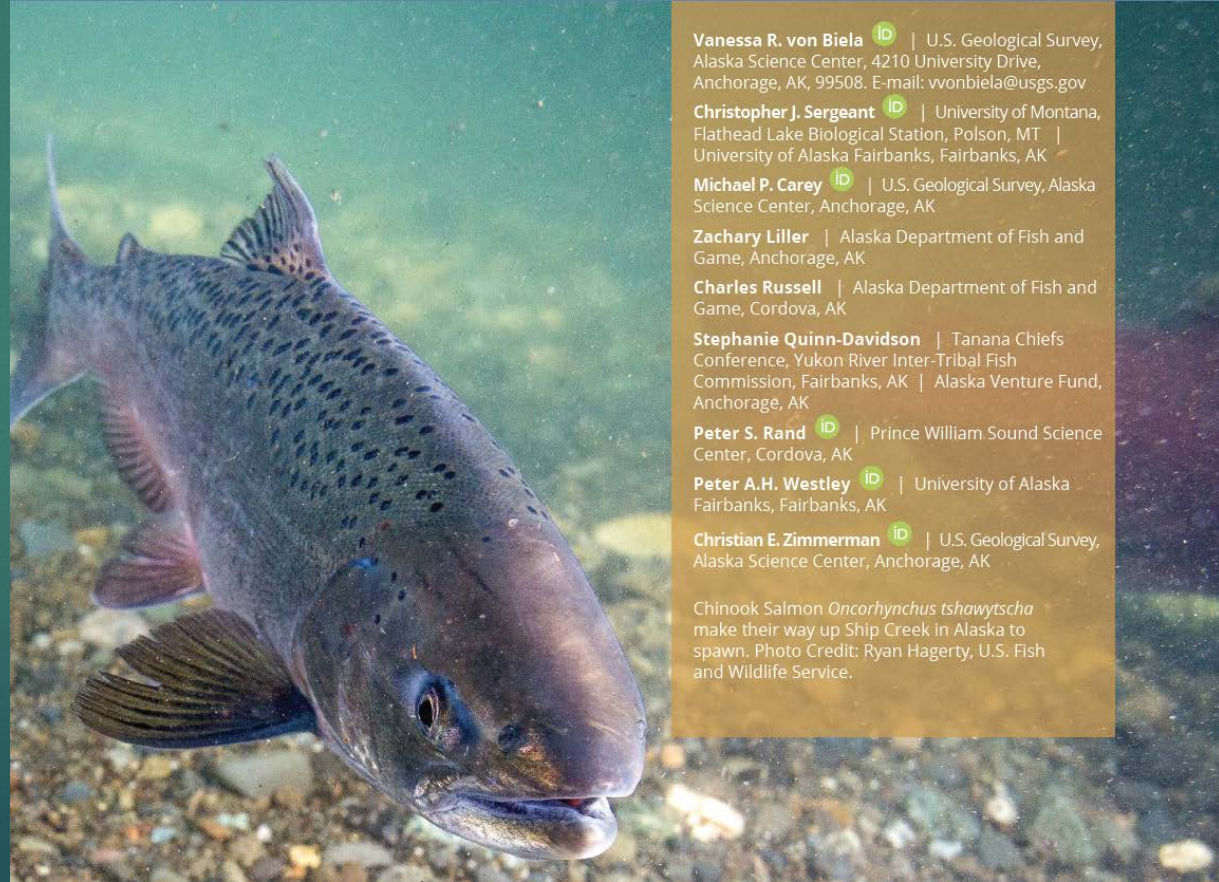



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Heat stress became an obvious issue for Alaska's salmon in summer 2019.


FEATURE

Premature Mortality Observations among Alaska's Pacific Salmon During Record Heat and Drought in 2019



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Chinook Salmon *Oncorhynchus tshawytscha* make their way up Ship Creek in Alaska to spawn. Photo Credit: Ryan Hagerty, U.S. Fish and Wildlife Service.

What is heat stress?

- ▶ Water is so warm that the body isn't working normally.
- ▶ Proteins inside cells are damaged.
- ▶ For adults, typically begins $\sim 18^{\circ}\text{C}/65^{\circ}\text{F}$
- ▶ For juveniles, $>20^{\circ}\text{C}/68^{\circ}\text{F}$
- ▶ Risk of mortality and reduced reproduction.



Stocks of 'Conservation Concern'

- ▶ State of Alaska has 19 stocks of 'conservation concern'
 - ▶ Nearly all are Chinook salmon (15 stocks)
 - ▶ No coho salmon stocks
- ▶ Chinook salmon and coho salmon have very different levels of conservation concern even though they co-occur in similar freshwater and marine habitats.

→ If we validate heat stress biomarkers in both species we can see how well each species is able to avoid heat stress.

Biomarkers

Gene transcription (mRNA)

- ▶ 13 genes
 - ▶ HSP genes
 - ▶ Immune genes
 - ▶ Detox genes
 - ▶ Metabolism gene
- ▶ Lab method: qPCR



Liz Bowen,
USGS

Heat shock protein 70

- ▶ One group of proteins; one data value
- ▶ Chaperone protein
- ▶ Elevated in response to damage in other proteins
- ▶ Provides a temporary increase in thermal tolerance
- ▶ Lab method: ELISA



Steve McCormick,
USGS & UMASS



Amy Regish,
USGS

Statistical approach



Move beyond describing mean/median differences in biomarkers



Classifications & % heat stress



More easily integrated in population dynamics & escapement management

Experimental validation



- Hatchery juveniles
 - Chinook salmon, n = 151
 - Coho salmon, n = 141
 - No temperature-related mortality
- 12 and 36 hr treatment
- Five water temperatures
 - 15, 17, 19, 21, and 23°C
 - Span the optimal to stressful transition
 - Ecologically relevant for the Deshka watershed

We have some concerns about temperatures limiting habitat availability for juvenile salmon

Juvenile are also useful for fine-tuning biomarkers we can use for adult salmon too



photarium
a product of Wild Fish Conservancy

Hatchery juveniles

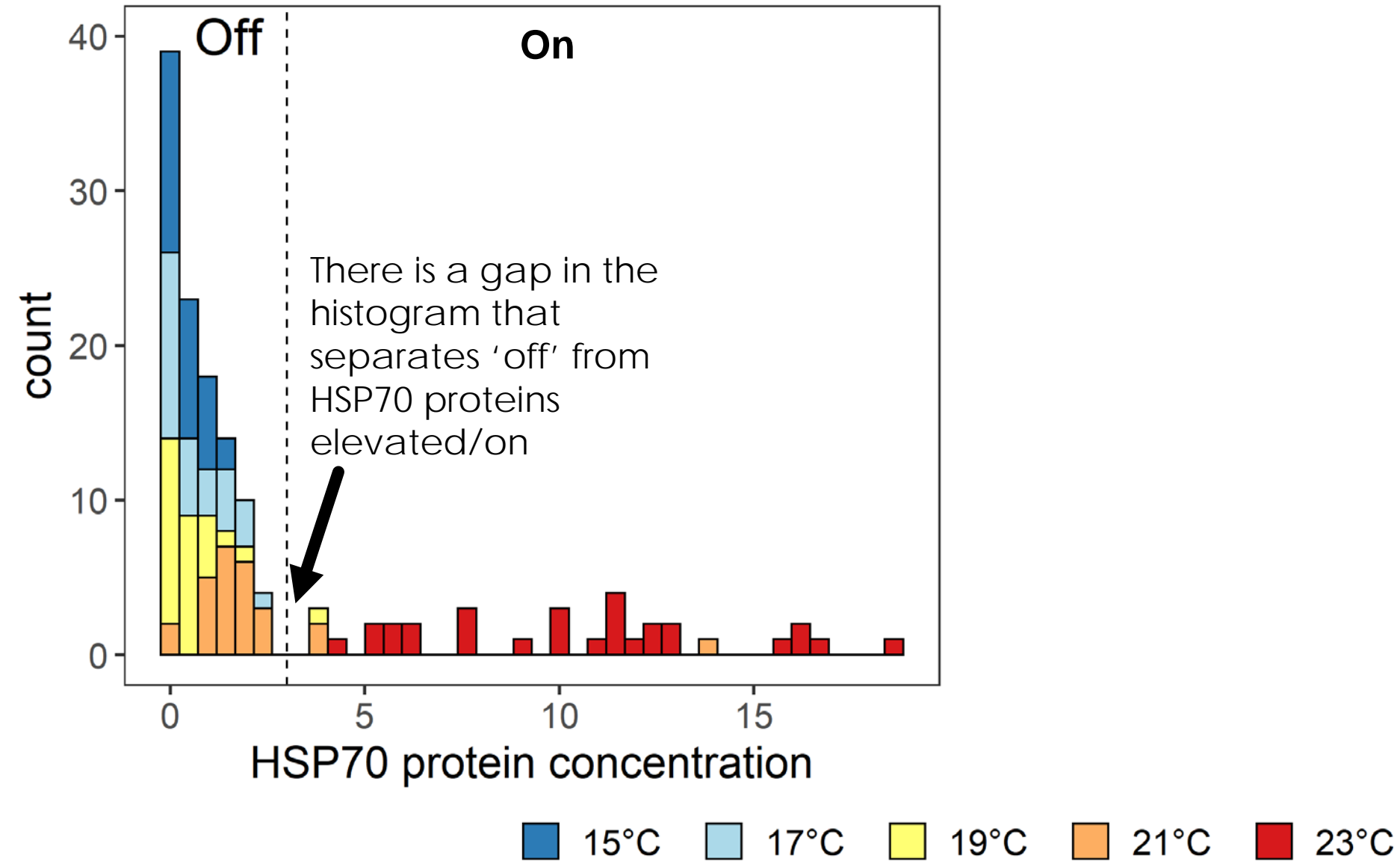
- ▶ ADF&G William Jack Hernandez Sport Fish Hatchery
- ▶ Anchorage, Alaska
- ▶ Both stocks originated from wild Alaskan fish from cold watersheds
- ▶ Chinook salmon May 2020 @ ~95mm FL
- ▶ Coho salmon May 2021 @ ~55 mm FL
- ▶ Treatment x species sample size ~30



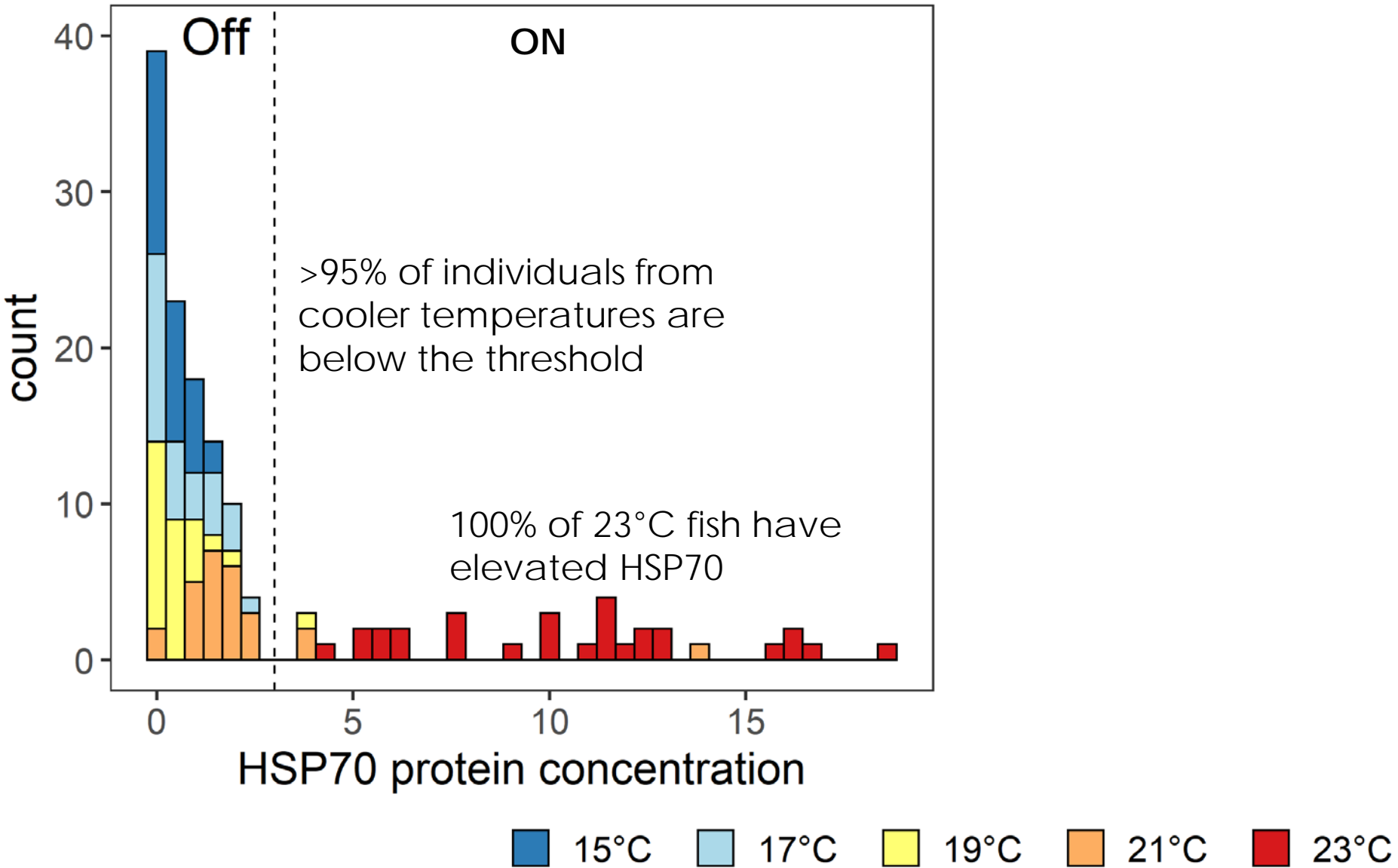
Classification analysis

- ▶ With these large sample sizes, we can plot HSP70 data as a histogram and fill in bar colors with water temperature treatments.
- ▶ We expect to see two groups of fish separated by a data gap
 - ▶ Group 1: Low baseline HSP70 at cooler water temperature ('OFF')
 - ▶ Group 2: Elevated HSP70 at warmer temperatures ('ON')
 - ▶ If there is a gap in data between the two states, that's a useful threshold for classification

Coho salmon

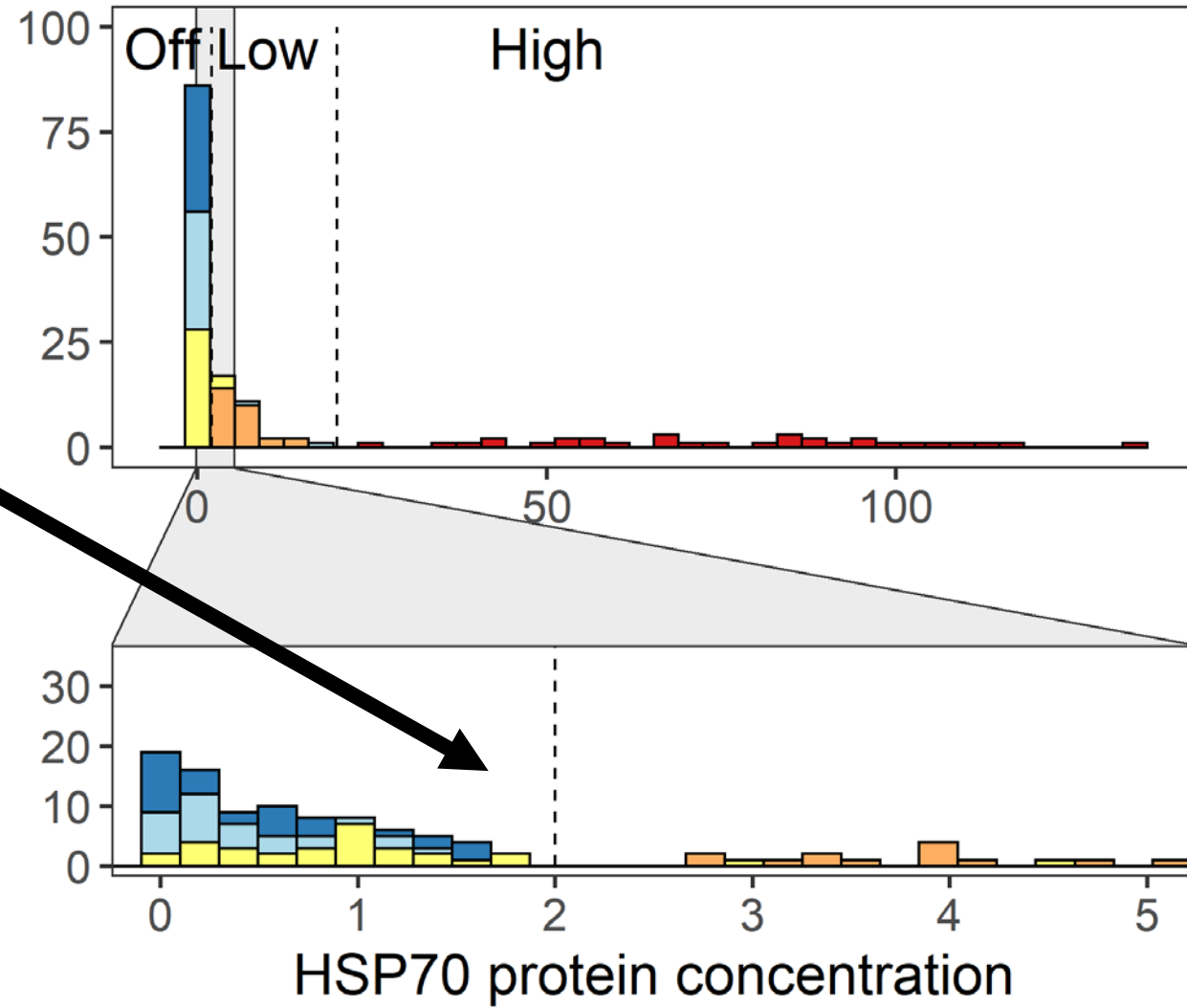


Coho salmon



Chinook salmon also have a gap in the histogram that shows when HSP70 is 'off'

Chinook salmon



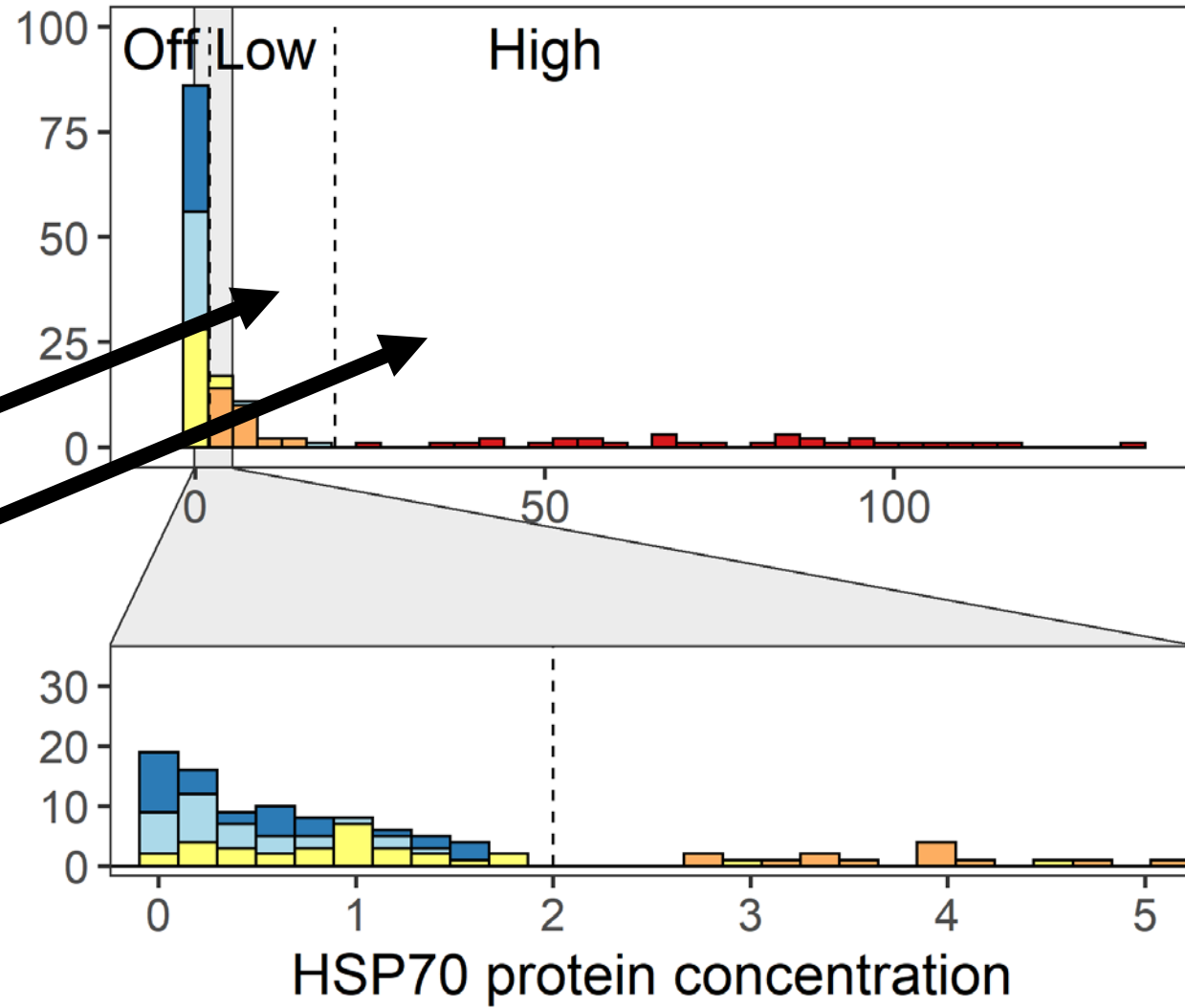
15°C 17°C 19°C 21°C 23°C

Chinook salmon also have a gap in the histogram that shows when HSP70 is 'off'

'On' is more complex:
21°C is a low level
23 °C is a high level

100% of these fish had elevated HSP70

Chinook salmon



15°C 17°C 19°C 21°C 23°C

Tool-box conclusion:

HSP70 protein concentrations from skeletal muscle tissue are a good biomarker for heat stress, separating individuals from warm and cool treatments correctly >95%

Coho salmon vs. Chinook salmon

Treatment	Coho salmon	Chinook salmon
15°C	No heat stress	No heat stress
17°C	No heat stress	No heat stress
19°C	No heat stress	No heat stress
21°C	Minor increase in HSP70, not distinct enough to classify as stress	HEAT STRESS Distinct increase in HSP70 (>2 ng HSP/mg total protein)
23°C	HEAT STRESS Distinct increase in HSP70 (>3 ng HSP/mg total protein)	HEAT STRESS Extremely high HSP70 (>20 ng HSP/mg total protein)

Chinook salmon were more temperature sensitive than coho salmon in this study

Questions?

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As we dive into the wild juvenile data, we'll be leaning on the water temperature monitoring data

