

The Effect of Thermal Stress on Juvenile Chinook Salmon in the Deshka River

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Background

- Climate warming is happening fastest at high latitudes such as Alaska.
- Chinook populations are declining with many drivers unknown.
- In recent freshwater temperatures within the state have begun to exceed the upper thermal limits of salmon.
- How are these warm freshwater conditions effecting juvenile Chinook?



PRESS RELEASE

FOR IMMEDIATE RELEASE:

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MORE INFORMATION:

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HEAT WAVE HITS COOK INLET SALMON STREAMS

Climate Crisis Sends Stream Temperatures Off the Charts

HOMER, AK— As Alaskans suffer through the smoke, haze and danger of a record-breaking heat wave, Alaska's salmon are suffering too. On July 7th, stream temperatures topped 81.7 °F (27.6 °C) in the Deshka River, a major salmon stream on the west side of Cook Inlet in the Mat Su Valley.

"We've been tracking stream temperatures in non-glacial systems across the Cook Inlet watershed since 2002," said Sue Mauger, Cook Inletkeeper's Science Director. "But this is a first – we've never seen stream temperatures above 76 degrees Fahrenheit."



<https://www.mcnaary.fish/juvenile-tucnonnon-river-spring-chinook-and-summer-steelhead>

We hypothesize that Alaska's warmest freshwater temperatures already impair the growth of juvenile Pacific salmon due to direct effects of heat stress or indirectly via increased metabolic rates that exceed consumption.

Critical Size Period Hypothesis

- Larger salmon entering saltwater have higher survival rates
- Decreased freshwater growth could be contributing to current population declines

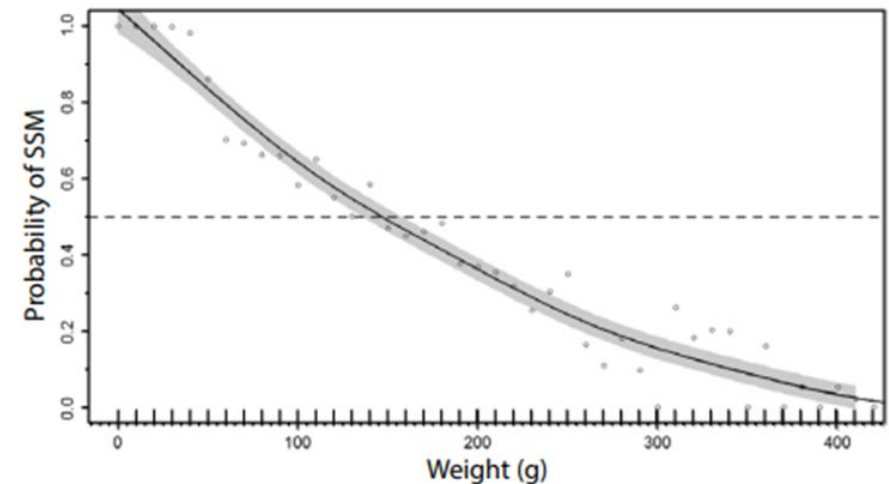
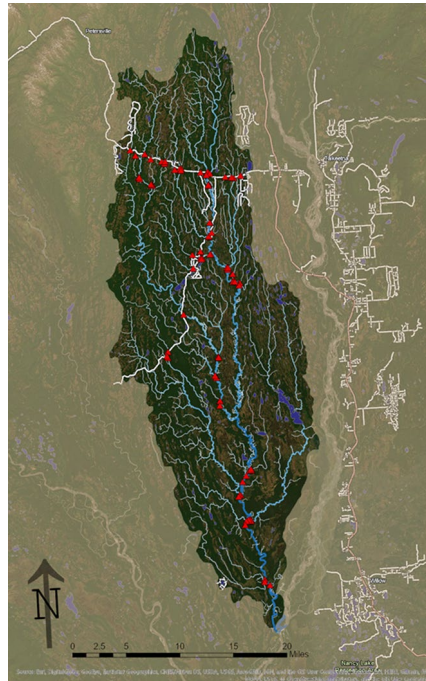


Fig. 7. Generalized additive model (thick solid black line) fit to size selective mortality (SSM) probabilities of juvenile Yukon River Chinook salmon based on differences between actual juvenile weights and the average of simulated back-calculated weights of adults at SCP. The horizontal dashed 0.5 probability line identifies the reference point of neutral selection on the GAM model; a selective disadvantage is expected for weights smaller than this point, a selective advantage is expected for weights larger than this point. Shaded area represents GAM model confidence intervals.

Howard, K., Murphy, J., Wilson, L., Moss, J., and Farley, E. (2016). Size-Selective Mortality of Chinook Salmon in Relation to Body Energy after the First Summer in Nearshore Marine Habitats. North Pacific Anadromous Fish Commission Bulletin, 6, 1–11.

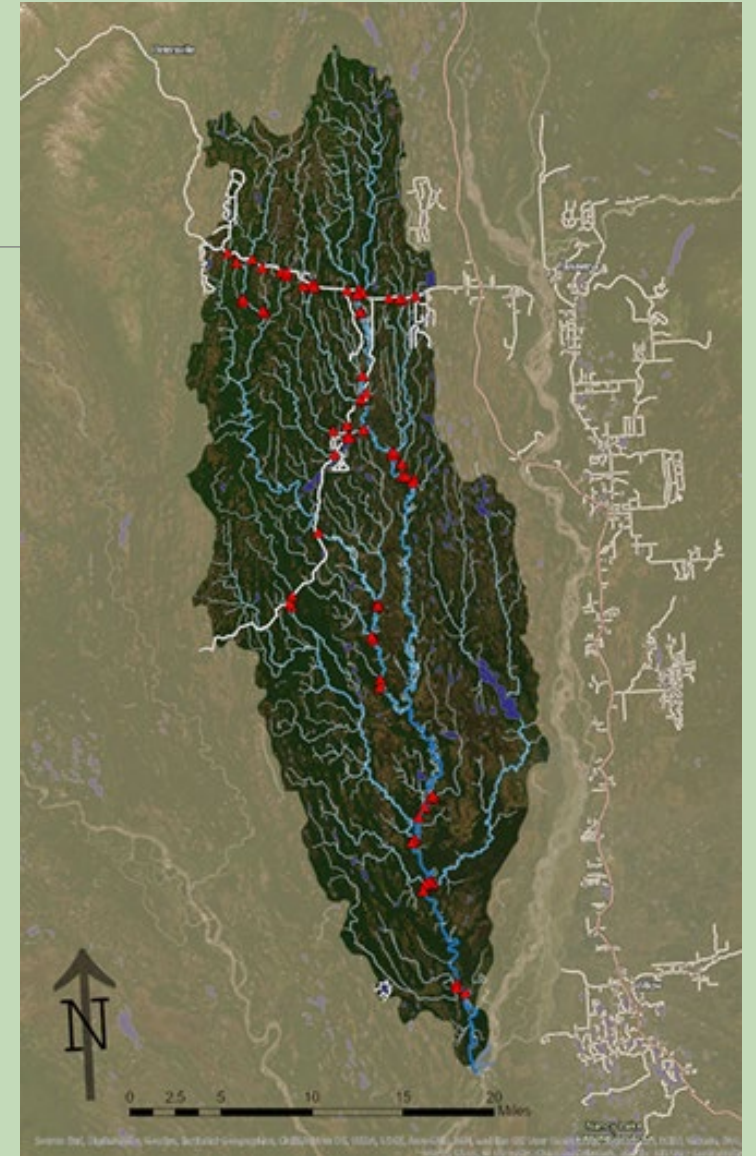
The Deshka River (Kroto)

- Non-glacial, warm, constantly above 20°C during summer months.
- Historically largest Chinook salmon run in the Northern Cook Inlet.
- Chinook returns have plummeted in recent years closing fisheries.
- Representative of the warmest salmon systems across the state
 - used to understand future change in cooler systems.



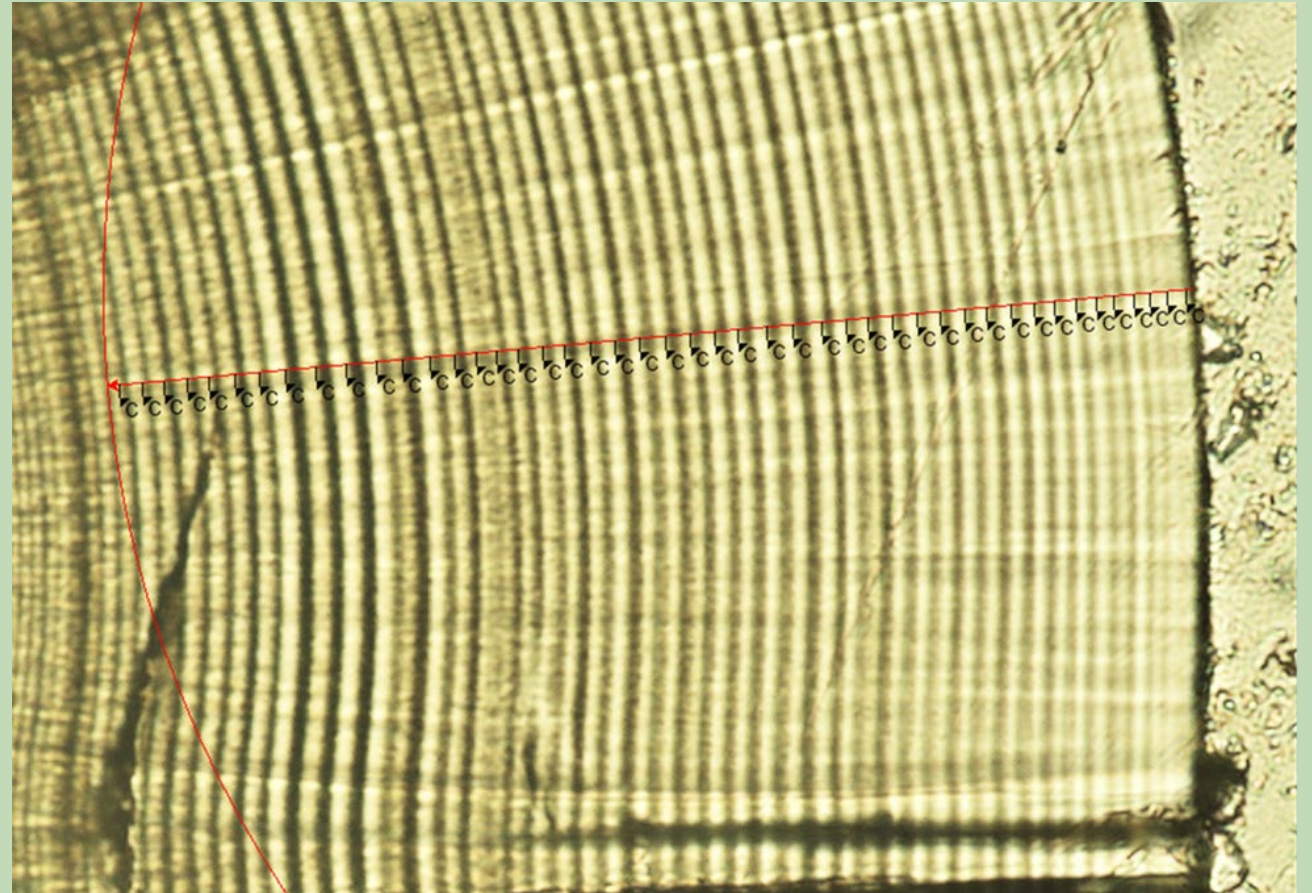
Data Collection

- Collected data from 2019 – 2022
- 68 temperature monitoring / sampling sites throughout watershed
- Trapped with baited minnow traps
- Collected subset of fish to be processed for
 - Growth: Otolith daily increment widths
 - Heat-stress: Heat Shock protein 70 (HSP70)
- We trapped fish in up to 25.5° C



Otolith Daily Growth Increments

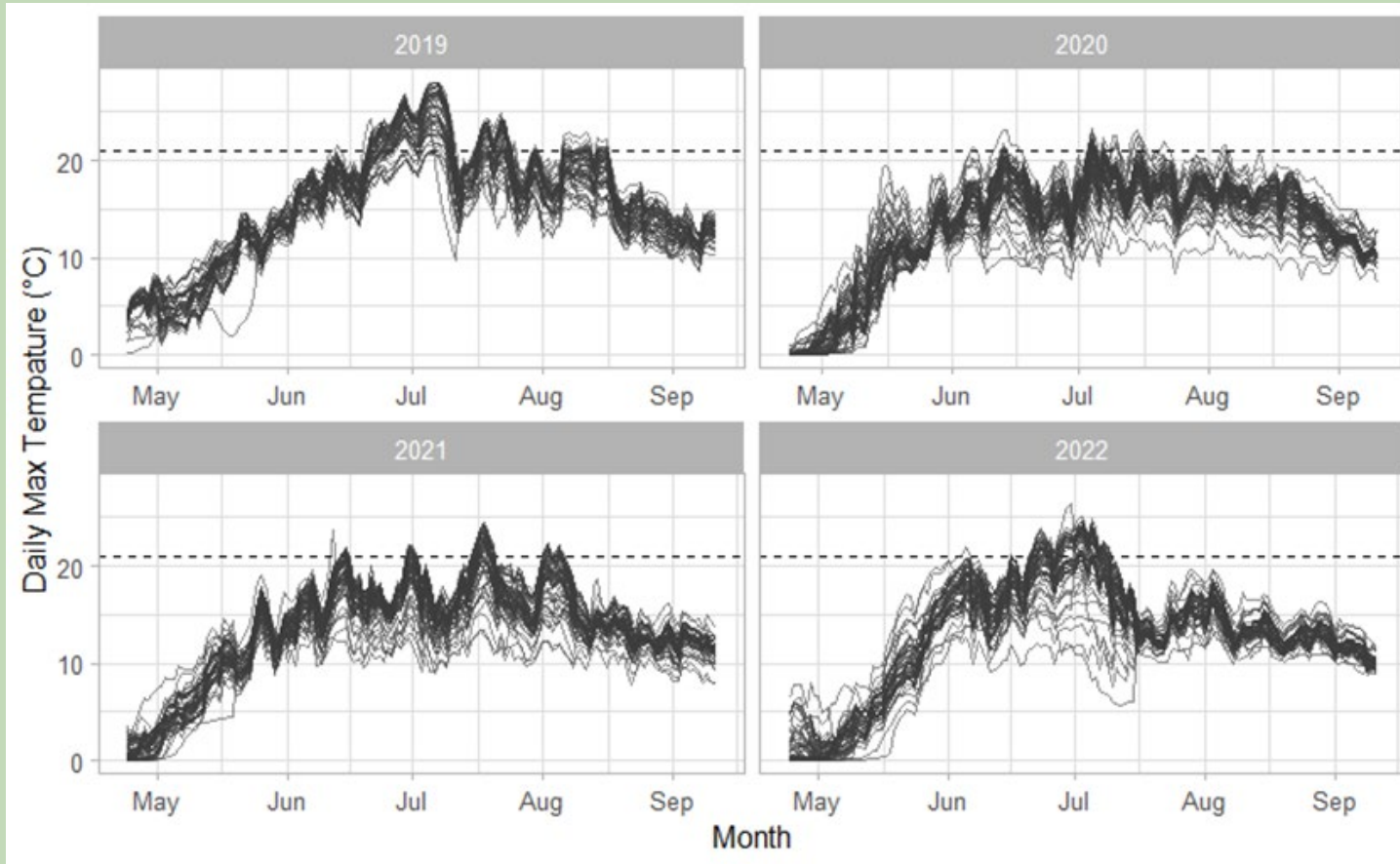
- Inner ear bone of fish
- Juvenile fish lay increments at a daily rate
- Increment width has been correlated to somatic growth in juvenile Chinook.
- Photographed at 40X magnification and analyzed using ImagePro by Media Cybernetics.
- Calculated a 10-day average for each fish to use as growth metric.



Heat Shock Protein 70 (HSP70)

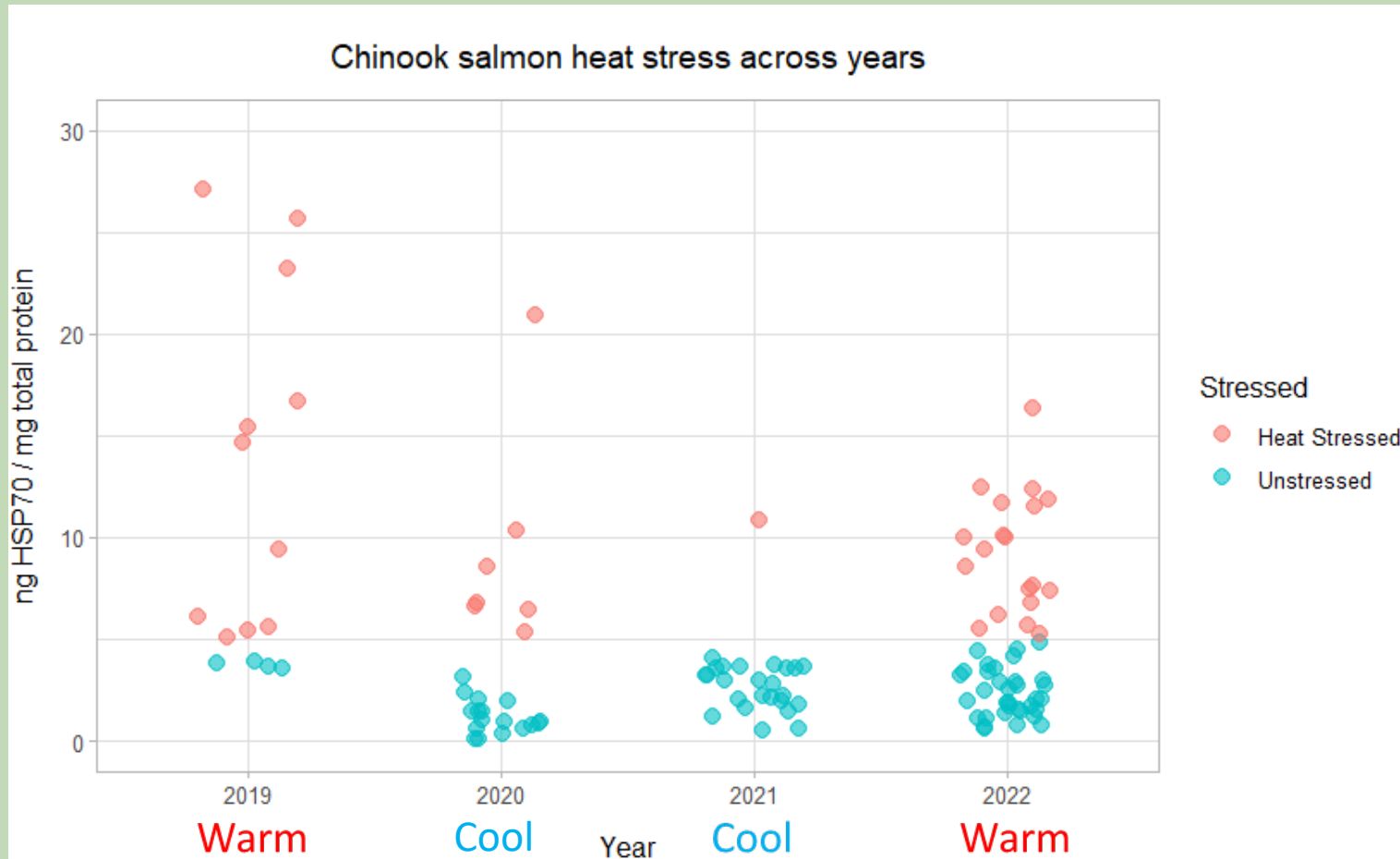
- HSP70 is a core component to cellular heat shock response.
- Production occurs in cells when warm temperatures begin to damage proteins required for normal cellular function.
- HSP70 assists other proteins to maintain proper folding, repair damage, and prevent aggregation.





Water Temperature

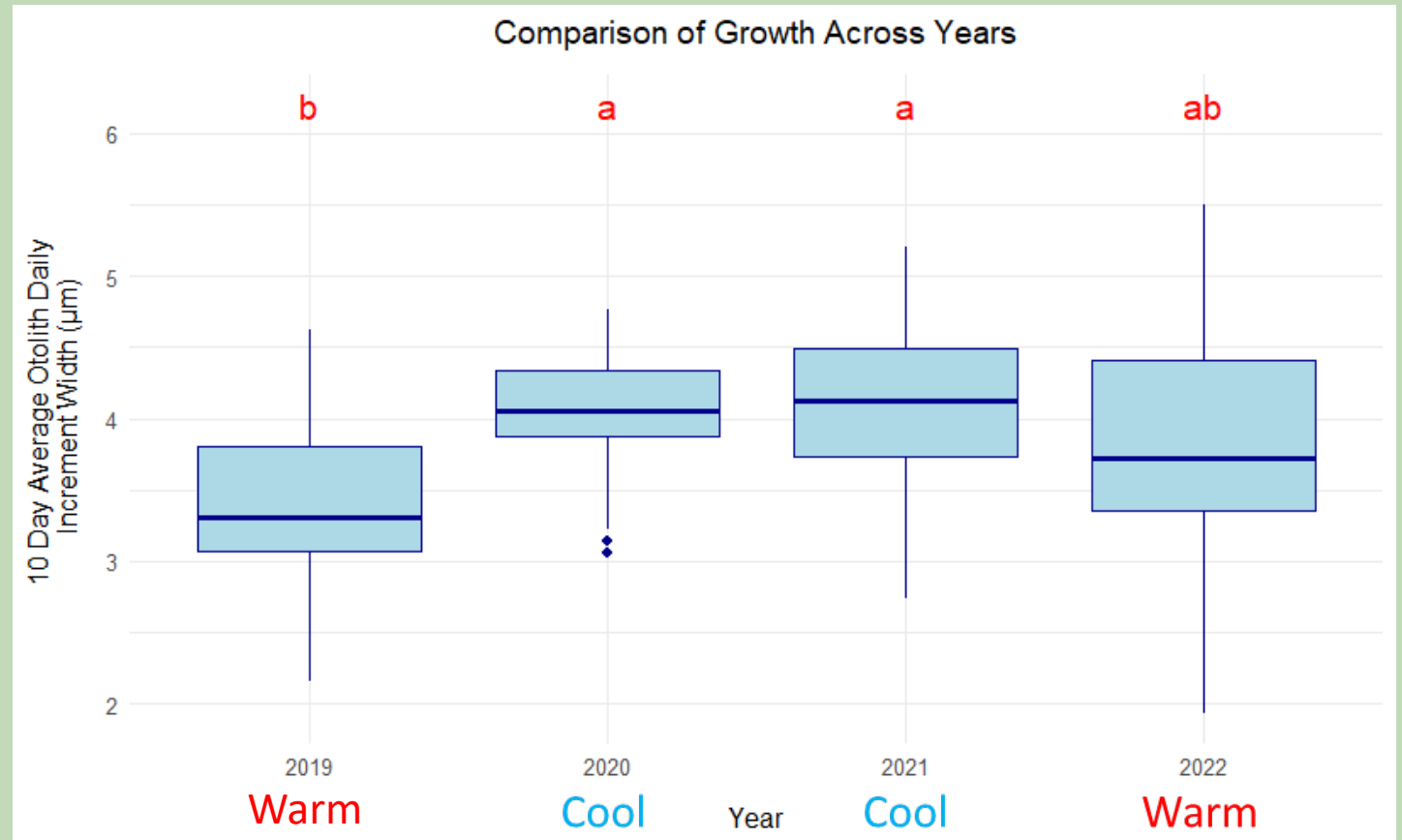
- Warm years:
 - 2019, 2022
- Cool Years:
 - 2020, 2021



- Cool years 2020, 2021
- Warm years 2019, 2022
- Extended temps above 21°C induce increased heat stress.

Growth Across Years

- ANOVA to compare growth across years
- Cool years:
 - similar high growth
- 2019 “extreme heat”
 - Significantly lower growth
- 2020
 - Lower growth observed than cool years, no significant difference among years.



Take Aways / Next Steps

- Extended heat waves raising water temperatures $> 21^{\circ}\text{C}$ have a negative effect on juvenile Chinook salmon growth
- Continue to explore data
 - Focus analysis during and post extended heat waves
- Create mixed effects model to include:
 - Water Temperature
 - HSP70
 - Stomach fullness
 - % total fish dry mass (lipid level)
 - Possibly discharge
 - Year
 - Site
- Repeat analysis with Coho data



Questions?

Acknowledgments:

Field crews over the years, specifically Ben Rich, and Tim Ericson.

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Growth Related to Water Temperature

- Growth peaks at ~ 20 °C
- Deshka Chinook are experiencing decreased growth

