Investigating Heat Stress in Two Subarctic Chinook Salmon Populations and Reproductive Consequences

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Growing Pressures on the Human-Salmon Relationship in Southcentral Alaska

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⬆ Anomaly summers

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- ⬆ Anomaly summers
- ⬆ Development

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- ↑ Anomaly summers
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- ↓ Chinook salmon runs

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- ↑ Development
- ↓ Chinook salmon runs
- ↑ Hatchery reliance

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- Remain elevated hours to 10 days

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- ⇧ Temps ⇩ Thermal sensitivity

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- Captivity vs. nature
- ⬆ Heat shock proteins in wild fish than hatchery

Broodstock Handling and Holding Can Cause Cellular Stress

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- ⬆ Cellular stress with handling, maturation, and reproduction
- Additive effect (Werner 2007)

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  - Increased developmental abnormalities

Overarching Questions

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3) How does heat stress expression differ **with involvement of hatchery broodstock collection**?

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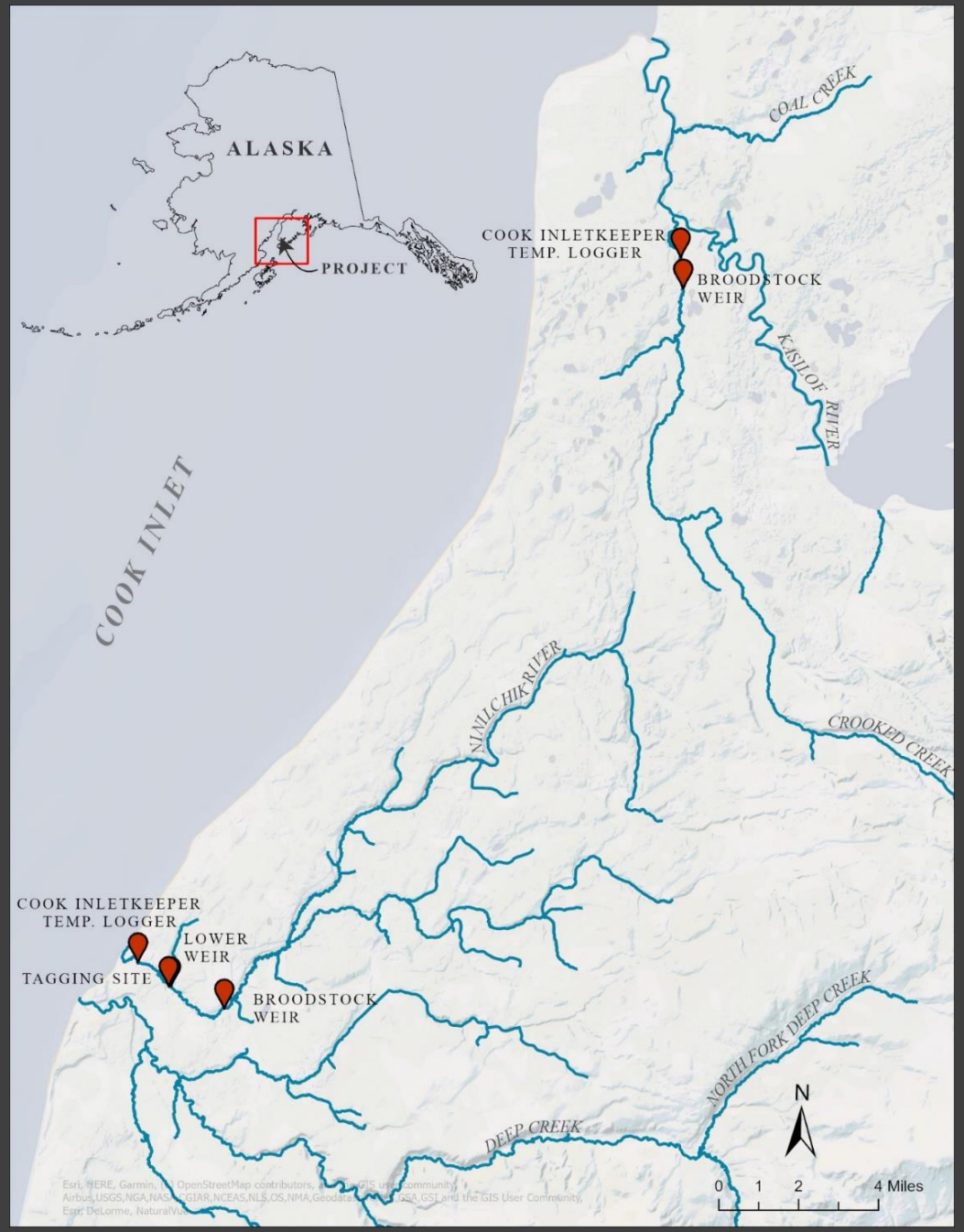
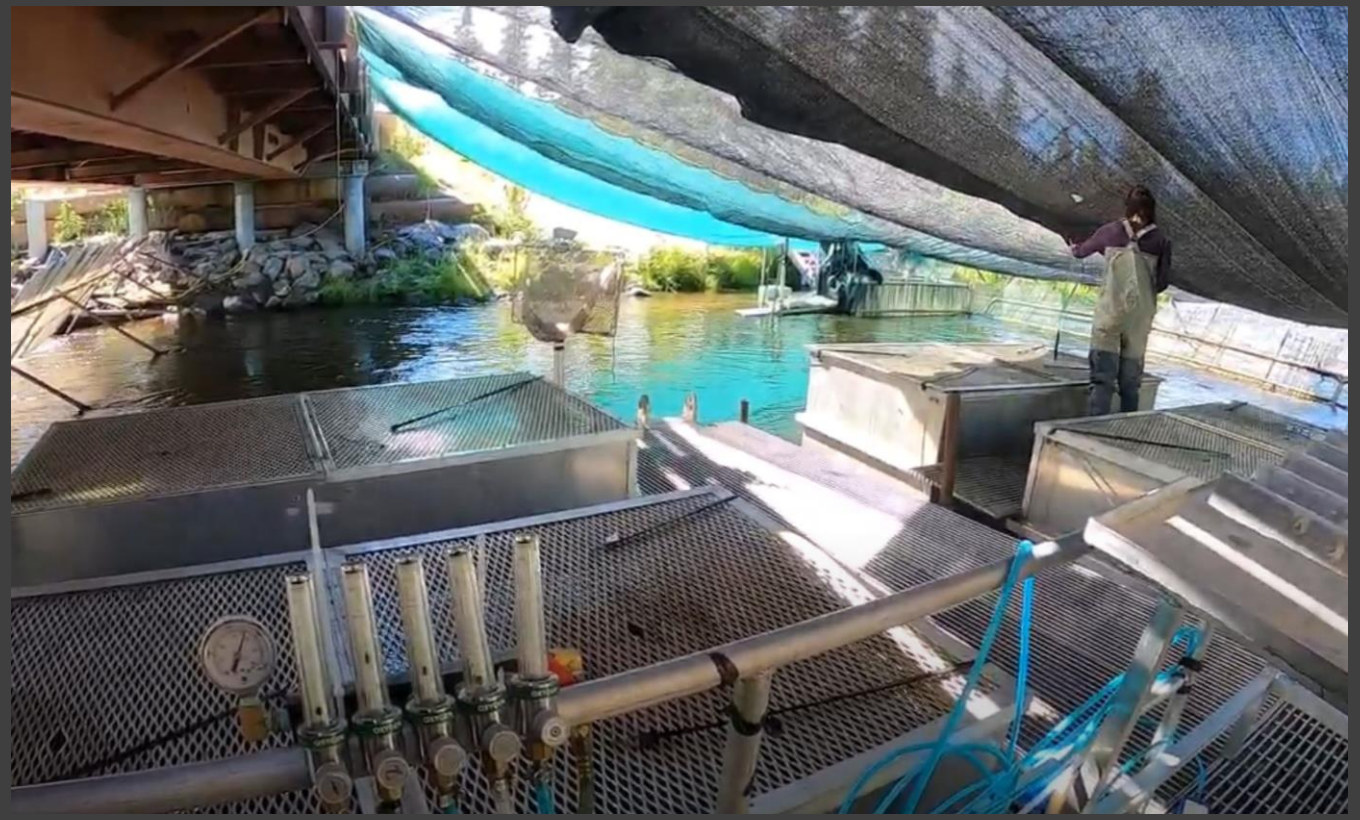
2) How does heat stress expression differ between **hatchery vs. wild rearing conditions**?

3) How does heat stress expression differ **with involvement of hatchery broodstock collection**?

4) Does heat stress in spawning adult females result in **lower egg survival** to the eyed stage in the hatchery?

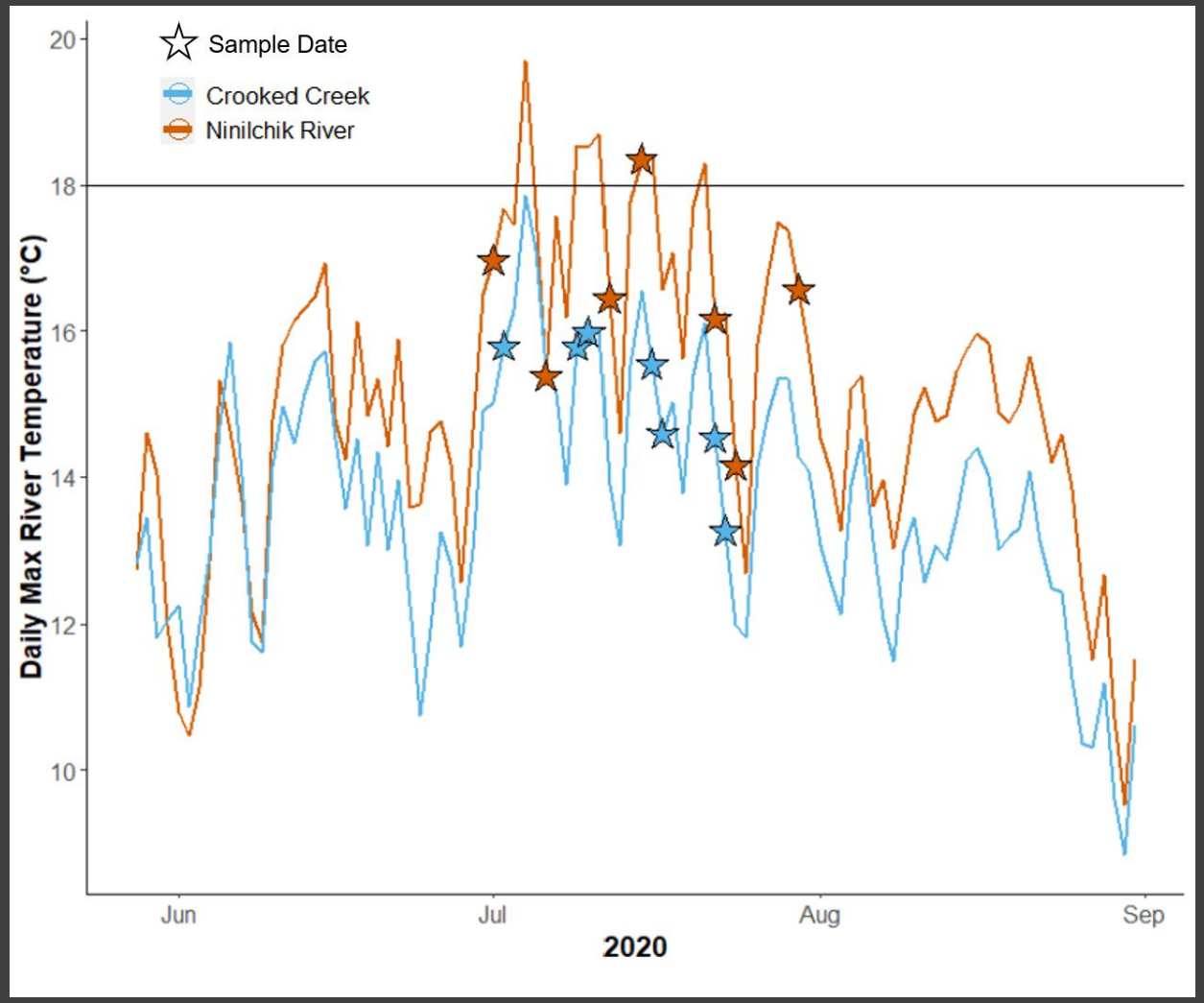




Study Sites: Crooked Creek & Ninilchik River

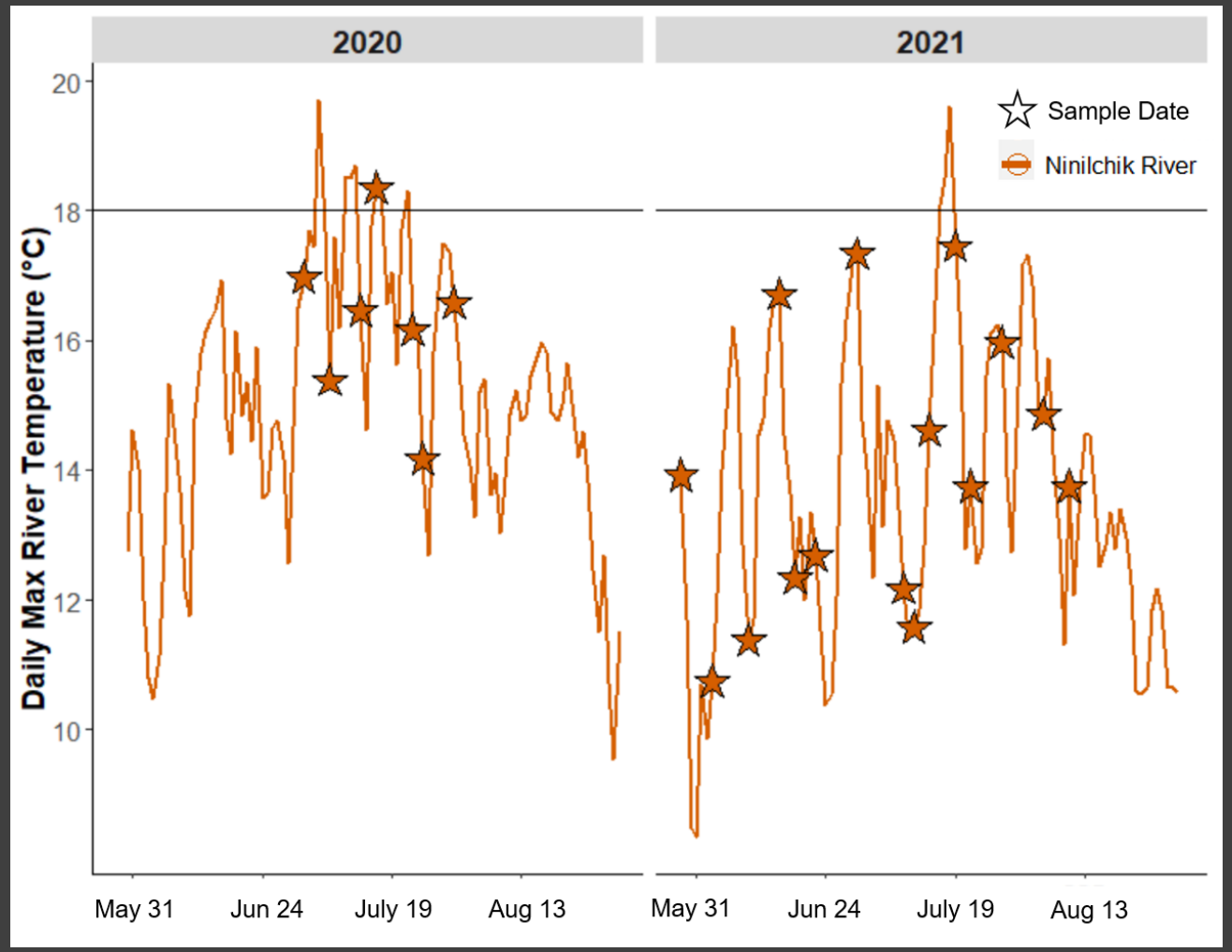
Daily Max Temperature in 2020

- Ninilchik River is warmer than Crooked Creek in 2020



Daily Max Temperature 2020-2021

- Ninilchik River reaches above 18°C threshold both years



Simplified Equation Showing the Variables Included in our Generalized Additive Model for Fish Not Used As Broodstock

$$HSP70 = s(\textbf{\textit{Temperature}}) + \textbf{\textit{River}} + \textbf{\textit{Rearing}} + \textbf{\textit{Size}} + \textbf{\textit{Day of Year}} + \varepsilon$$

- Stepwise regression approach for reduced model selection

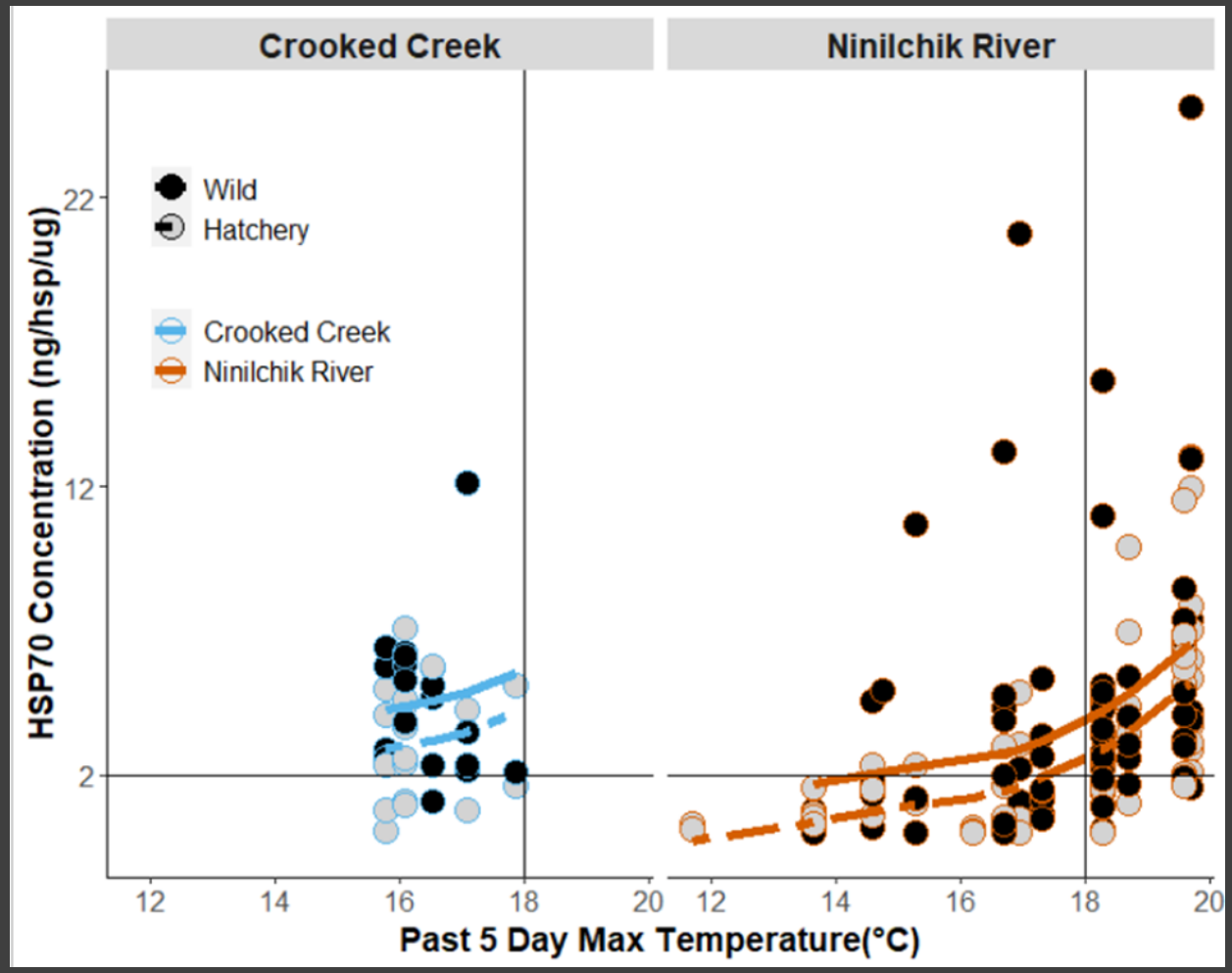
Reduced Generalized Additive Model for Fish Not Used As Broodstock

$$HSP70 = s(\textbf{Temperature}) + \textbf{River} + \textbf{Rearing}$$

	---- Step 1		*---- Step 2*		*---- Step 3*	
Terms	**Coefficient**	**P**	**Coefficient**	**P**	**Coefficient**	**P**
River (Ninilchik)	-1.73	0.02	-1.85	<0.01	-1.85	<0.01
Rearing (Wild)	1.09	0.07	1.09	0.06	1.35	<0.01
Body Size	<0.01	0.43	<0.01	0.41		
Day of Year	<0.01	0.69				

Cold Adapted Fish Population & Wild Reared Increases HSP70

- Cooler river and wild fish are more thermally sensitive



Simplified Equation Showing the Variables Included in our Generalized Additive Model for Fish Used As Broodstock

$$HSP70 = s(\textbf{\textit{Temperature}}) + \textbf{\textit{Broodstock}} + \textbf{\textit{Rearing}} + \textbf{\textit{Size}}$$

- Same approach as previous model

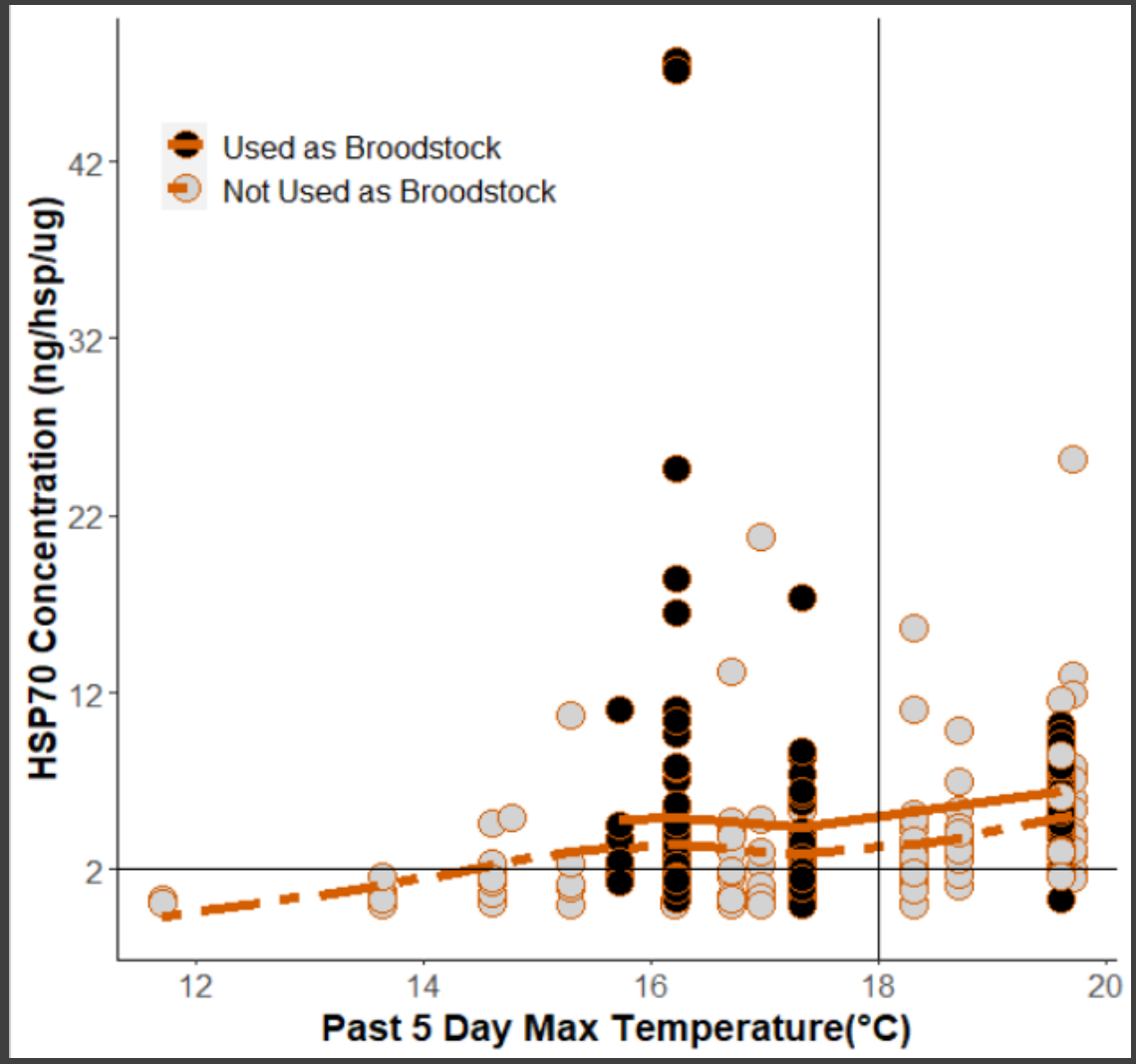
Reduced Generalized Additive Model for Fish Used As Broodstock

$$HSP70 = s(\textbf{Temperature}) + \textbf{Broodstock}$$

	---- Step 1		*---- Step 2*		*---- Step 3*		*---- Step 4*	
Terms	**Coefficient**	**P**	**Coefficient**	**P**	**Coefficient**	**P**	**Coefficient**	**P**
Broodstock (Yes)	2.28	0.01	2.26	0.01	2.19	0.01	1.50	0.03
Rearing (Wild)	0.29	0.72	0.22	0.76				
Body Size	-0.00	0.83						

Broodstock Handling Increases HSP70

- Below 18°C ⇧ HSP70 not temperature related but stress related



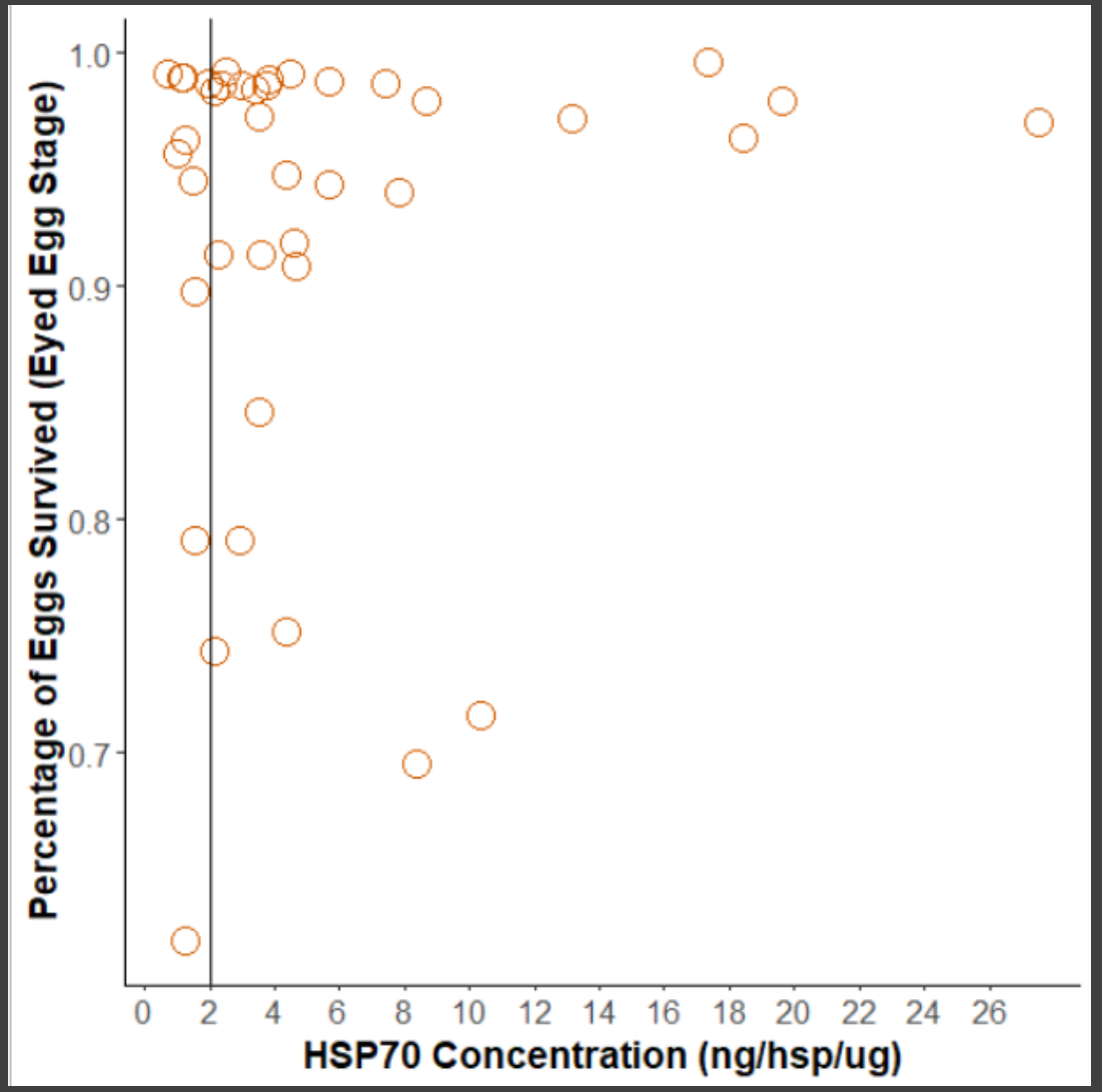
Simplified Equation Showing the Variables Included in Our Global Generalized Linear Model for Egg Survival to the Eyed Stage in the Hatchery

$$\boldsymbol{EggSurvival} = \boldsymbol{Temperature} + \boldsymbol{HSP70} + \boldsymbol{Rearing} + \boldsymbol{Size} + \boldsymbol{Day}$$

- Same approach as previous model
- No significant effects

HSP70 Doesn't Decrease Egg Survival

- Lowest percentages of egg survival have low HSP70 expression, hovering around the thermal threshold for juvenile salmon (2 ng/hsp/ug)



Concluding Remarks

☑ ⬆ HSP70 ⬆ temperature

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- **Crooked Creek (Cooler)** than Ninilchik River (Warmer)
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☑ HSP70 expression does not influence egg survival

Suggestions for Hatchery Managers

- Rear hatchery fish with varying temperatures to mimic wild rearing
- Reduce unnecessary handling and holding stress when possible
- Track HSP70 expression from the spawning adults to the fry stage

Acknowledgements

Ninilchik
Natives Association, Inc
To Enhance the Pride of Our People