Bering Sea Chum Salmon Marine Distribution and Survival

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Cunningham Lab Background

- Research focus: ***Population*** and ***spatial*** dynamics of salmon and groundfish
  - What drives variation in ***survival*** and ***growth***?
  - Can we ***predict*** the species' ***distributions*** in the marine environment, using survey and fishery-dependent catch (or bycatch) observations?
  - What are effective harvest and bycatch mitigation ***strategies***?
- Species distribution models used for both ***retrospective*** and ***prospective*** spatial prediction
  - Essential Fish Habitat (retrospective)
  - Improved understanding of spatial ecology
  - Spatial bycatch risk (prospective)
- Bayesian ***lifecycle*** models to estimate ***relationships*** between stage-specific survival and environmental and harvest processes

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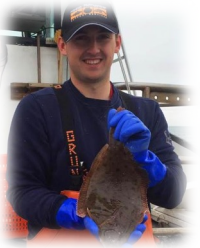
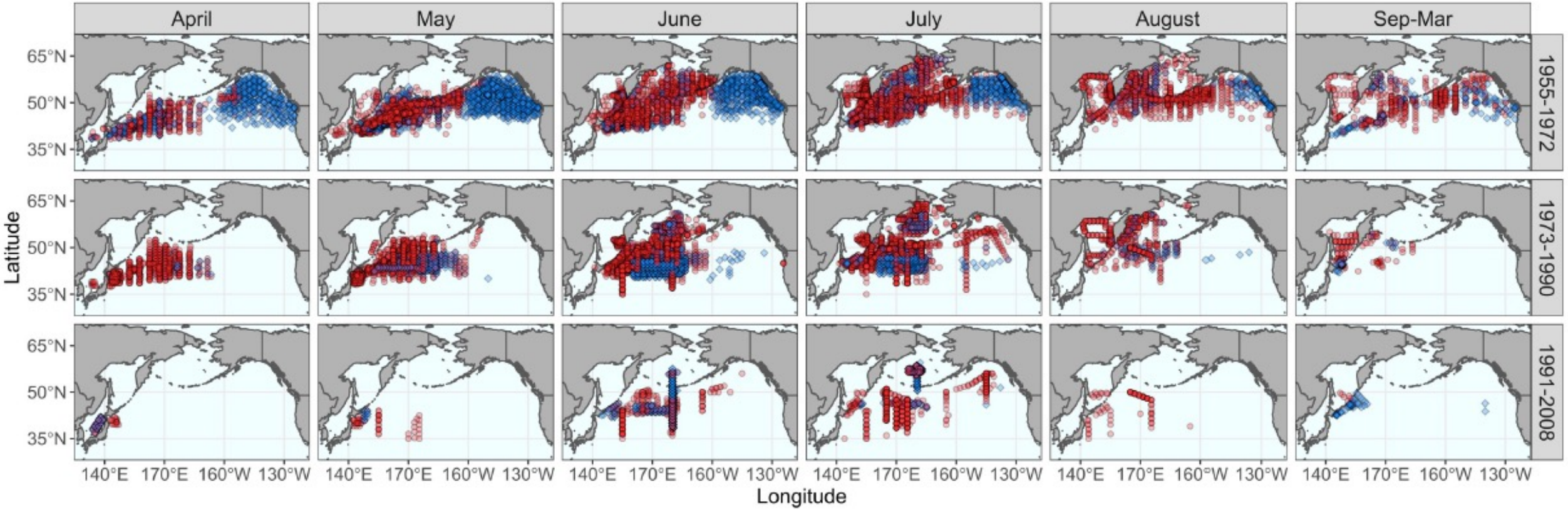


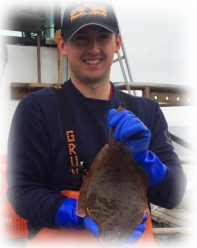
North Pacific Salmon Salmon Synthesis

- Objectives
  - Compile historical high seas salmon survey data (US, Canada, Russia, Japan, Korea): 1950's - 2000's
  - Describe the distribution of salmon relative abundance across the North Pacific
    - And temperature preferences, across spatially-unbalanced surveys and gear types

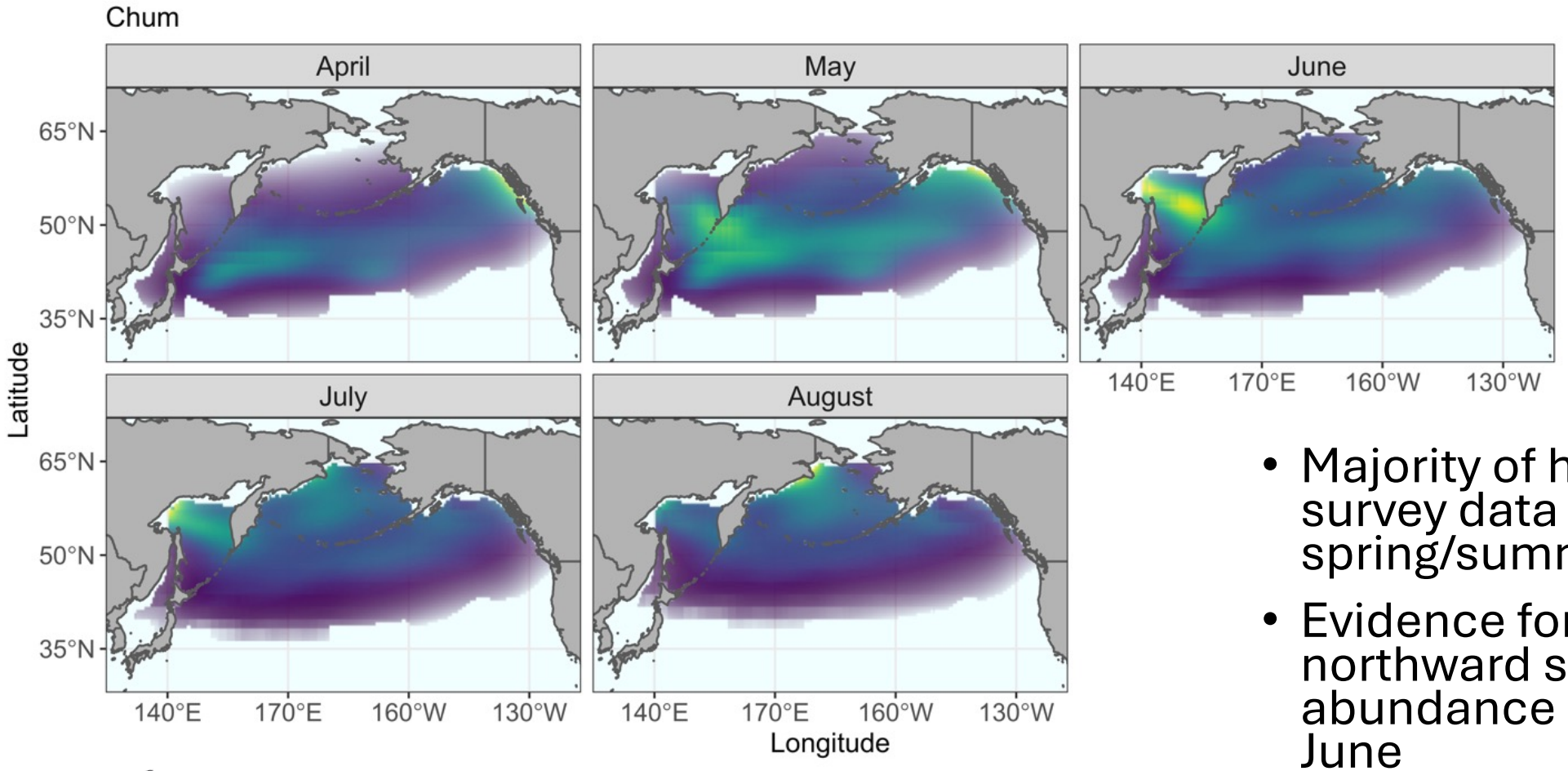


Data from the NPAFC/INPFC

Collaborator: Skip McKinnell (DFO Can Ret.)

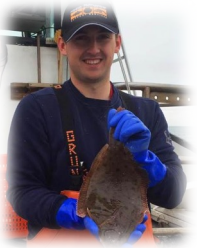


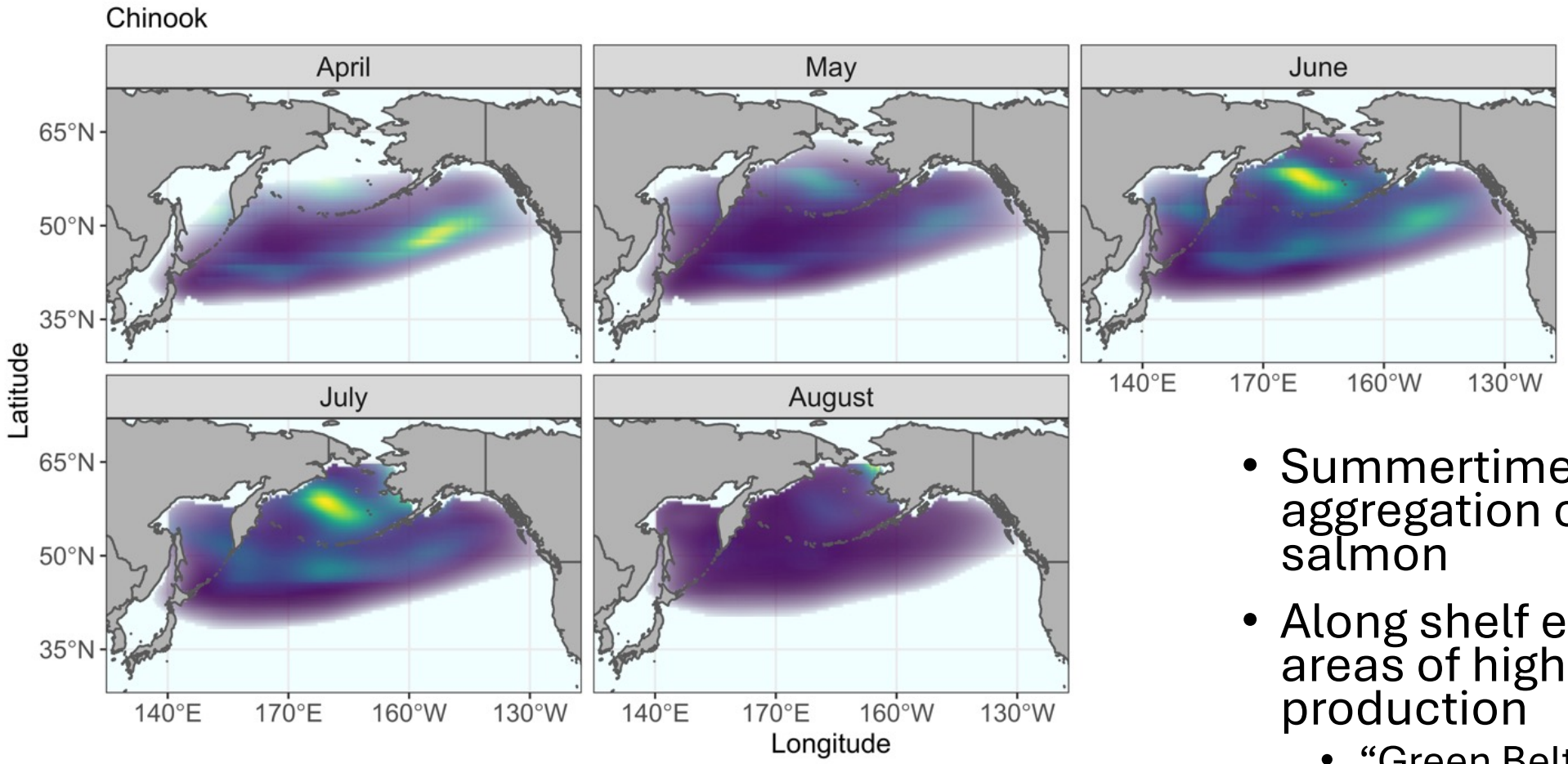
North Pacific Salmon Distribution: Chum



- Majority of high seas survey data from spring/summer
- Evidence for general northward shift in abundance beginning in June

North Pacific Salmon Distribution: Chinook



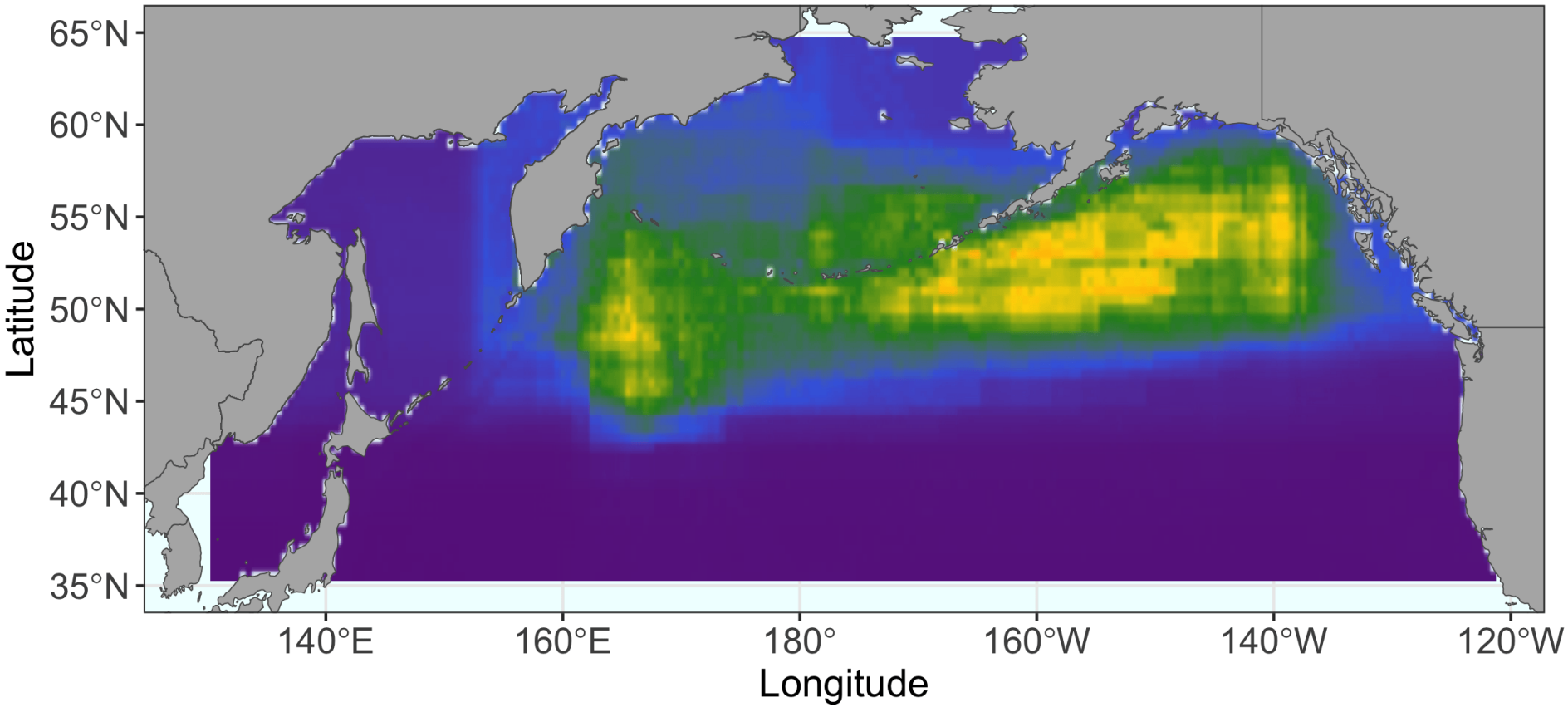


- Summertime (June/July) aggregation of Chinook salmon
- Along shelf edge near areas of high primary production
  - “Green Belt” (Springer et al., 1996)

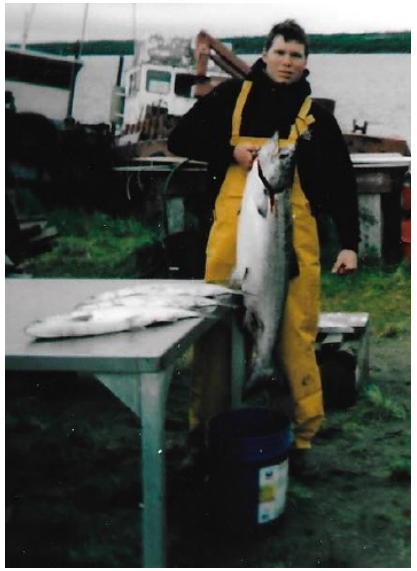
North Pacific Salmon: Spatial Predictions

Apr-1

BRT

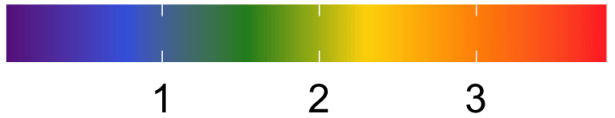


Naknek River, 2006



Sockeye Salmon

Predicted Gillnet sqrt(Sockeye CPUE)



Better Descriptions of Chum Salmon Distribution by Genetic Reporting Group

Data: Mothership and CP Chum

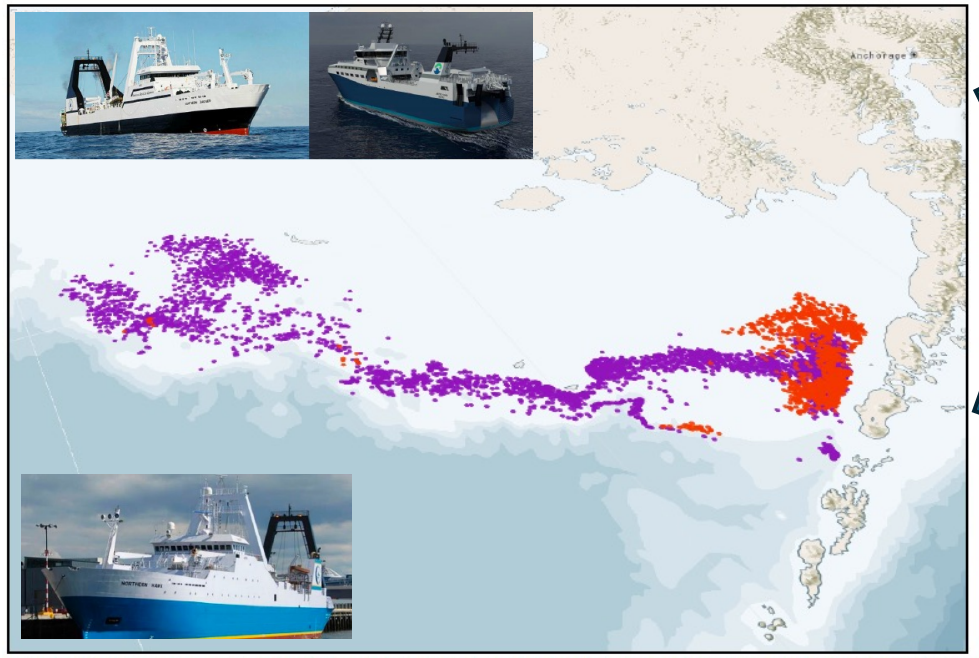
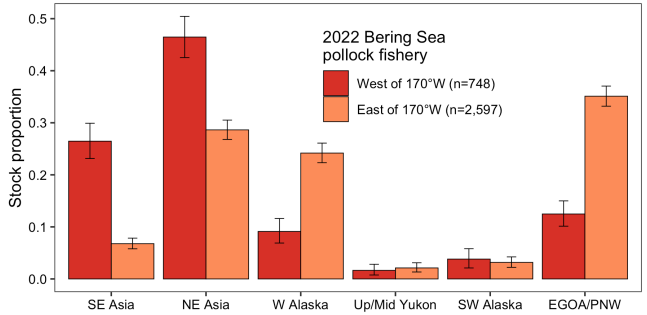


Figure 8. Pollock CP trawl locations between September 1st and February 28th for the years 2008-2010 (blue), 2022-2023 (orange).

Figure source:
AFA Catcher Processor Sector Chinook and Chum Salmon Bycatch
Incentive Plan and Agreement – Annual Report 2022

$P(stock_i)$

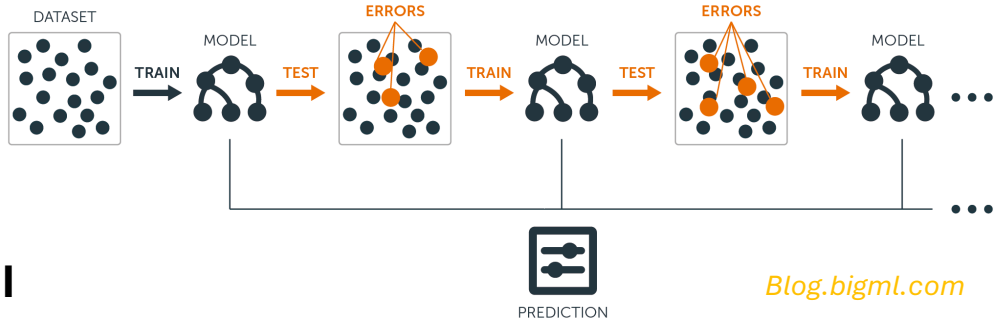
Genetic Stock Composition Estimates from NOAA-ABL Genetics Lab:
Stratified in space and time



Barry et al. (2023)

$\ln(CPUE_i + 1)$

Boosted Regression Trees:
Predict bycatch rate based on climate, environmental and space-time predictors



Funding: AYK-SSI

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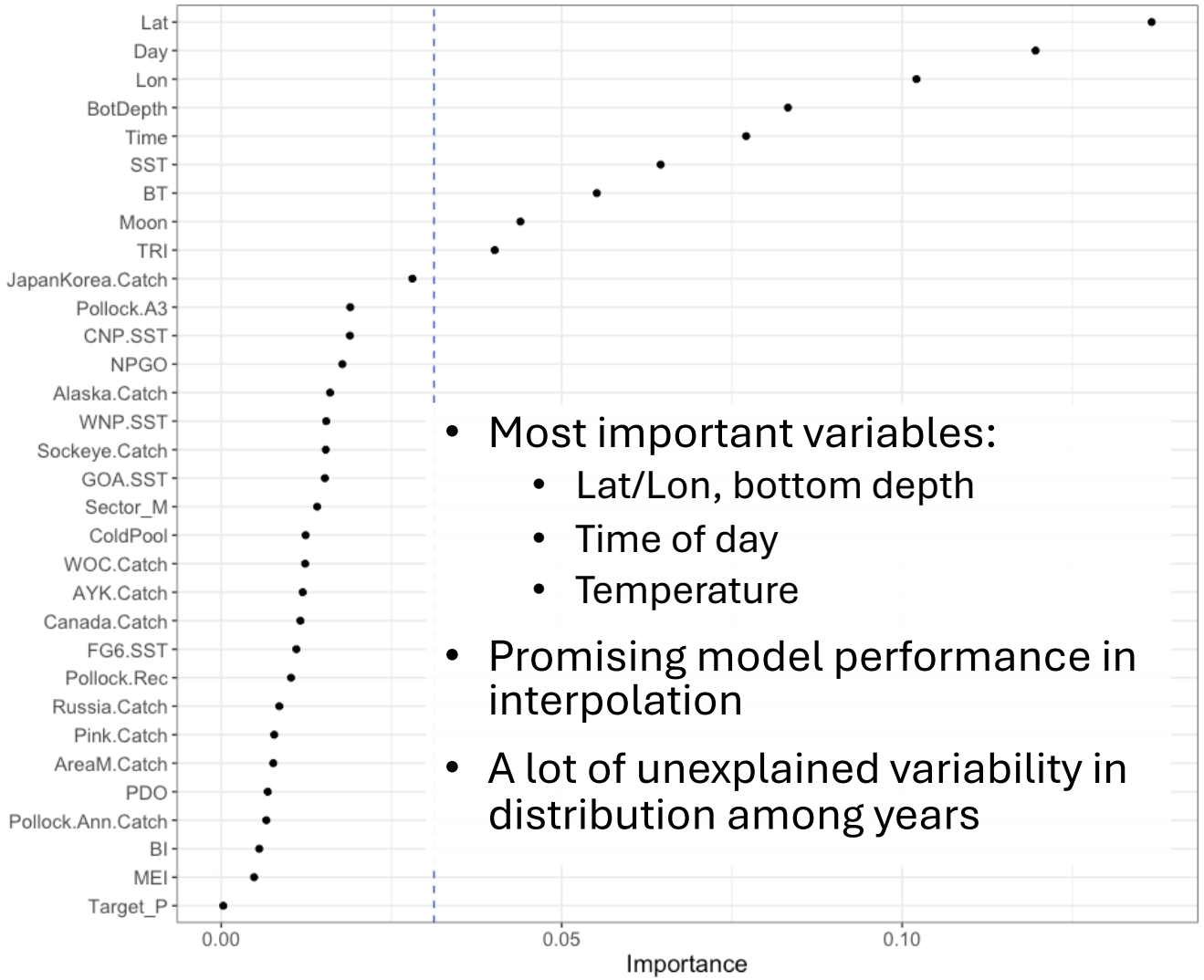
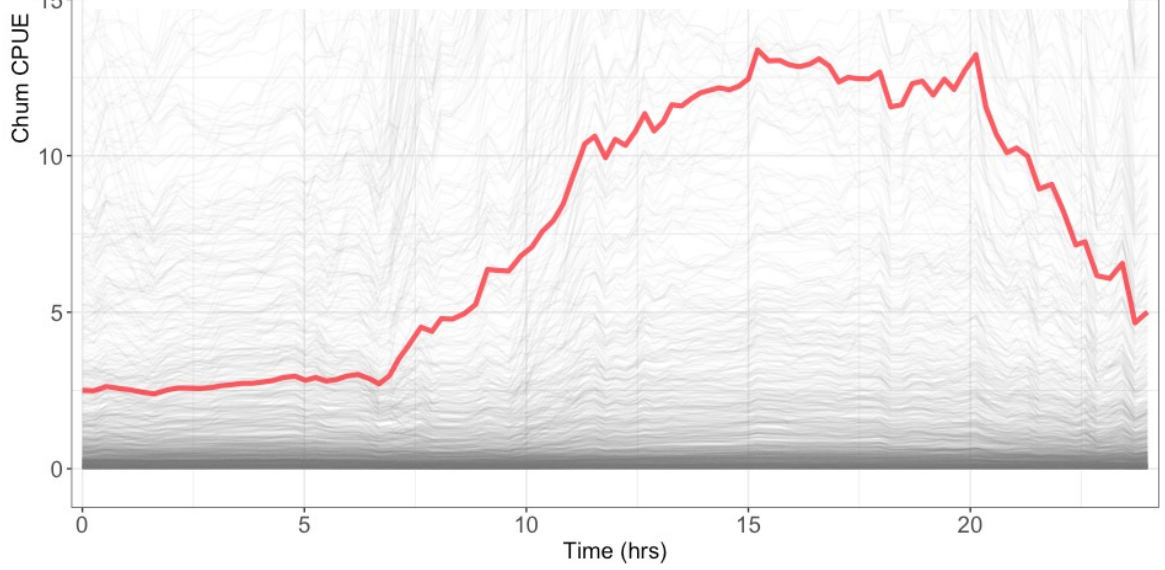
Preliminary Results

Preliminary Results: Covariates



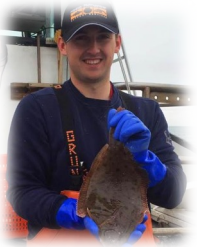
- Most important variables:
  - Lat/Lon, bottom depth
  - Time of day
  - Temperature
- Promising model performance in interpolation
- A lot of unexplained variability in distribution among years

- Model fit suggests low chum bycatch at night
- Matches local knowledge from groundfish fleet
- Likely a result of diel vertical migration behavior associated with feeding



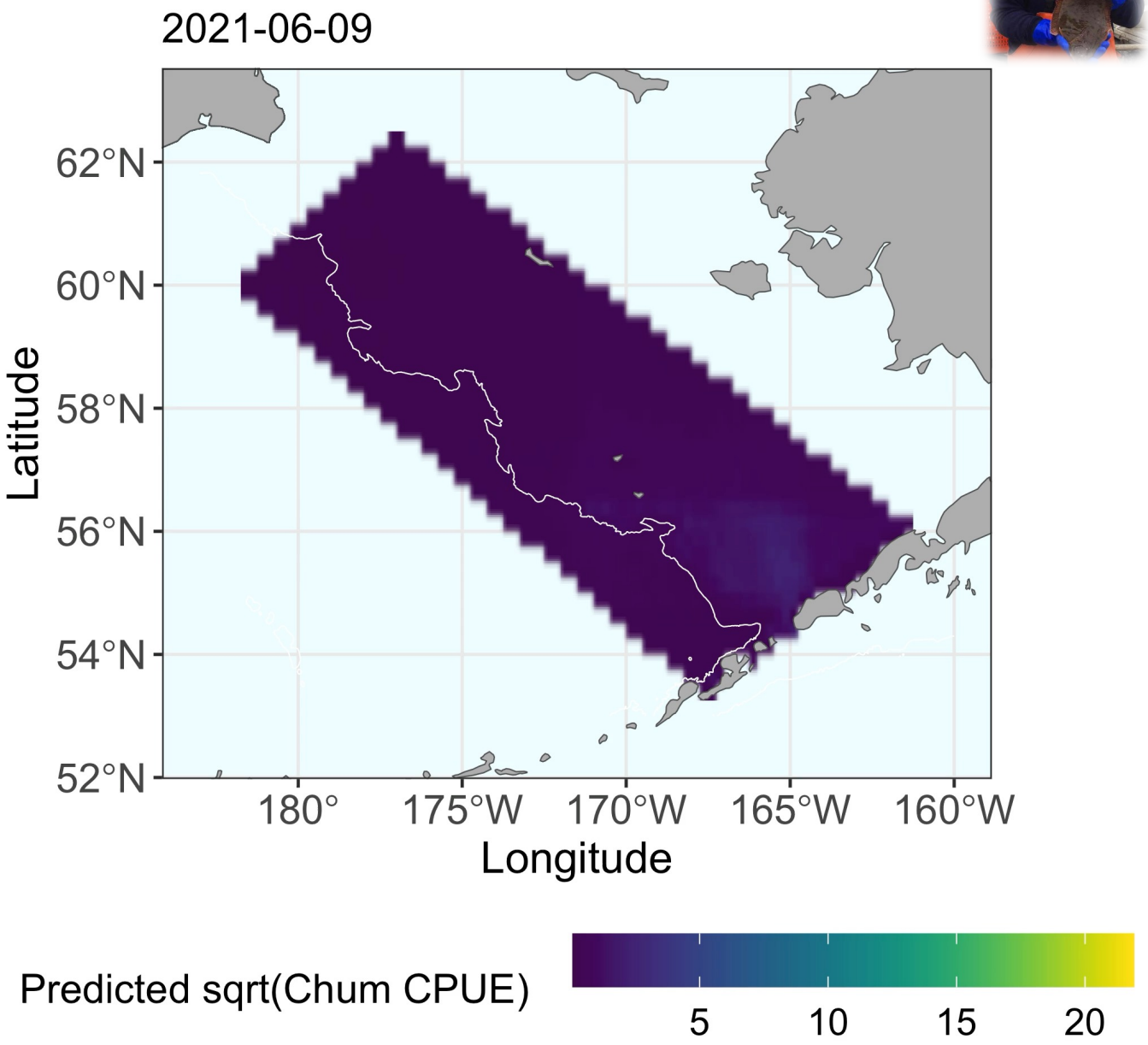
Night Day Night

Preliminary Results

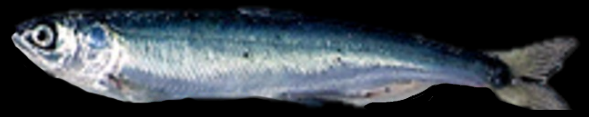


Distribution patterns

- High (relative) abundance near Alaska Peninsula early in the Pollock B Season (summer)
- Chum spread NW up the continental shelf as the season progresses
- Largely follow the shelf break



What is the relative influence of environmental processes and competition on Yukon River Fall Chum salmon survival?



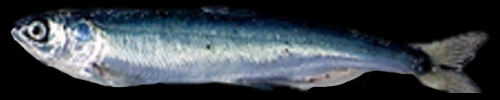
Methods:

Lifecycle model

Estimate **survival** from eggs to juveniles

2. $N_{j,t+1}$: Abundance after first summer at sea (August/Sept)

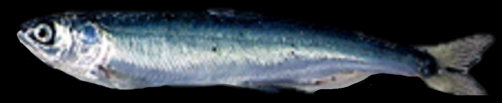
Juvenile Index from Northern Bering Sea surveys
(Data: NOAA/ADFG, Modeled Index: Cunningham, Garcia, et al.)



→ Estimate egg to juvenile survival based on *freshwater* covariates

Methods:
Estimate marine survival

3. $N_{m,t+a+1,a}$: Returning fish abundance
Age structure recruit abundance (ADFG)



2. $N_{j,t+1}$: Juvenile abundance
Juvenile index from Northern Bering Sea surveys (NOAA/ADFG)

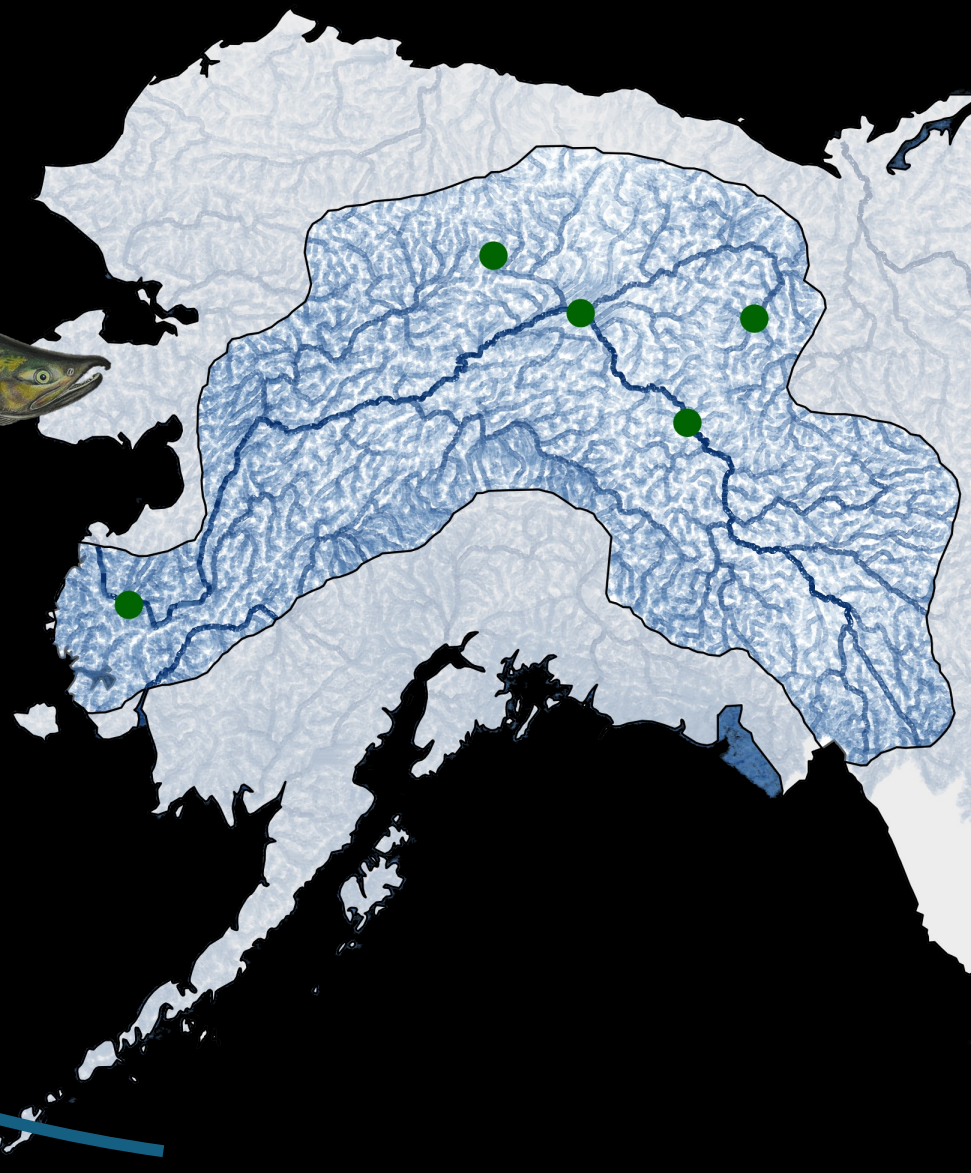
- Estimate **survival** during the first winter at sea
- Include age specific cumulative mortality (Beamish 2018)

Methods:

Estimate age composition, harvest and spawning abundances

5. $N_{s,\ t+a+1,a}$: Spawning abundance

Age structured (ADFG)



4. $N_{h,t+a+1,a}$: Harvest abundance

Age structured (ADFG)

3. $N_{m,t+a+1,a}$: Returning fish abundance

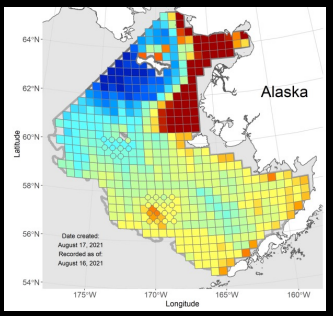
Covariates inform survival estimates

1. Higher **mainstem river discharge** has a **negative** relationship with brood year productivity as it makes foraging more difficult (Neuswanger et al 2015).

- Data: USGS

2. N Bering Sea Summer Cumulative Degree Days slight positive relationship between temperature and juvenile abundance (Farley et al 2024, Agler et al 2013).

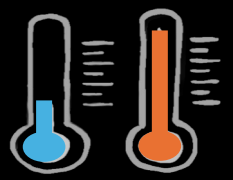
- Data: AKFIN, NOAA



3. **Large zooplankton** provide lipid rich prey. More abundant lipid rich prey may be related to greater **early marine survival** (Murphy et al 2016).

- Index estimated from NBS surveys (data: NOAA & ADFG).

Covariates inform survival estimates

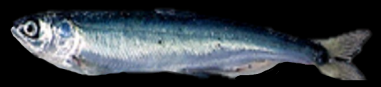


Warm ocean temperatures increase metabolic demand and stress leading to **poor marine survival.**

7. Aleutian temperature during 1st winter

(Data: AKFIN, NOAA)

Better juvenile condition leads to **greater marine survival.**



6. "Juvenile fullness index"

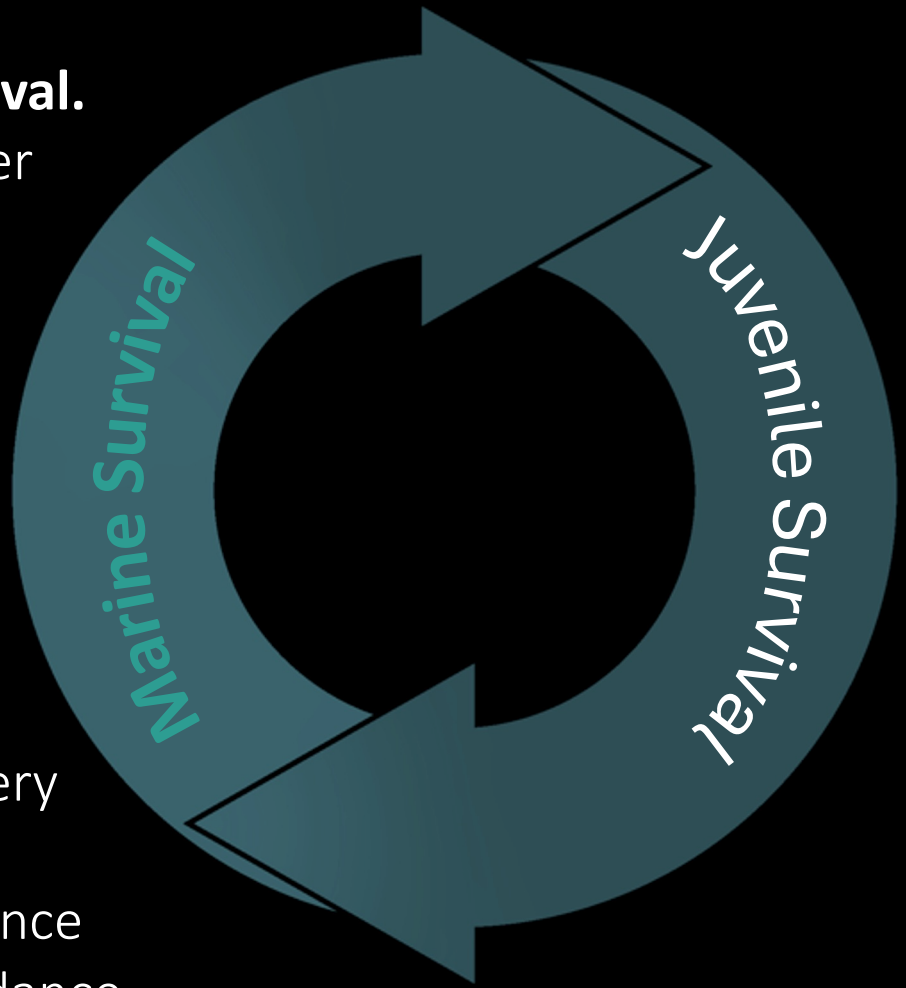
(Estimated from NBS surveys, data: NOAA & ADFG).

Increased competition at sea via hatchery production **decreases marine survival.**

4. Pink hatchery salmon abundance

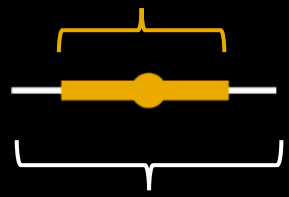
5. Chum hatchery salmon abundance

(Data: NPAFC)

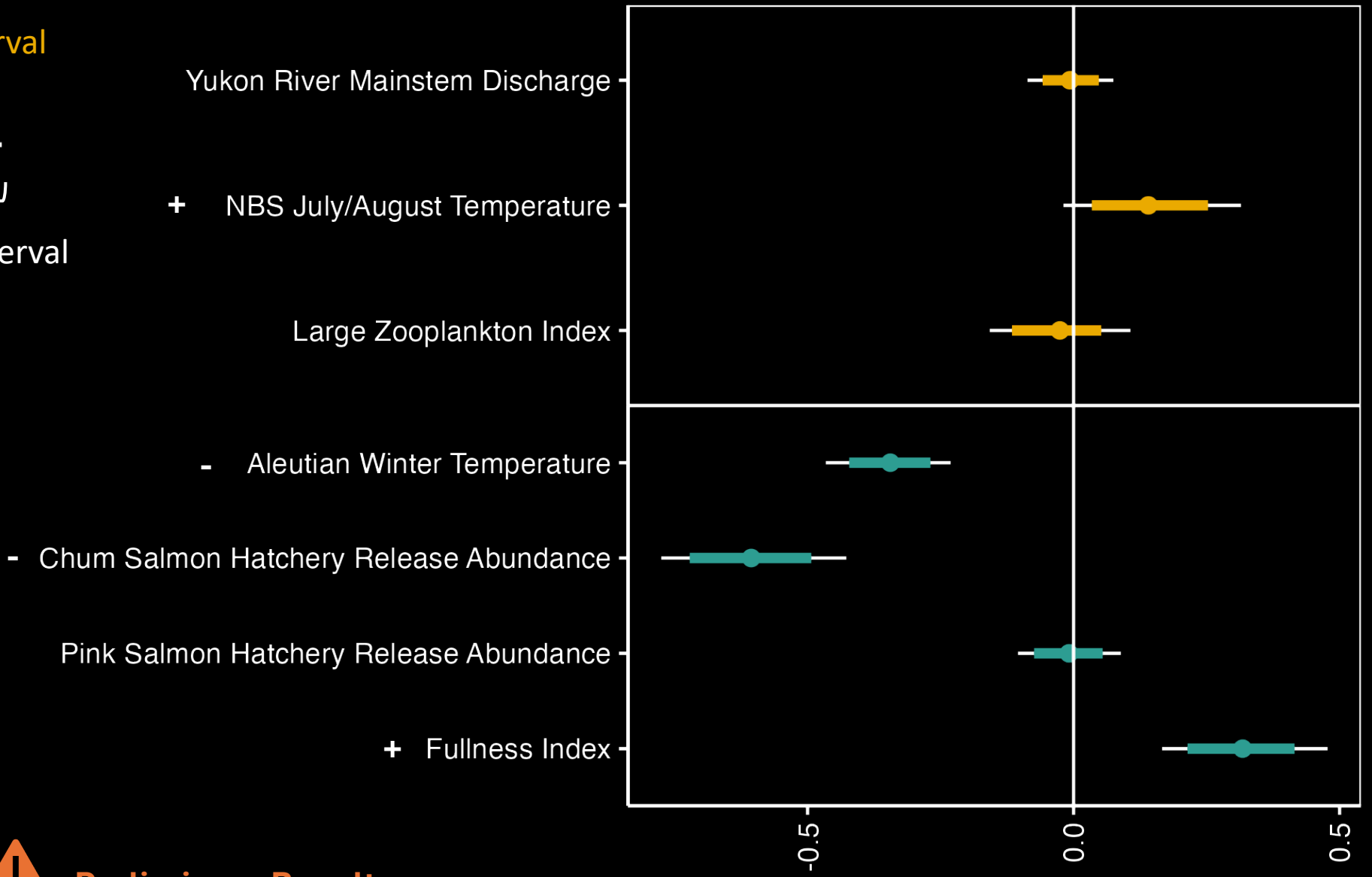


Marine density dependence and environmental change impact Chum salmon survival

80% credible interval



95% credible interval



Preliminary Results

Thank you for your interest!

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Opening the black box: New insights into the role of temperature in the marine distributions of Pacific salmon

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