Integrating US and Canadian marine data to identify region-specific limiting factors across a transboundary salmon migration

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Mapping Vulnerabilities to Climate Change

NOAA Fisheries assessed the vulnerability of 33 population groups* of Pacific salmon & steelhead to climate change along the West Coast.

Number & Risk Level of Population Groups

Chinook	5 5 1	
Coho	1 4	
Chum	1 2	
Sockeye	1 1	
Steelhead	6 5	
Pink	1	

Vulnerability

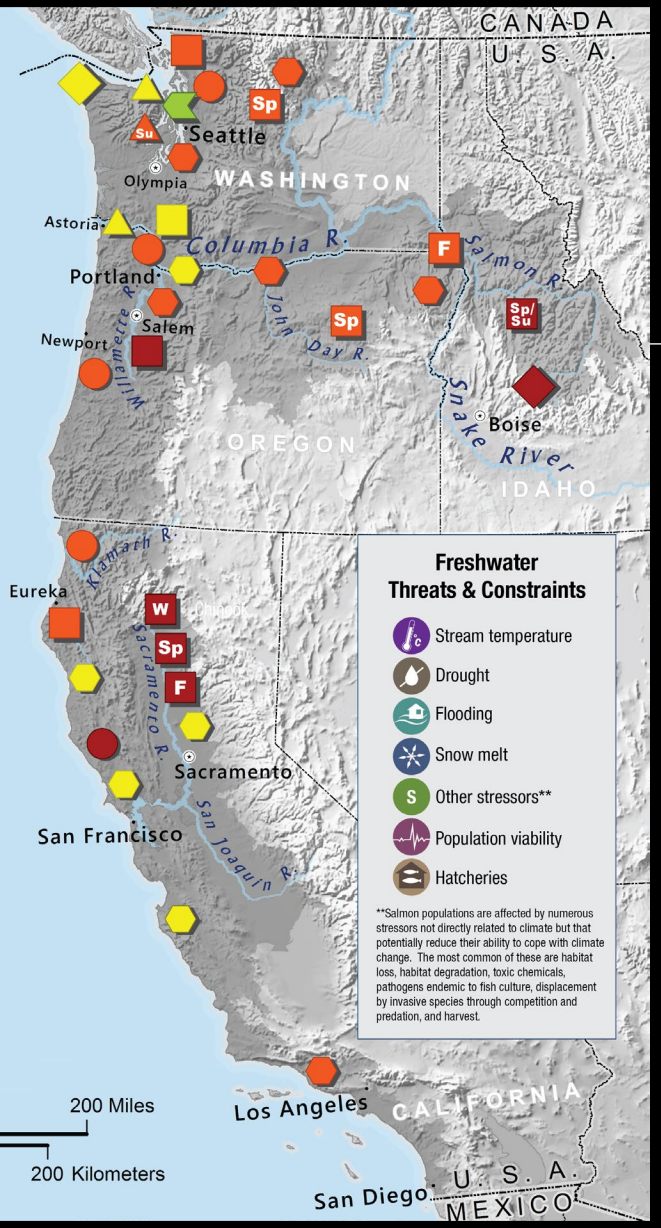
Very High — High — Moderate — Low

F = fall run
W = winter run
Sp = spring run
Sp/Su = spring/summer run
Su = summer run

*Population groups refer to distinct population segments (DPS) & evolutionarily significant units (ESU).

Marine Threats

- Sea surface temperature
- Ocean acidification
- Sea level rise
- Upwelling



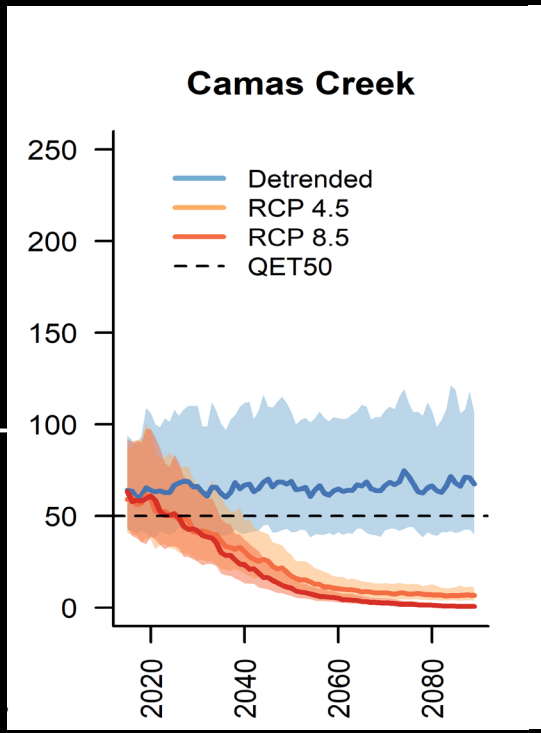
Freshwater Threats & Constraints

- Stream temperature
- Drought
- Flooding
- Snow melt
- Other stressors**
- Population viability
- Hatcheries

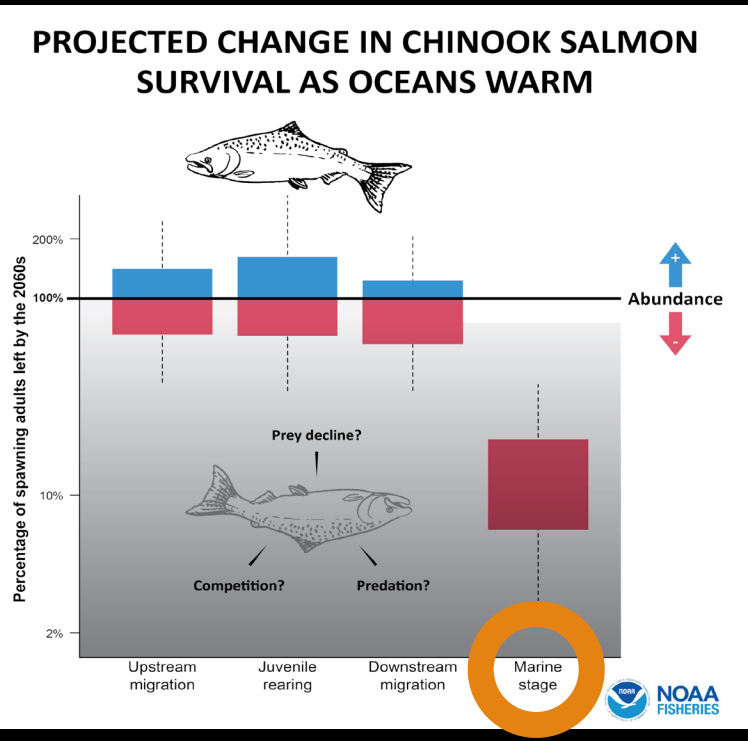
**Salmon populations are affected by numerous stressors not directly related to climate but that potentially reduce their ability to cope with climate change. The most common of these are habitat loss, habitat degradation, toxic chemicals, pathogens endemic to fish culture, displacement by invasive species through competition and predation, and harvest.

NOAA FISHERIES

Many species were already endangered, and climate change compounds threat – particularly the marine stage of spring Chinook salmon



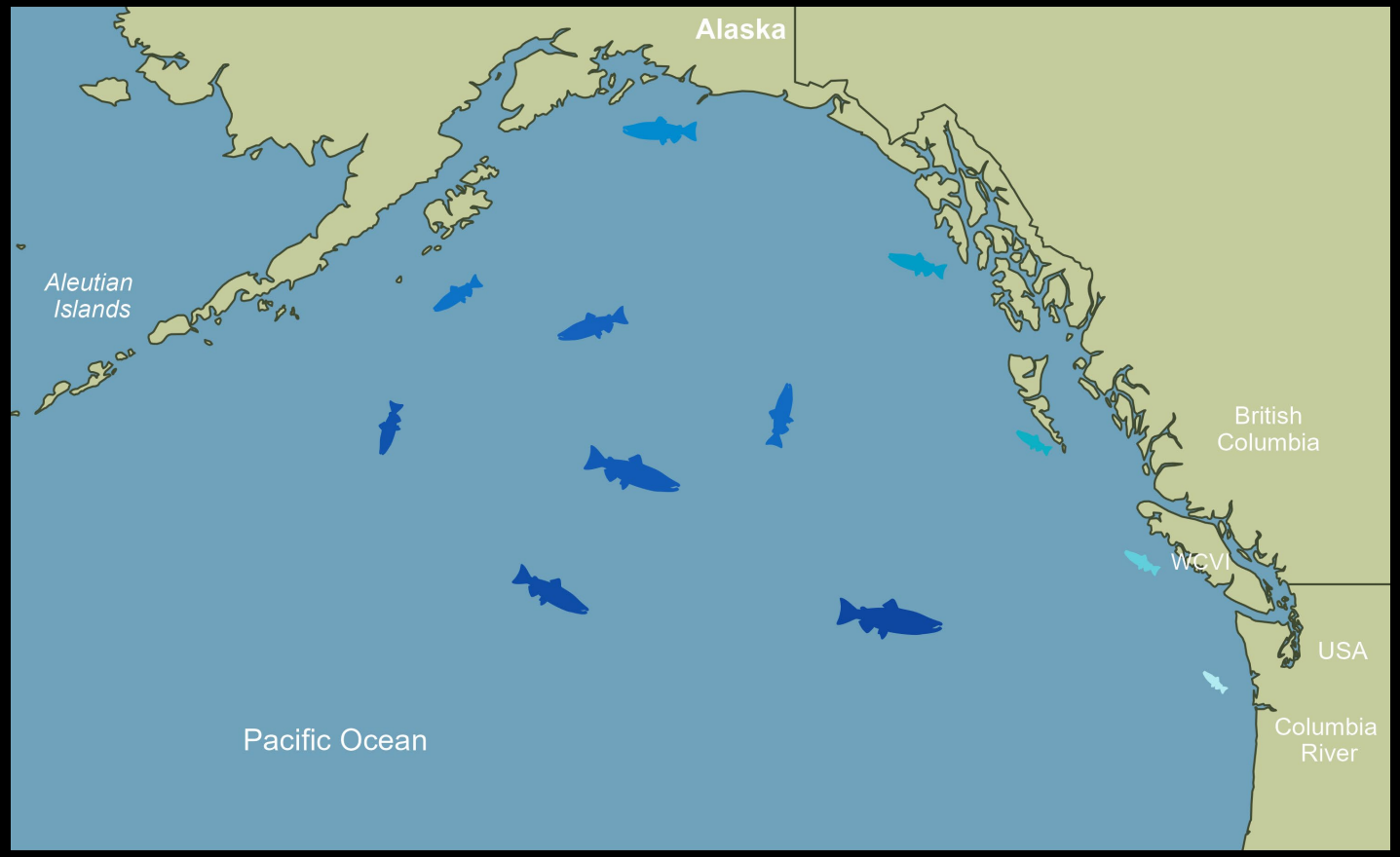
Winter/spr PDO/SSTarc
Burke et al 2025:
CMISST r^2~ 0.5-0.6



Crozier, et al (2021)
https://doi.org/210.1038/s42003-42021-01734-w



Snake River/ Upper Columbia Spring Chinook 1-3yr in ocean



Snake River/ Upper Columbia Spring Chinook 1-3yr in ocean

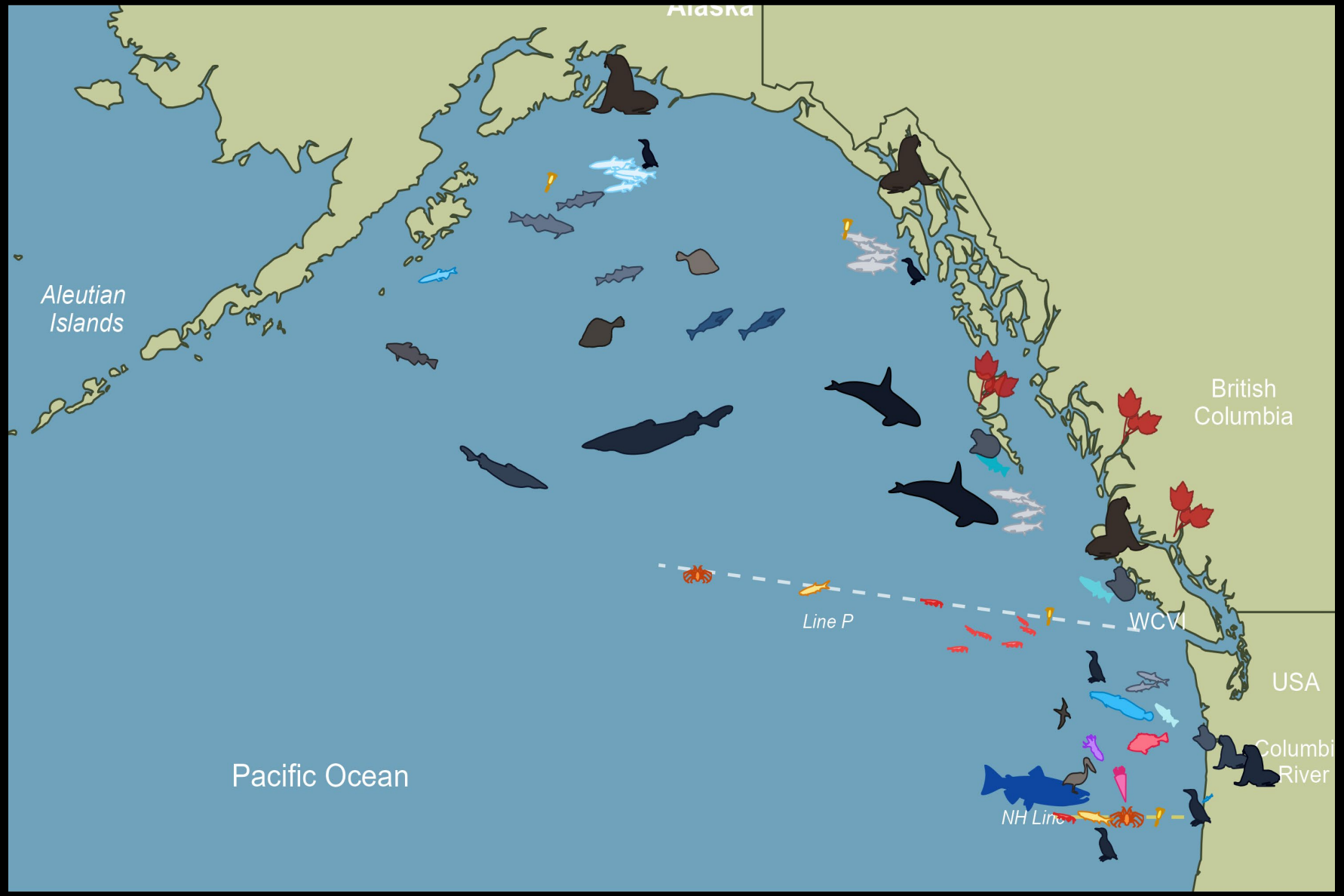
Final model

133 indicators
27 sub-guilds
(latent variables, e.g., pisciv. birds in NCC)
6 trophic/region nodes

AK: 35 series

BC: 37 series

WA: 83 series



Structural Equation Model Approach

H1

Early marine stage:

<June smolt mig yr
Data from
JSOES survey

PreyNCC

PredatorsNCC

Marine Growth Rate
(IGF + stomach fullness
or fork length)

Early Marine Survival
(cpue June JSOES survey +
sdmTMB modeled abundance)

Smolt to Adult Return
(BON-BON, pittagged SR+UC)

Late marine stage:

>June smolt mig yr
Data from
BC/AK surveys
Columbia River mammals

PreyAK

PredatorsAK



JSOES survey 2025

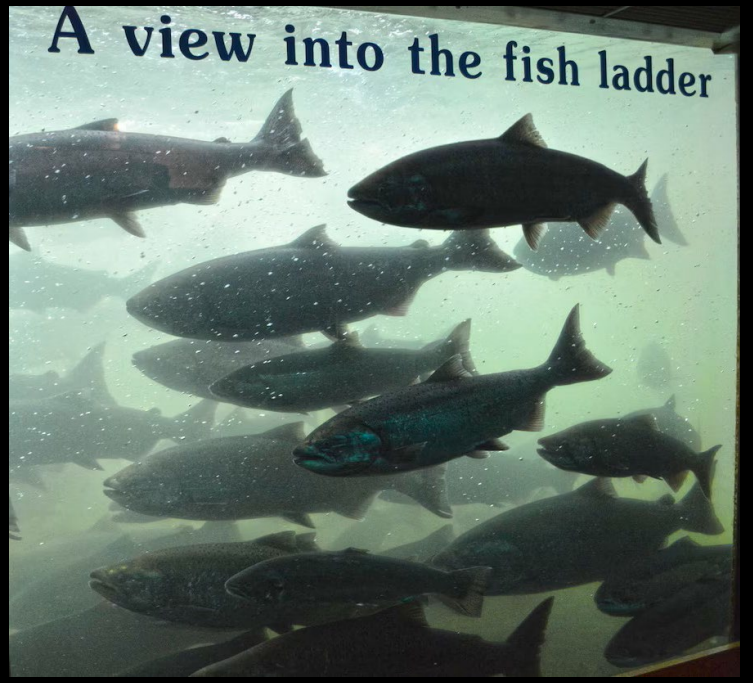


Photo: usace.army.mil

Structural Equation Model Approach

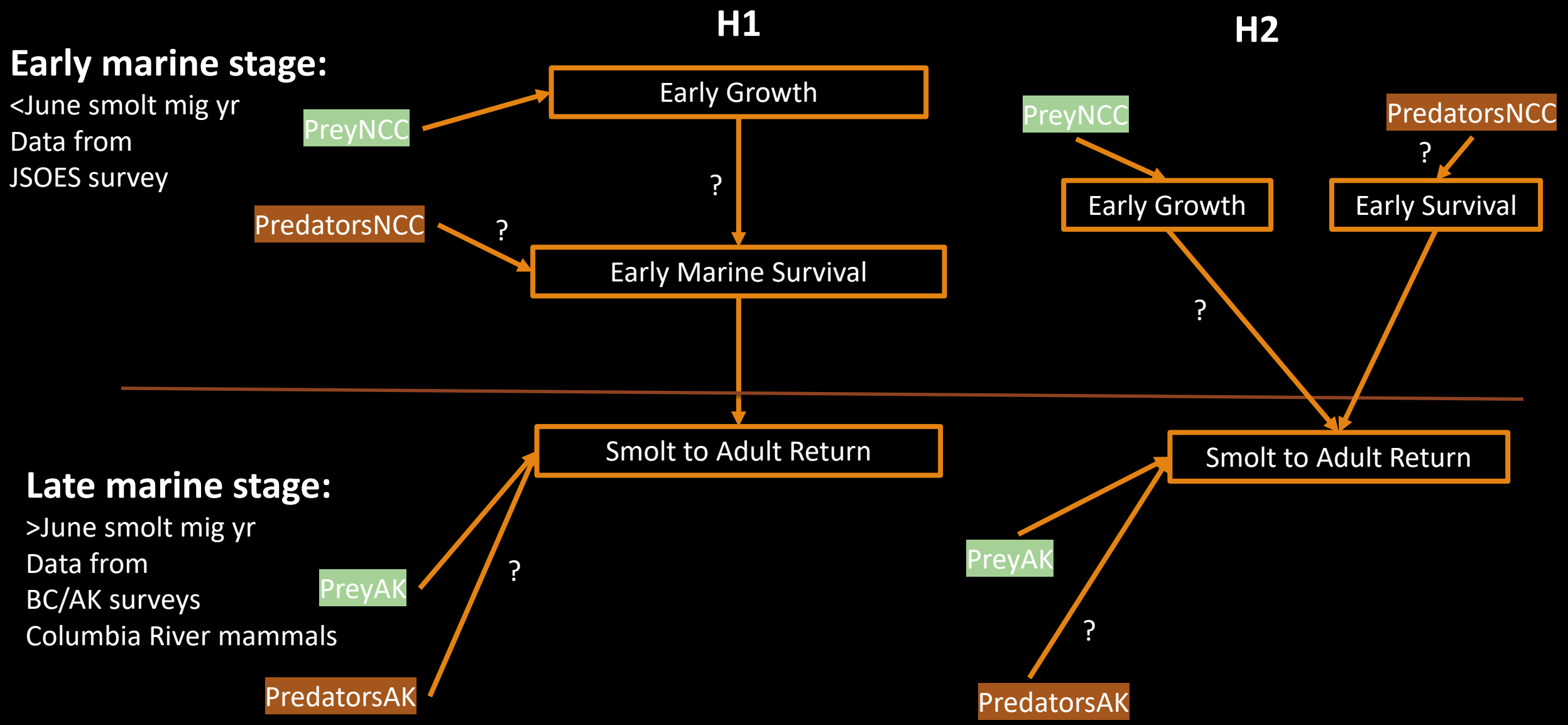


Photo: usace.army.mil

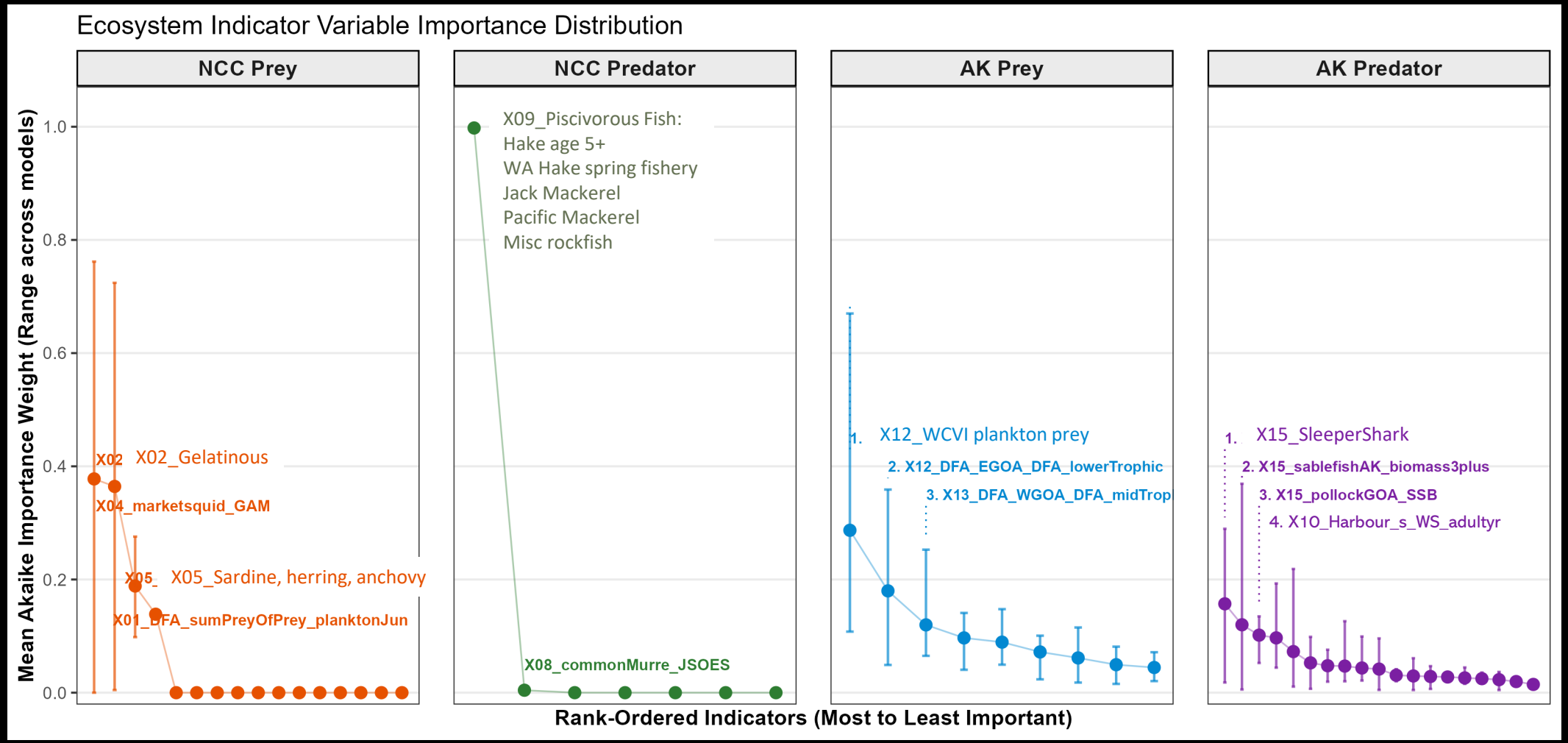
Goals

Identify viable models to reduce the number of candidate indices

Test hypotheses:

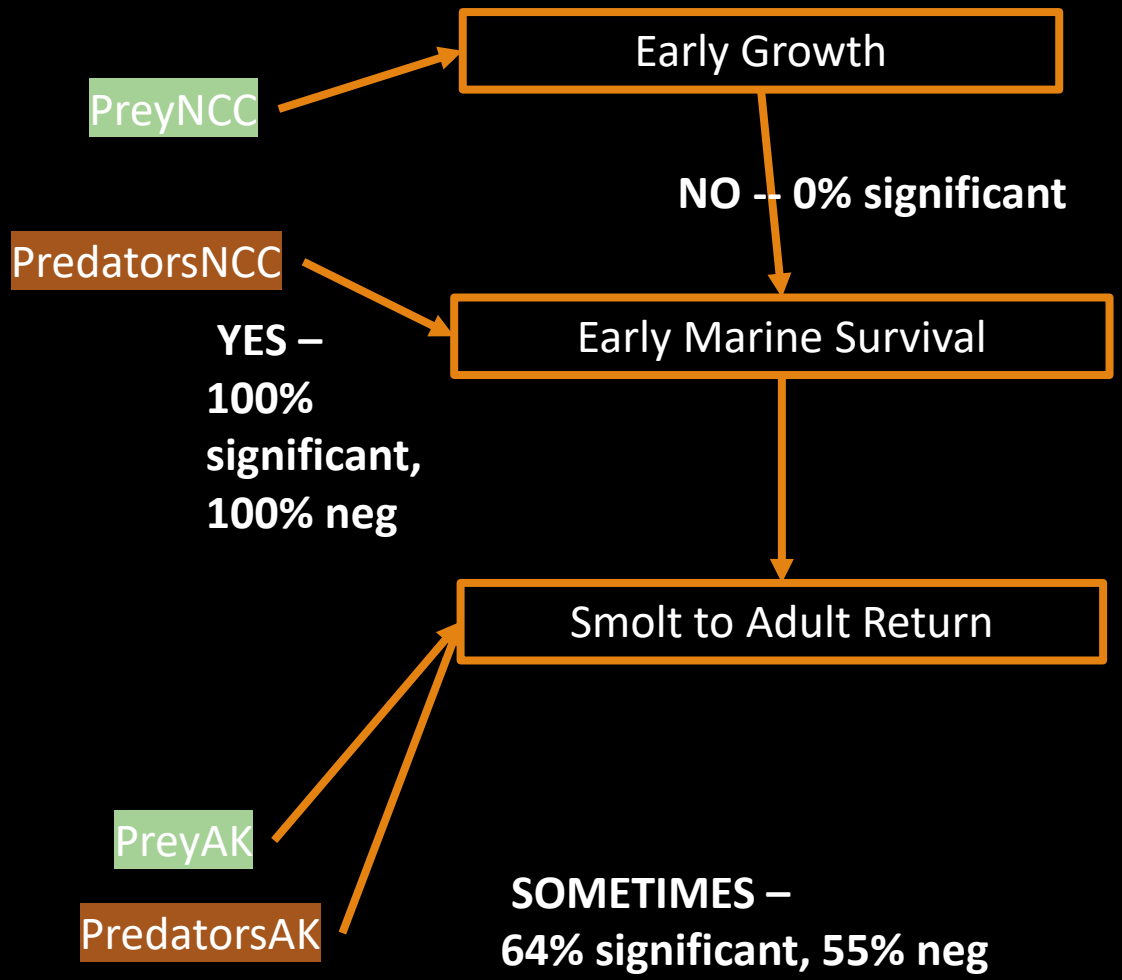
Bigger is better (bottom-up regulation)	Predator abundance drives salmon survival (top-down regulation)	Conditions modulate predator impact (top-down modulated)

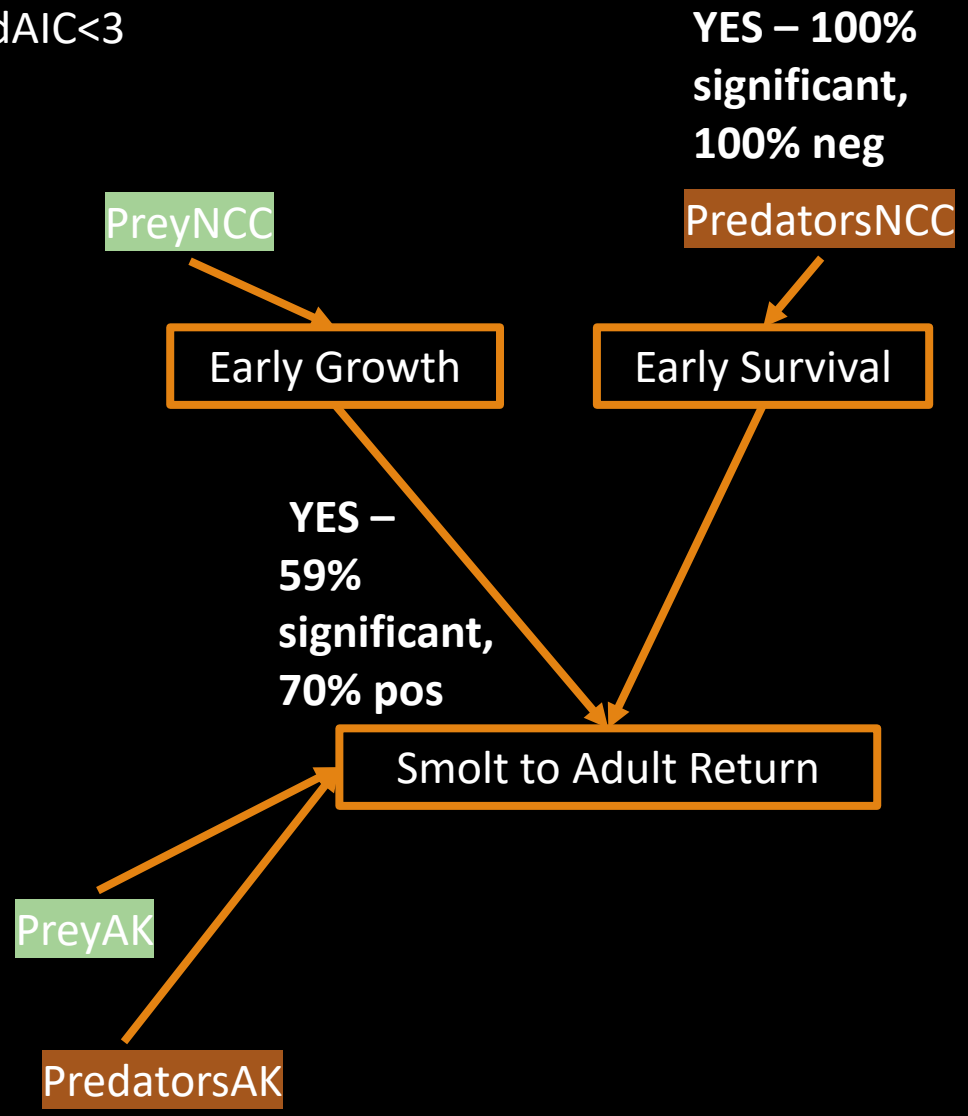
Goal 1 – YES!!!
A few predictors dominated results



Goal 2 regulation hypo -- sometimes

Summary of coefficients in all models with dAIC<3





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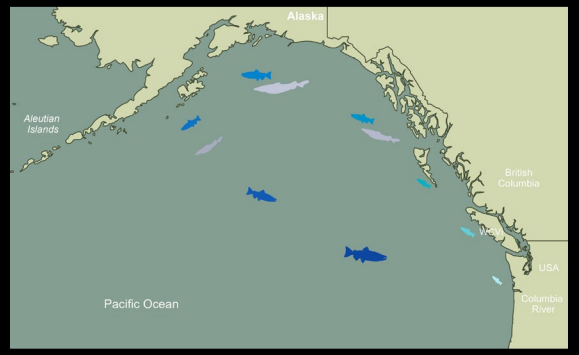
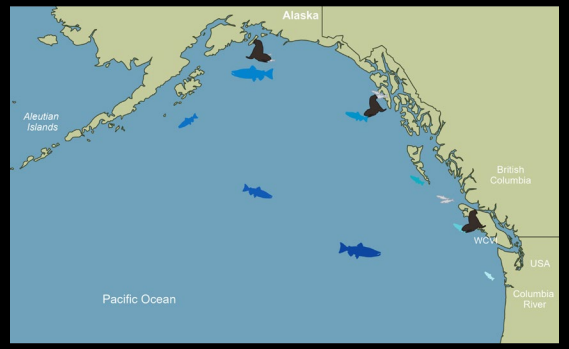




H1: temperature->spatial overlap





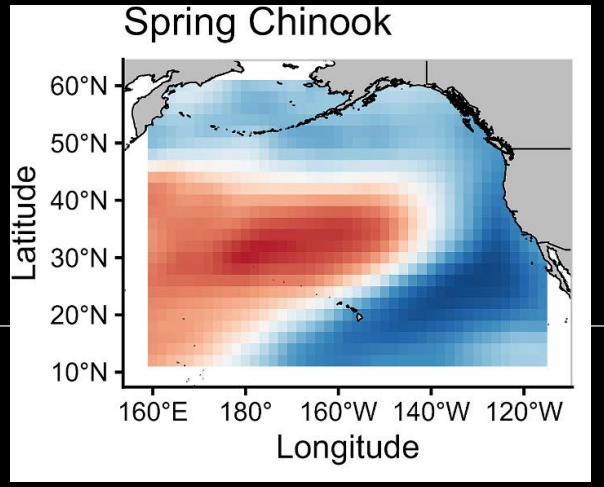
H2: alternate prey->prey switching

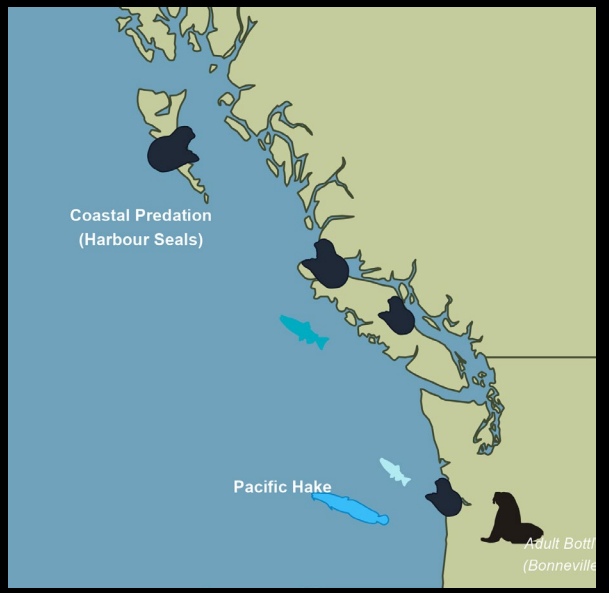
Goal 3

Explore modulated predator impacts

Results – multiple candidate models







Next steps: refine models (plausibility, spatial specificity), extend to individual SEM (freshwater effects, Eve Pugsley, UW)

CONCLUSIONS

BENEFITS OF REGIONAL SURVEYS & DATA SHARING

- Allows characterization of WA coast, WCVI, BC coast, and AK species interactions
- Improved “limiting factor” identification, despite regional correlations
- DFAs often combine data from different regions that were + and - correlated –> more questions!!!

AK PREDATORS EXPLAIN SUBSTANTIAL VARIATION IN SALMON SURVIVAL

- Experiments and more insights needed to prove causal relationships

Thank you – DFO/NMFS Climate and Fisheries Collaboration Pacific working group membership!

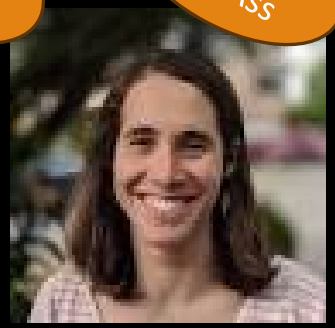


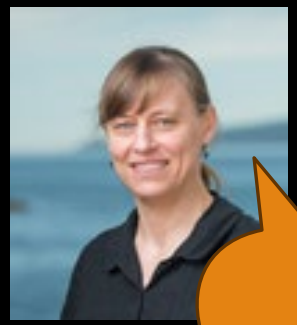


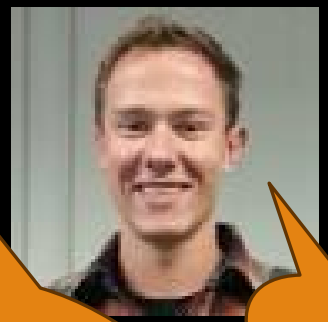











Groundfish /dogfish

DFO Juv salmon survey

Climate Vuln Ass

AK ESR DFAs

Mammal models

AK ESR

ocean data wrangler

Pacea R Pkg

Co-author, bird/mammal data wrangler

MOM ocean projections

Int Pelagic survey Herring data

Salmon and sablefish

BCCM ocean model incl CFS

Co-author, data wrangler

AK salmon surveys

AK larval fish

Researchers on JSOES, NHL, Hake, Coastal Pelagic Surveys,WCGFS, mammals (ODFW, WDFW, ACOE) and birds (Yaq., WA, AK)