Temperature effects on patterns of prey occurrence in Gulf of Alaska groundfish diets

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Kerim Aydin, Jon Reum, Kirstin Holsman

University of Washington
School of Marine and Environmental Affairs
NOAA Alaska Fisheries Science Center

PHOTO: NOAA FISHERIES

BACKGROUND
Temperature Shifts

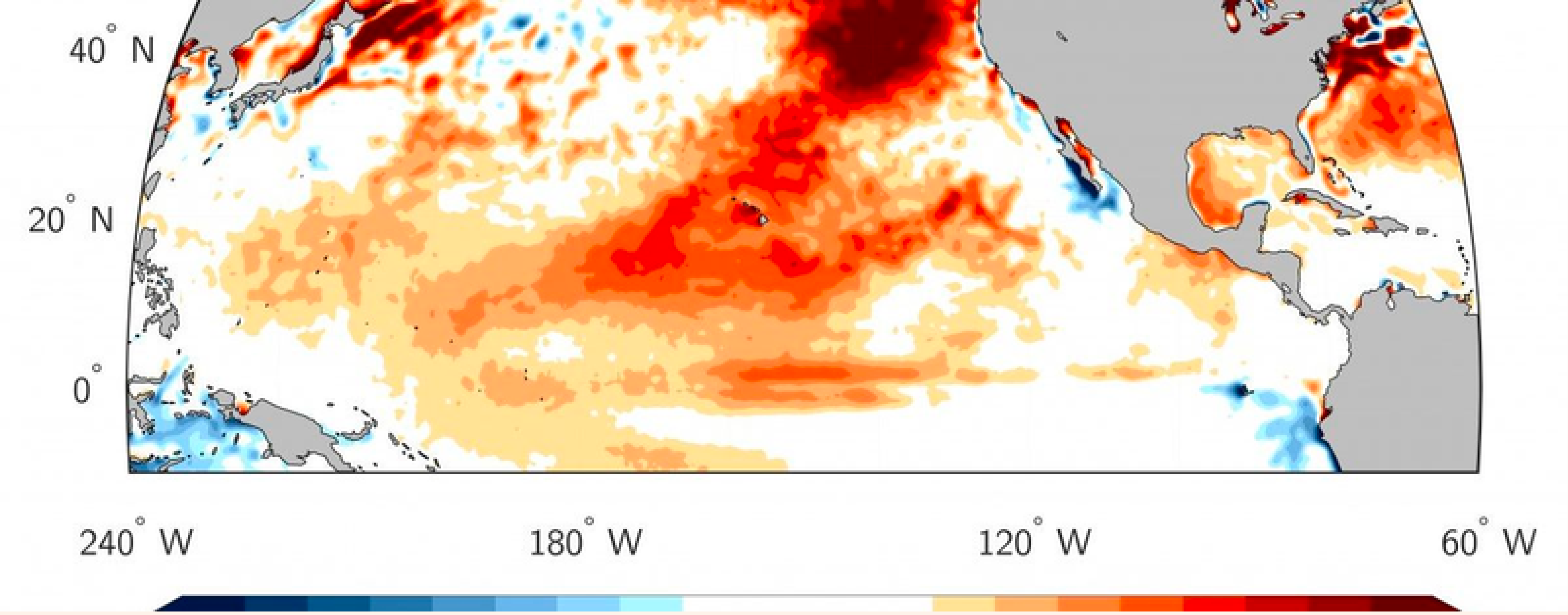

PHOTO: DILLON AMAYA

1976:
REGIME SHIFT

Period of warming led to shift from crustacean to groundfish dominated.

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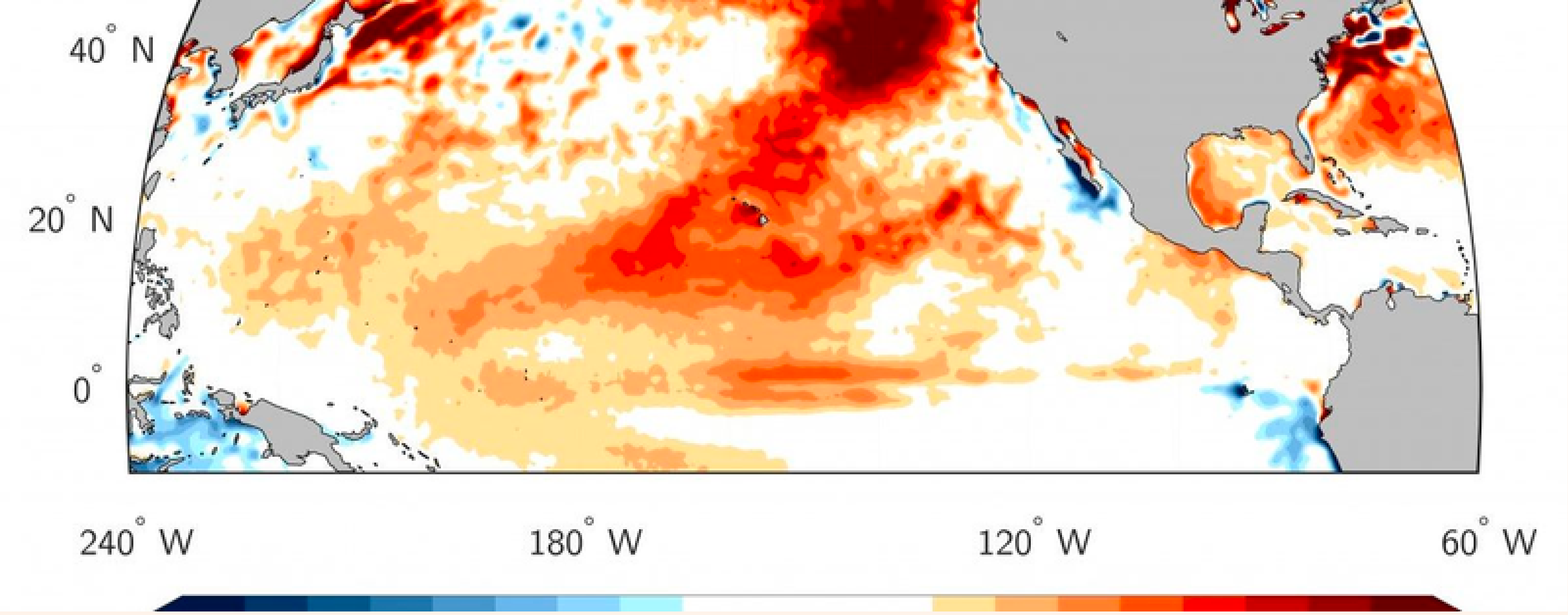

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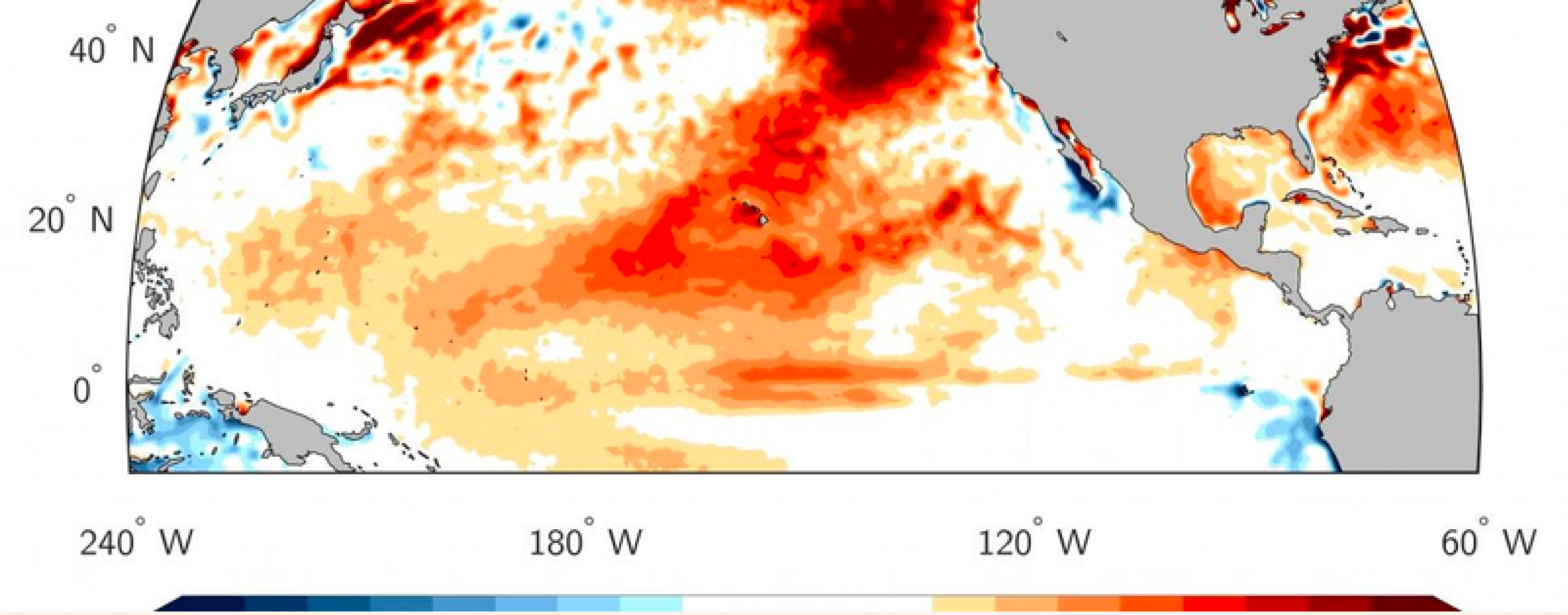

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The MHW was long lasting, and the re-intensification may cause compounding effects.

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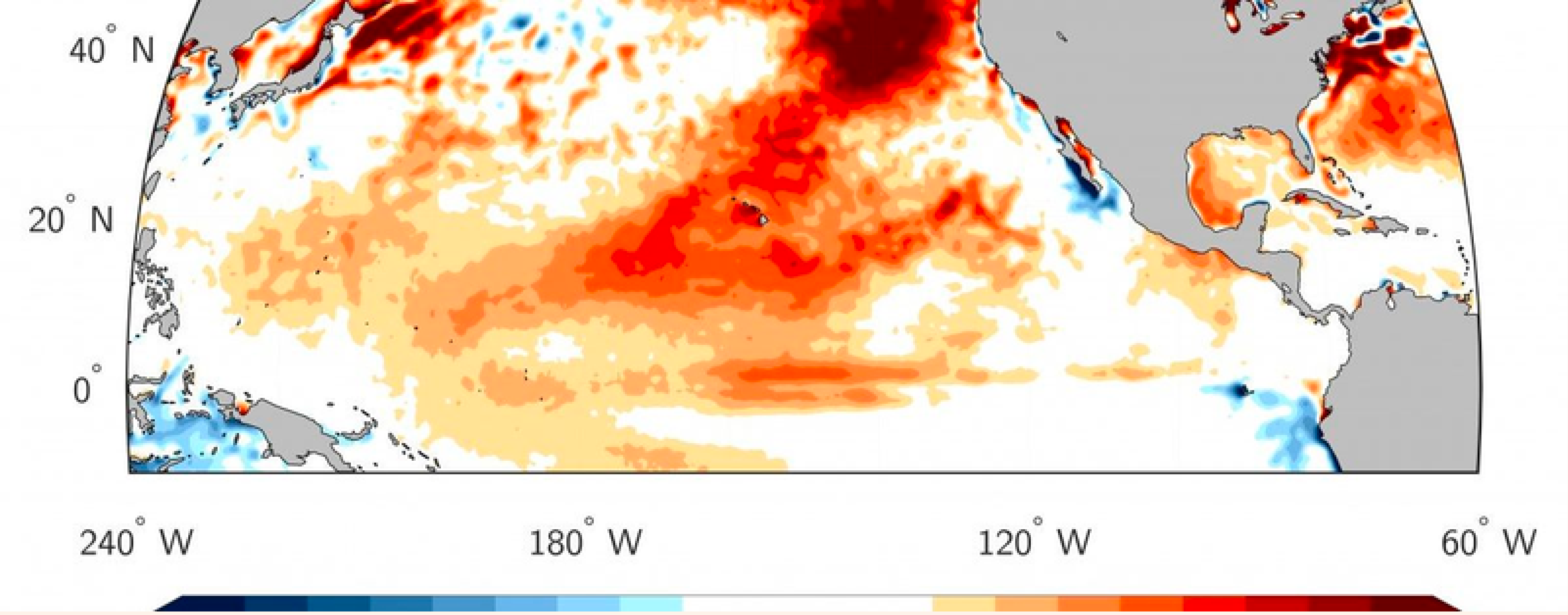

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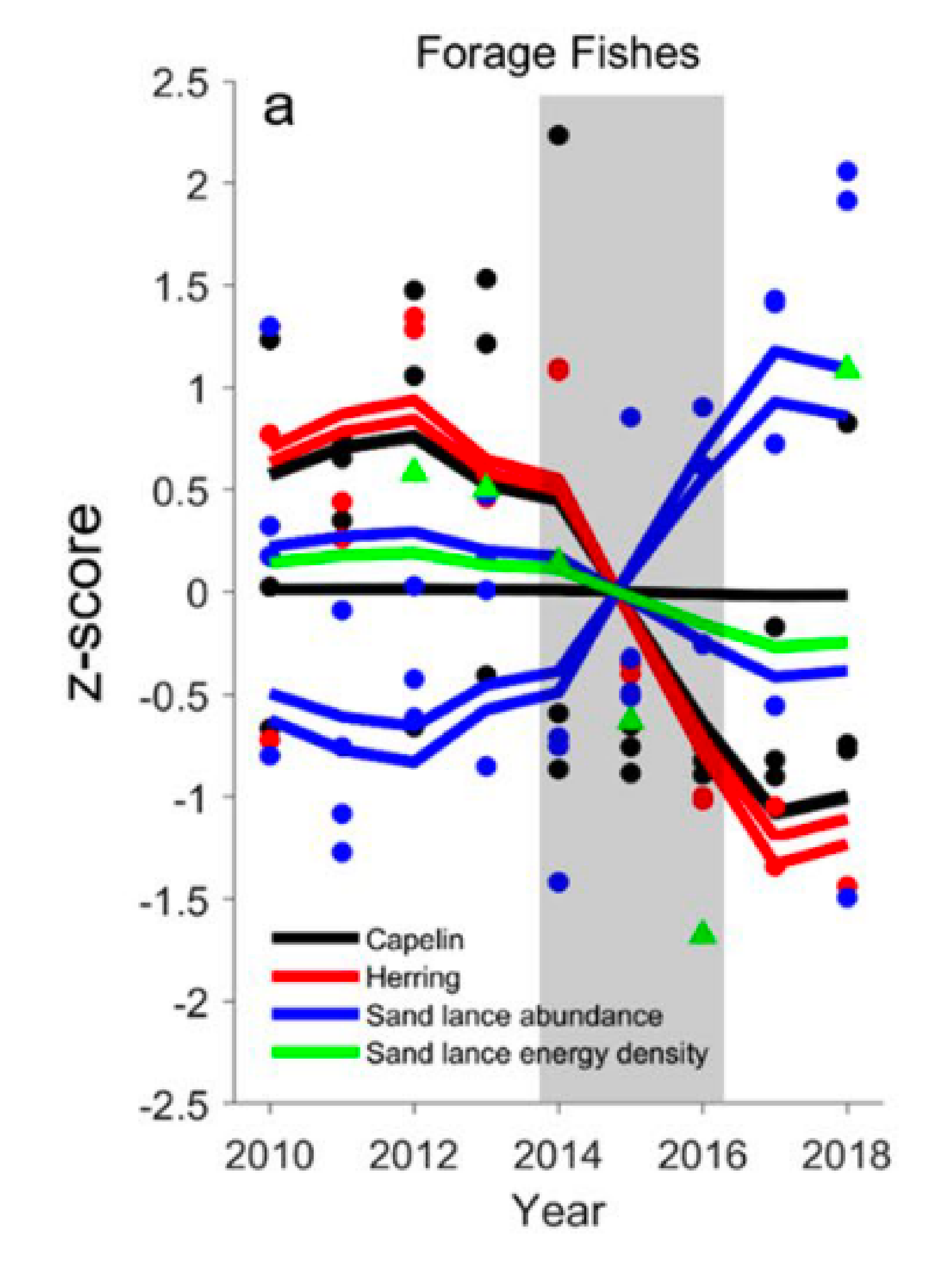
FUTURE OCEANS

The Gulf of Alaska is warming rapidly due to climate change, and extreme temperature events are becoming more common.

BACKGROUND
Insight through diets

Suryan et al. 2021

- Declines in forage fish (capelin and herring) within seabird diets.



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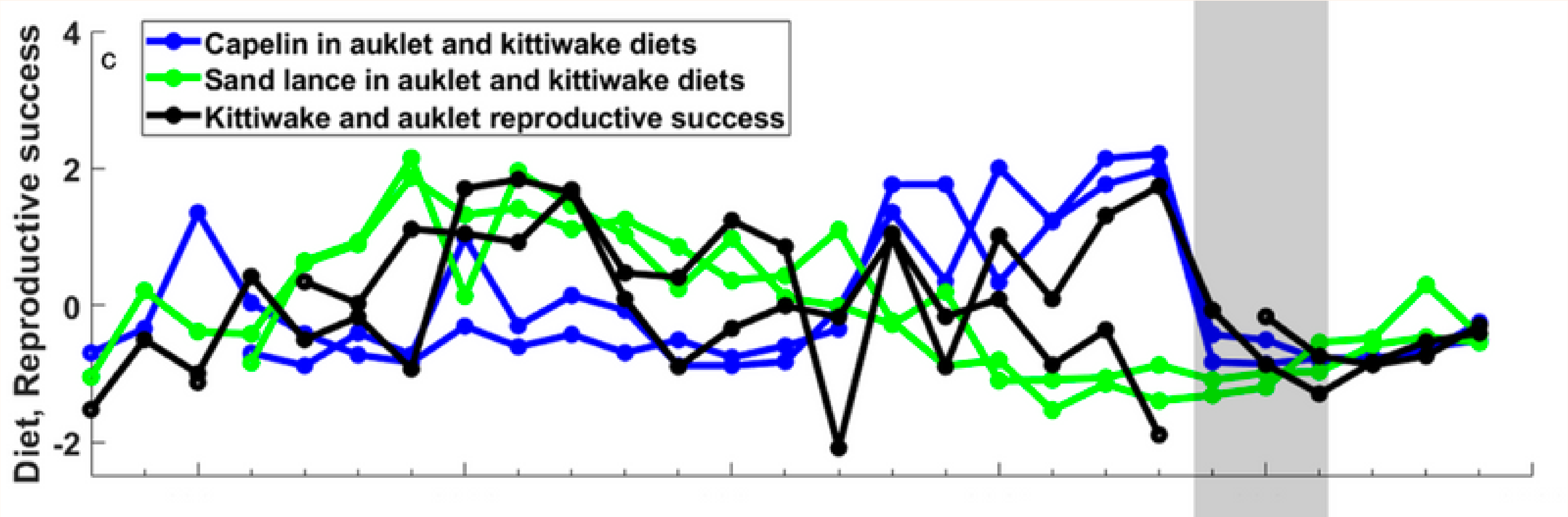

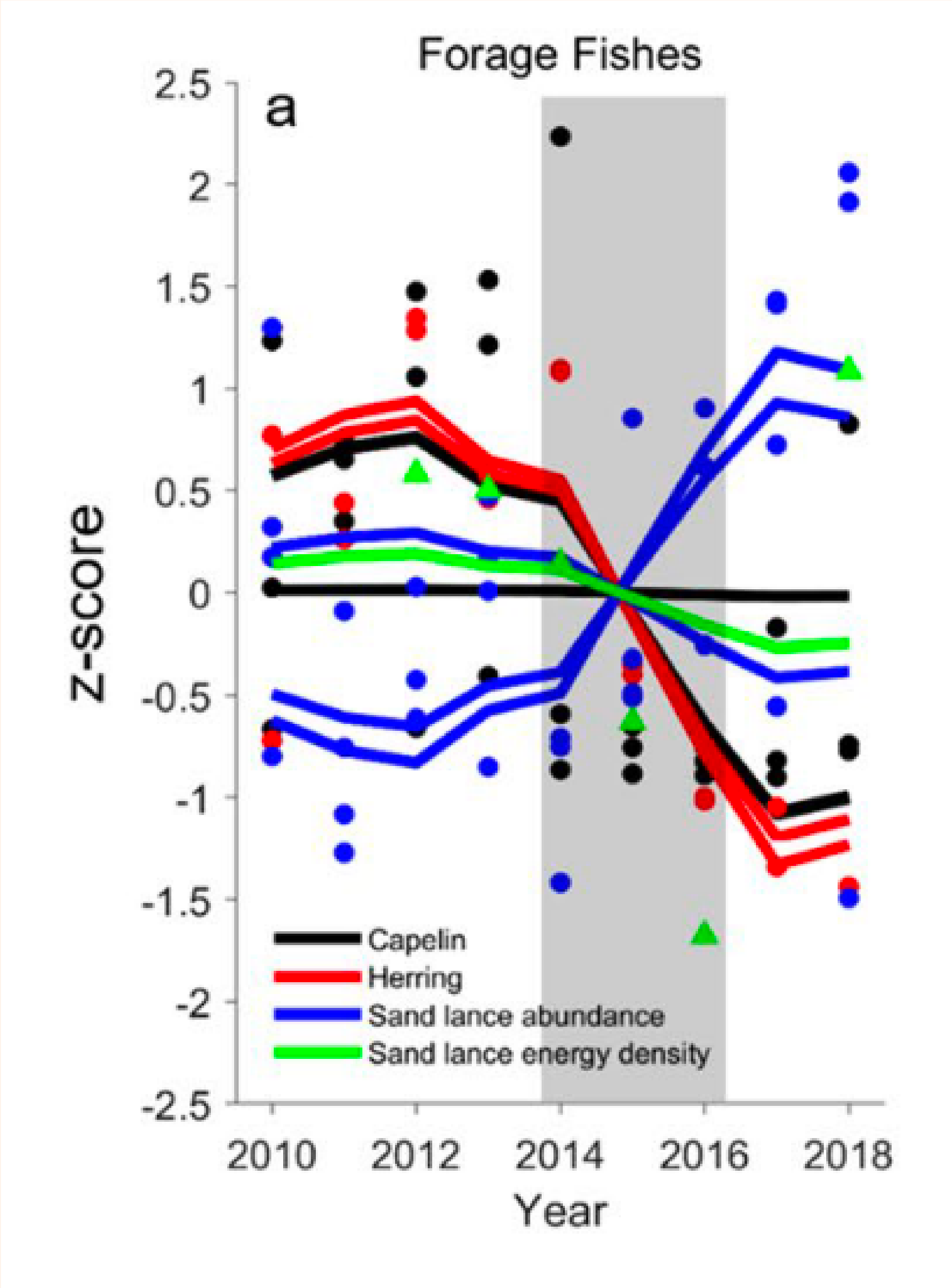

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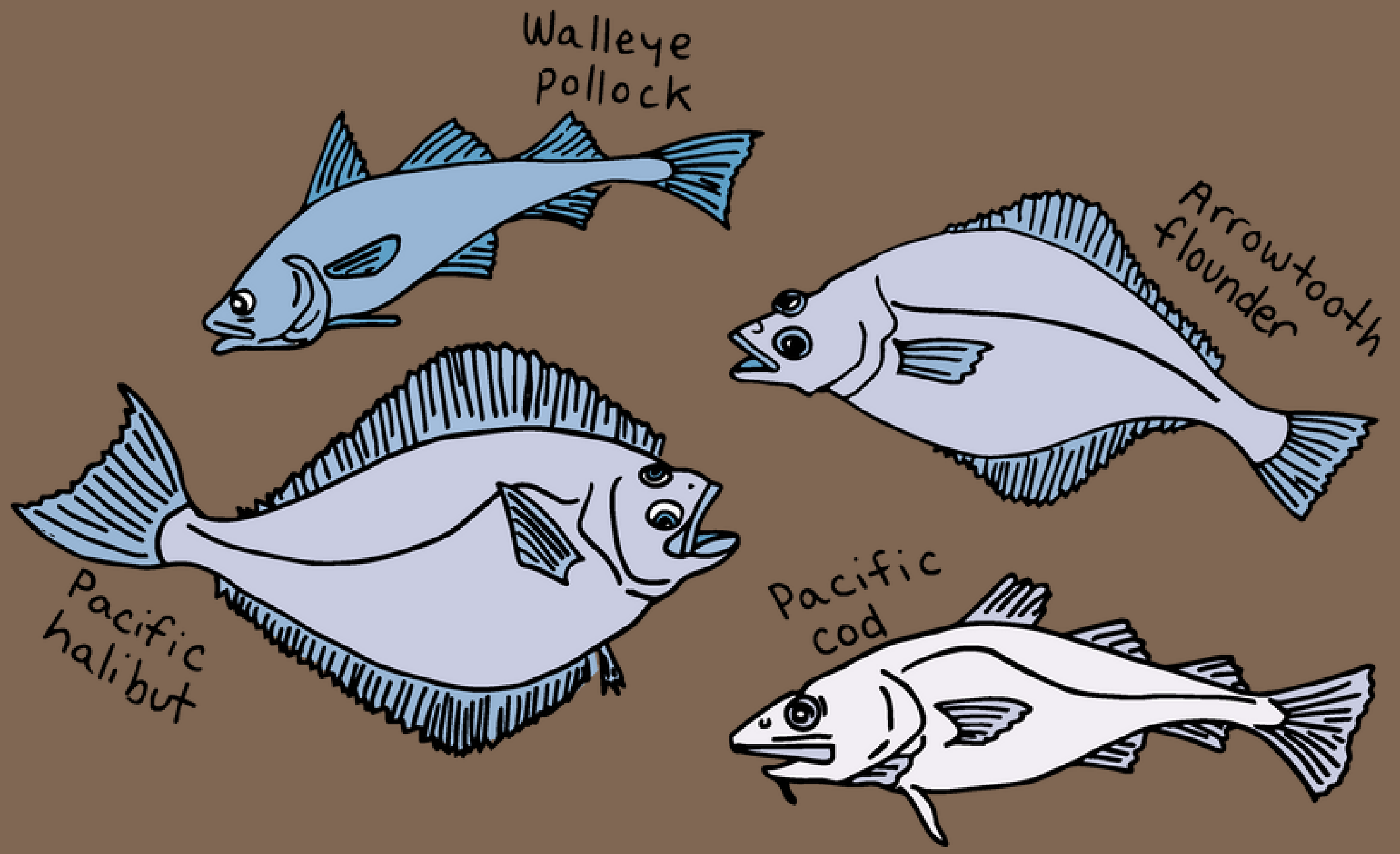
Groundfish Diets



- **How do temperature shifts affect groundfish predation and diets?**
  - Spatiotemporal mismatch between predators and prey
  - Bioenergetics changes lead to altered nutritional demands
  - Mortality events lead to prey switching

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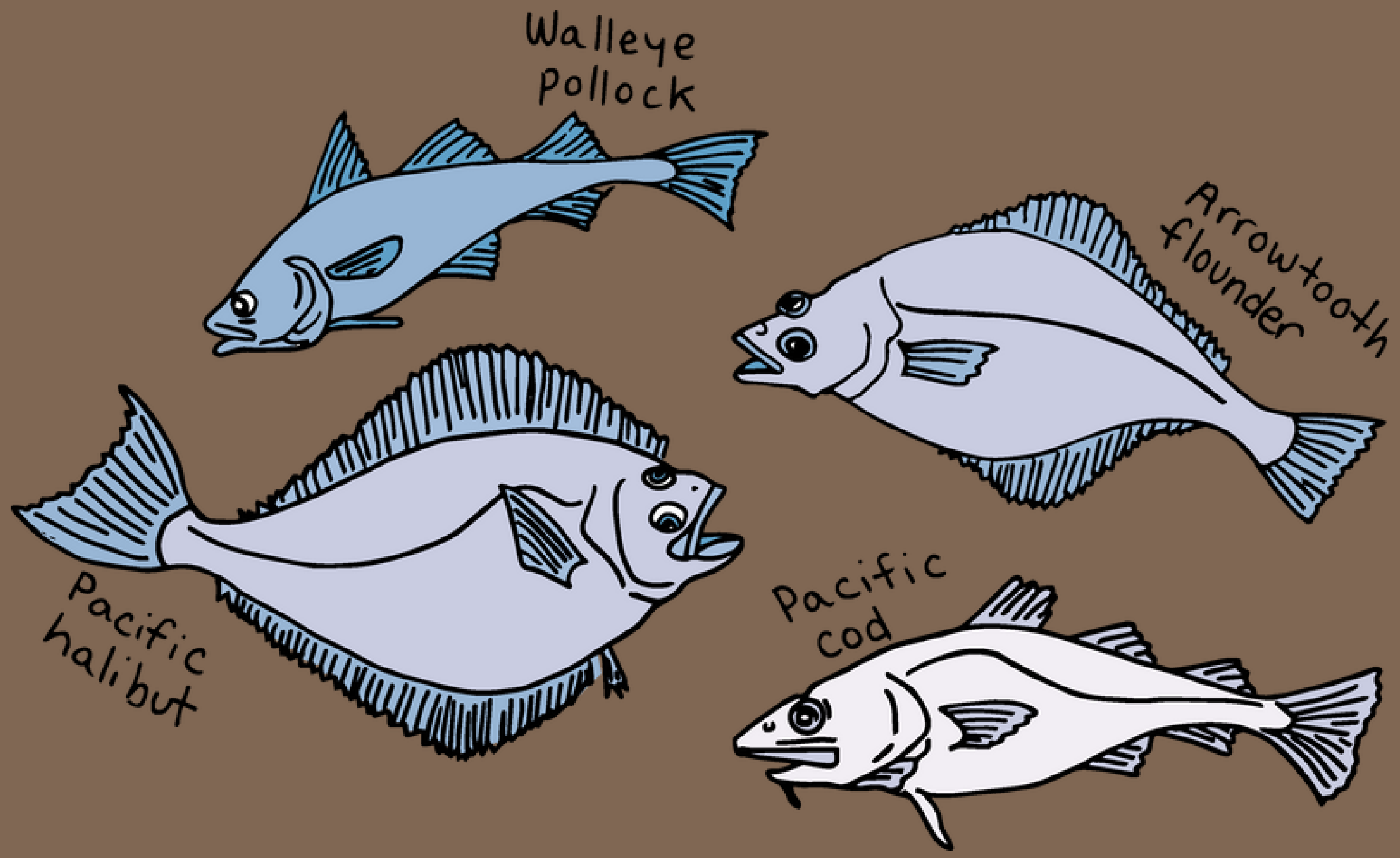

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  - NOAA Resource Ecology and Ecosystem Modeling (REEM) GOA bottom trawl surveys

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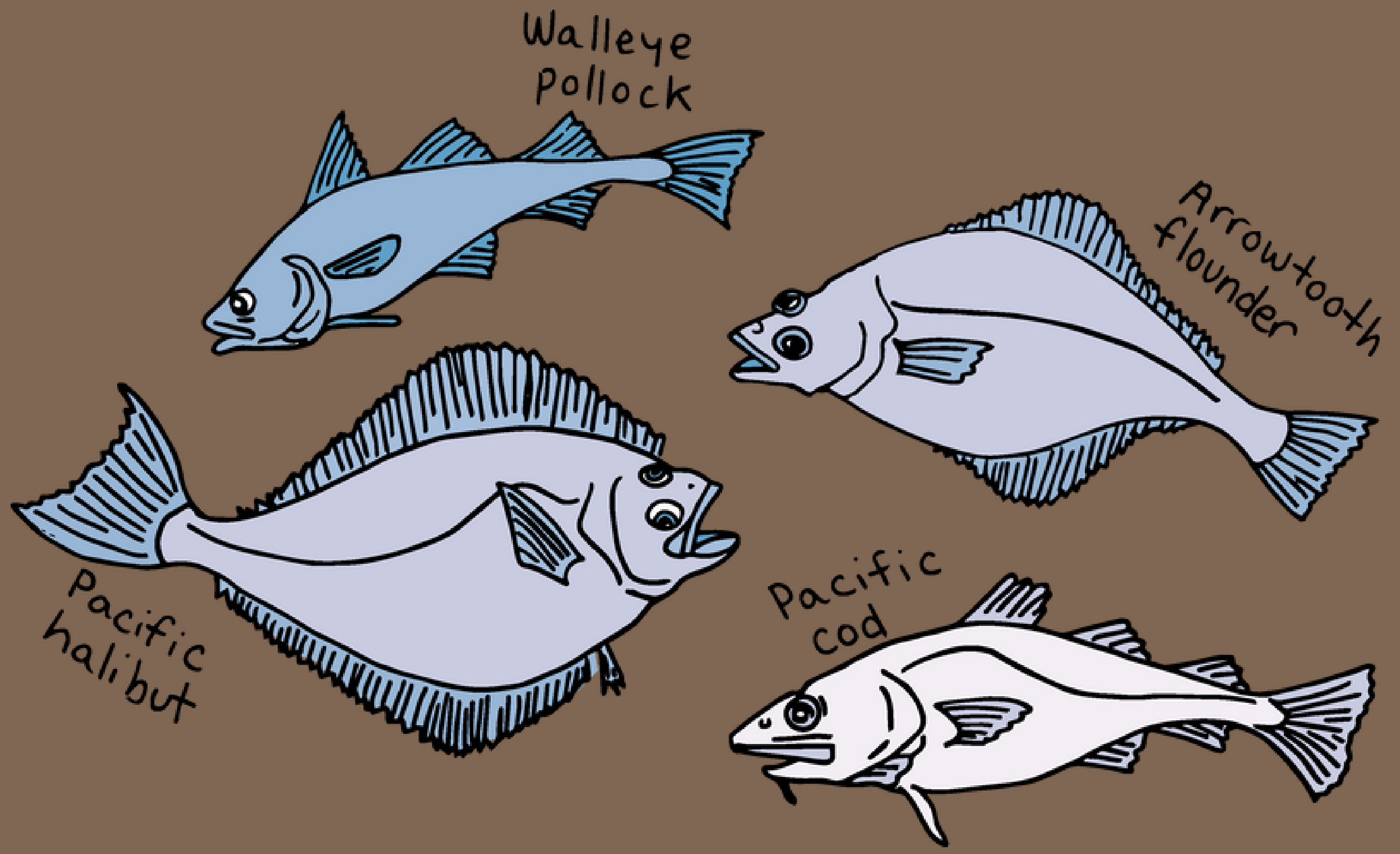

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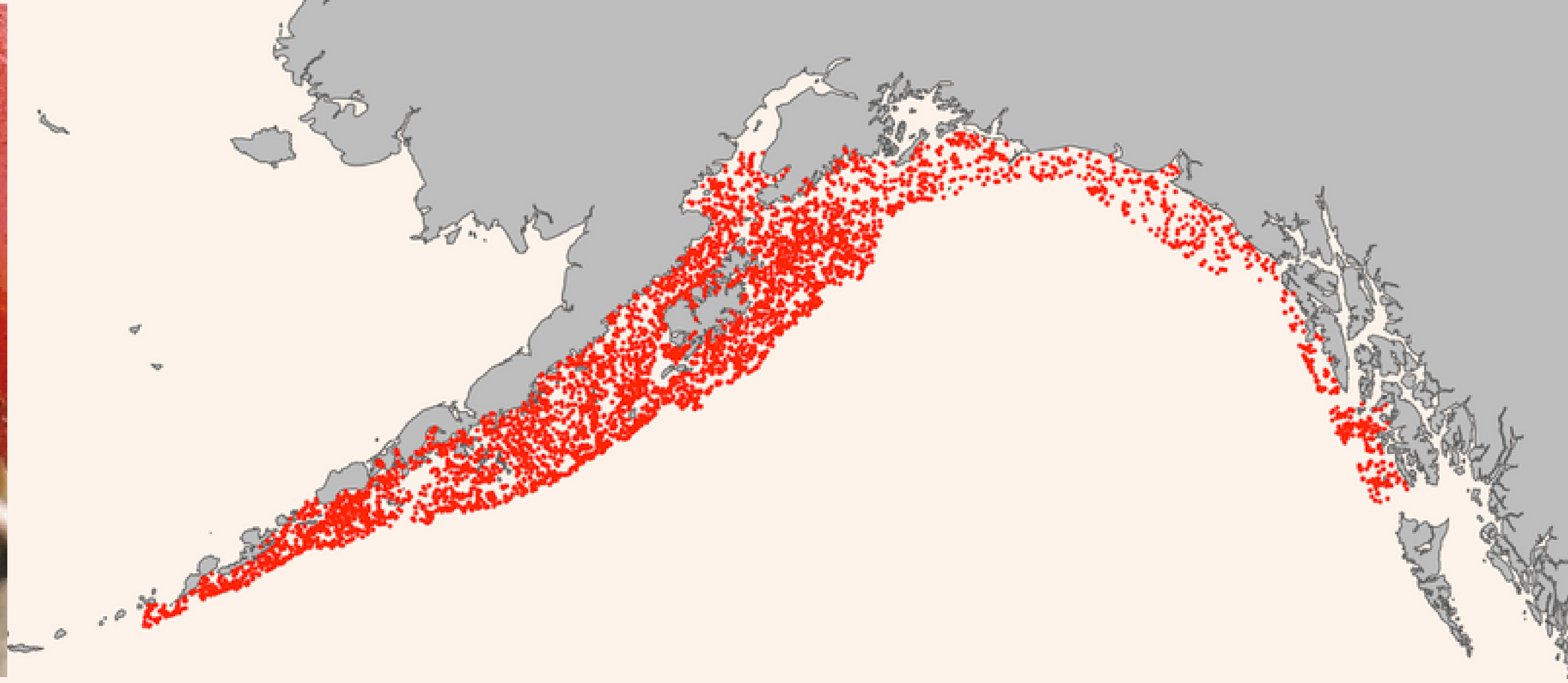
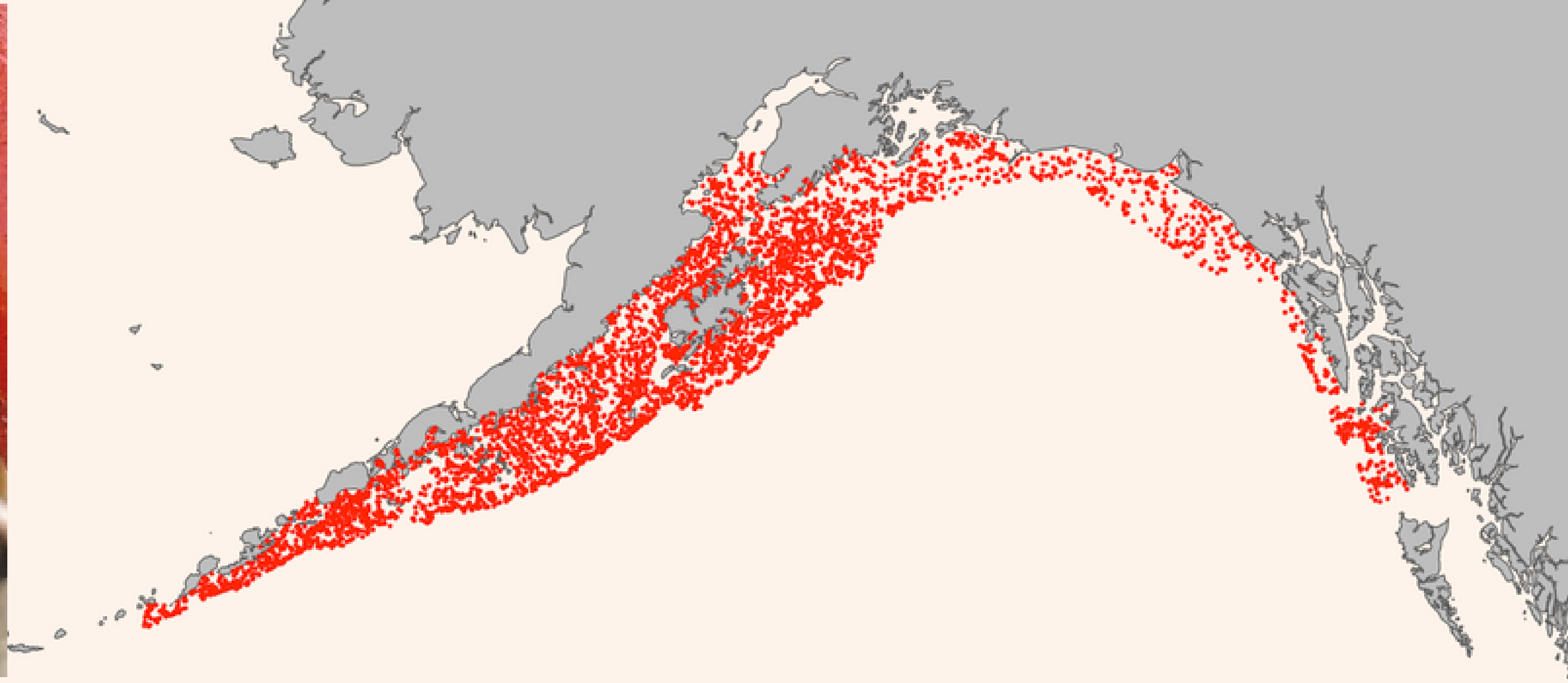
- **15 years of diets data (1990 - 2021)**
  - NOAA Resource Ecology and Ecosystem Modeling (REEM) GOA bottom trawl surveys
- **Focal predators**
  - Arrowtooth flounder, Pacific halibut, Pacific cod, walleye pollock



OBJECTIVES

1) Characterize spatiotemporal patterns of predation on key prey species by four focal groundfish predators

PHOTO: NOAA FISHERIES



OBJECTIVES

1) Characterize spatiotemporal patterns of predation on key prey species by four focal groundfish predators

2) Evaluate effects of temperature on patterns of prey occurrence in predator diets

PHOTO: NOAA FISHERIES

METHODS
Identify key prey species

- Summarize diet compositions
  - percent weight
  - percent frequency of occurrence

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- Visualize size-based patterns
  - ontogenetic shifts

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Identify key prey species

- Summarize diet compositions
  - percent weight
  - percent frequency of occurrence
- Group prey items based on taxonomic or functional groups
- Visualize size-based patterns
  - ontogenetic shifts
- Identify focal prey
  - High proportion of diet
  - Shared by multiple predators
  - Previous research

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METHODS

Develop testable hypotheses for key prey species

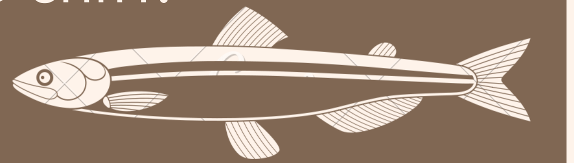
FORAGE FISH

Clupeidae (-)

- declined during MHW.

Osmeridae (-)

- declined during MHW/regime shift.



CRUSTACEANS

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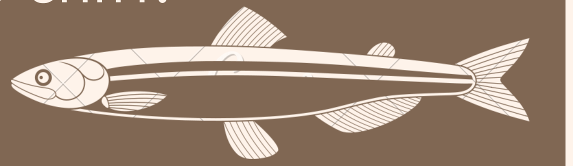
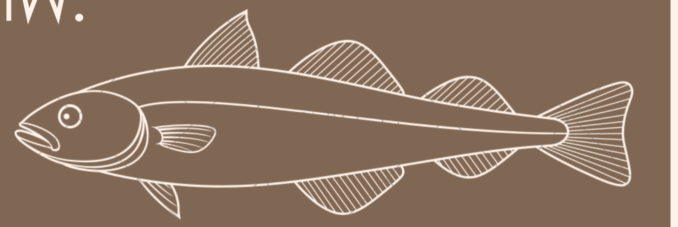


Walleye Pollock (-) / **No Effect**

- Negative relationship between temperature and halibut consumption of pollock.
- Important component of cod diets, and cod crashed following MHW.



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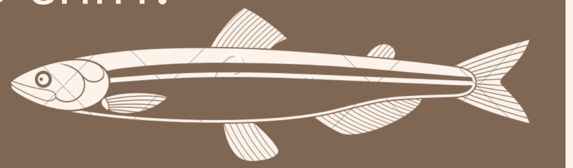

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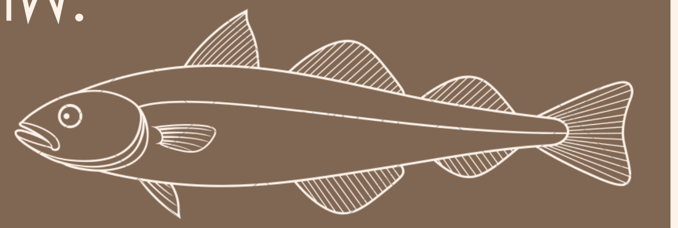

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Euphausiacea (-)

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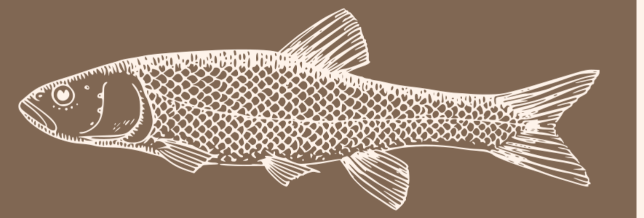

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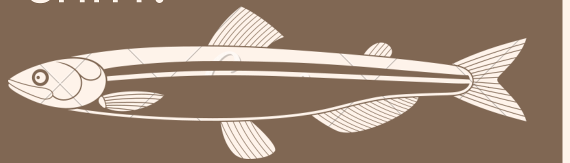

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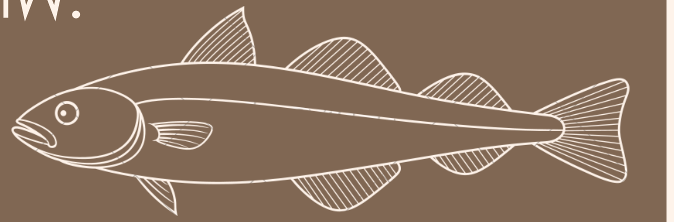

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Tanner Crab (-)
- Collapse of snow and king crab attributed to loss of cold pool.

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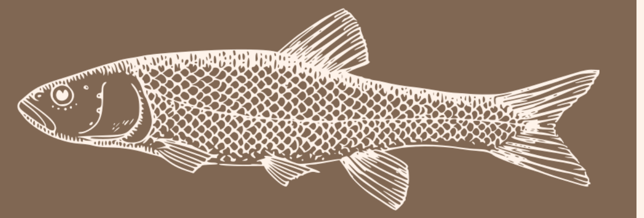

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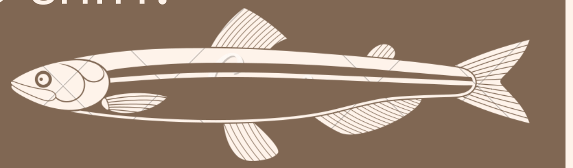

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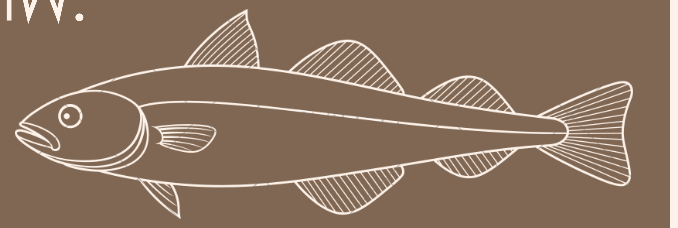

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Pandalidae shrimp (-)

- Declined during regime shift.

METHODS
Develop a model to test hypotheses

Probability of Prey Occurence ~ s(Gear Temperature) + s(Gear Depth) + s(Latitude, Longitude) + Year + Predator Length Bin + Predator Species

Generalized additive model with a logit link function

RESULTS

Prey Occurrence

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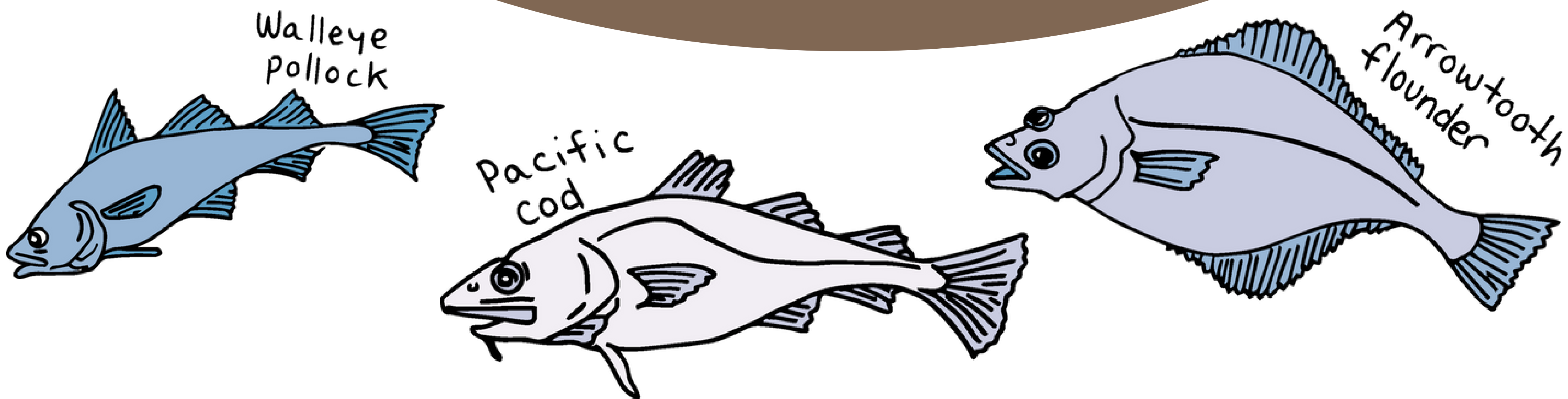

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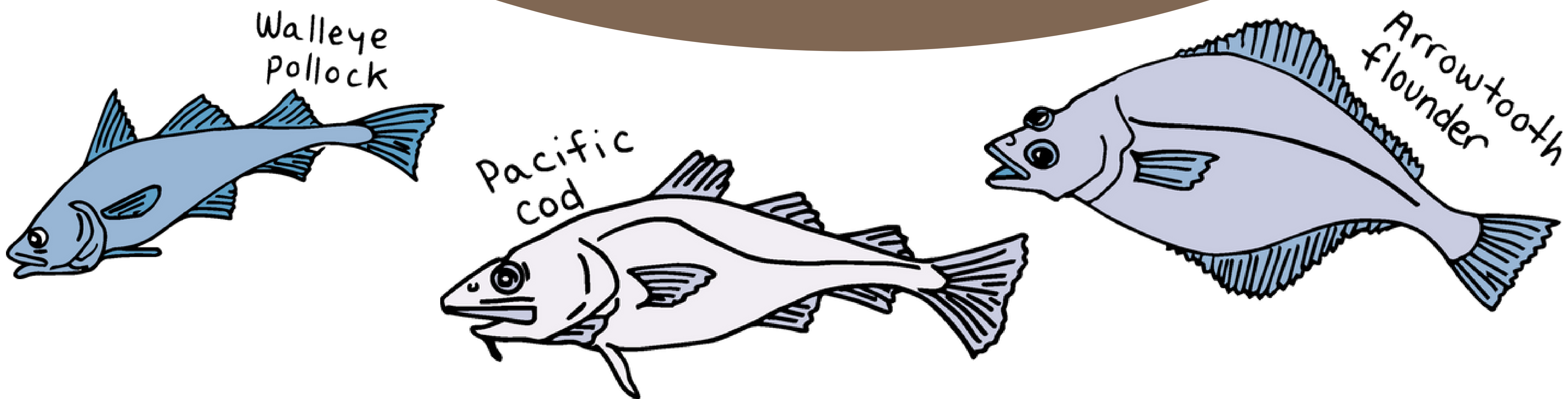

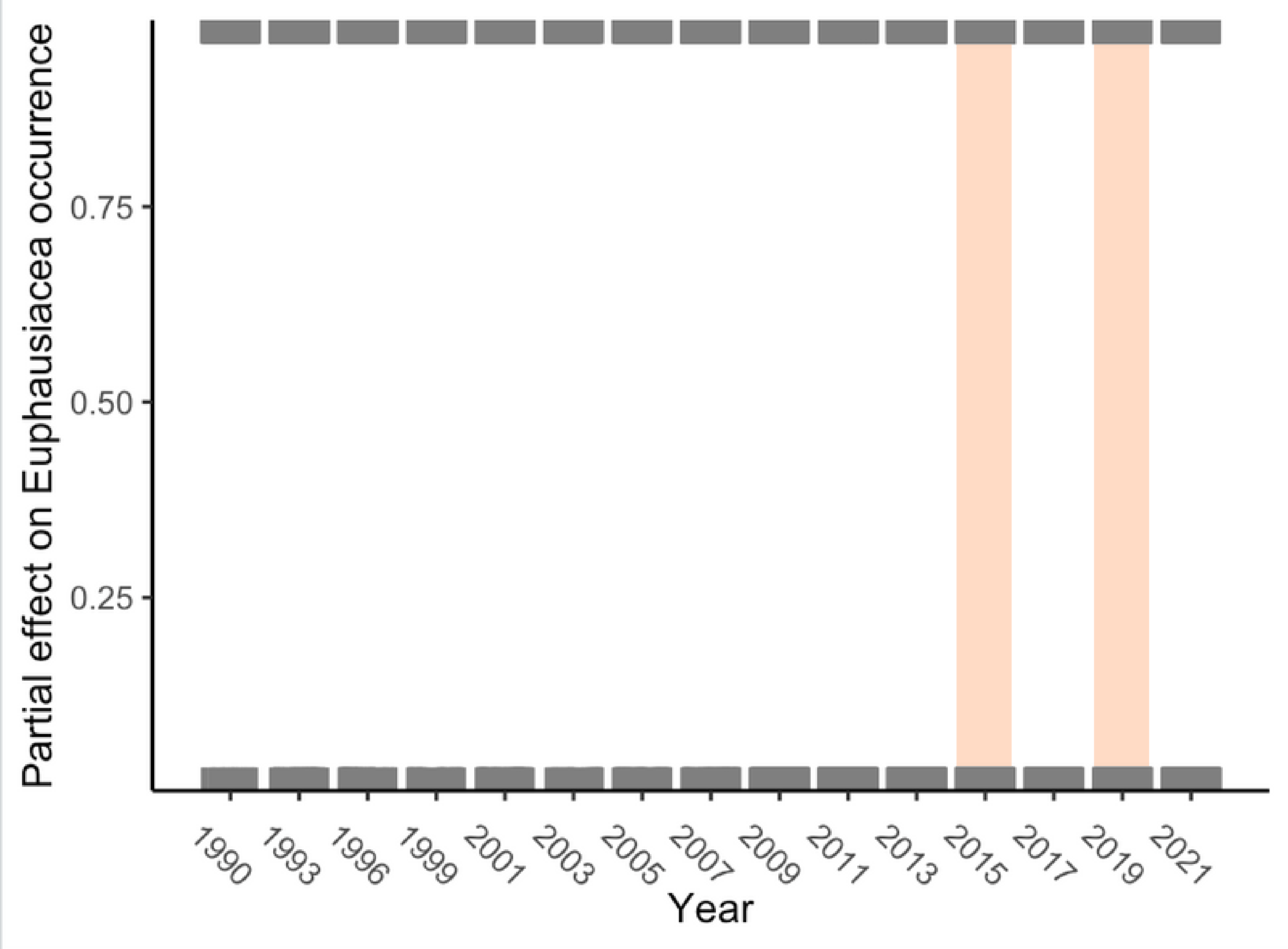

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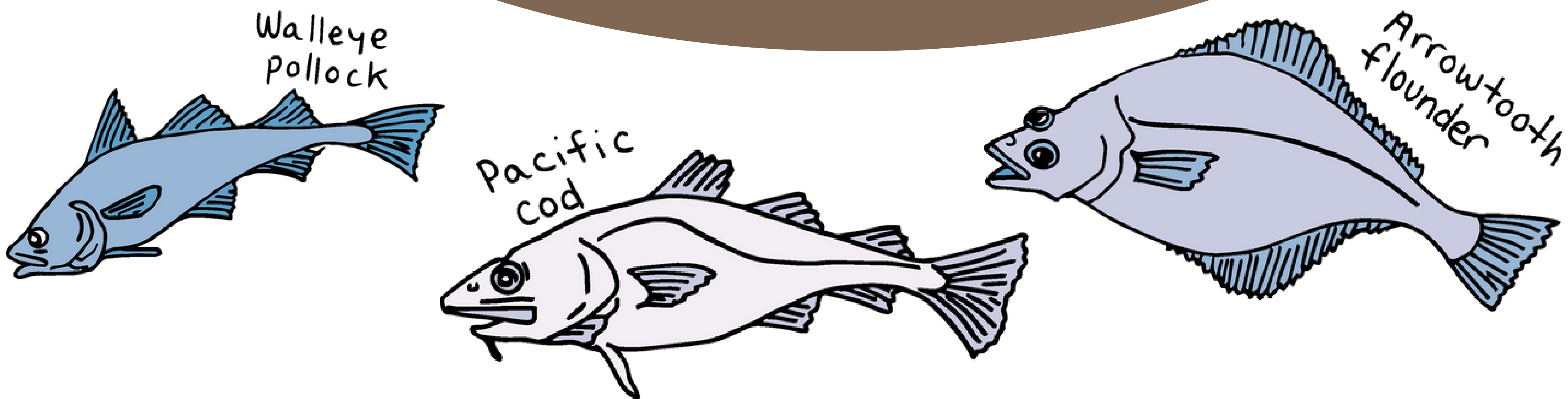

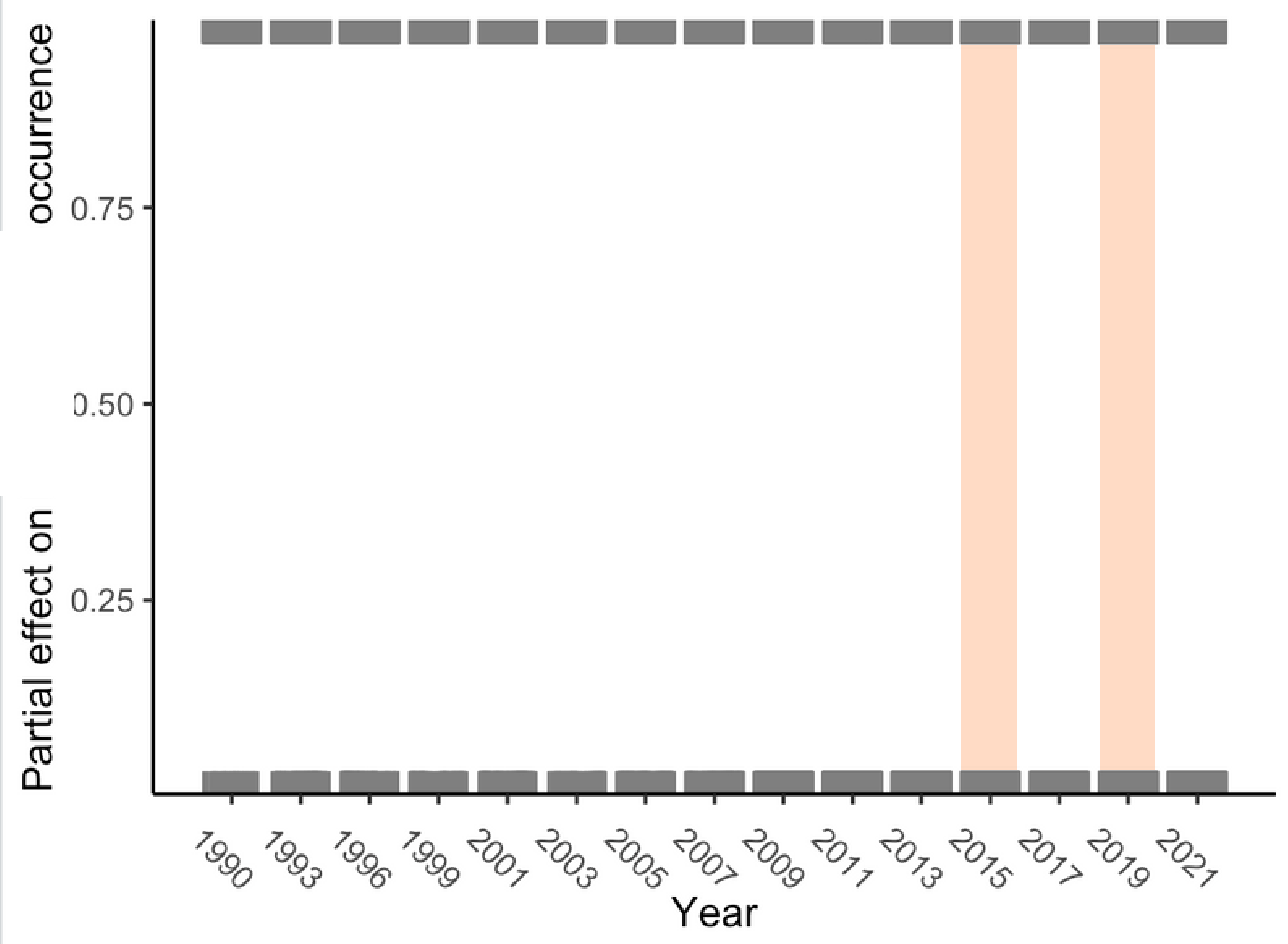

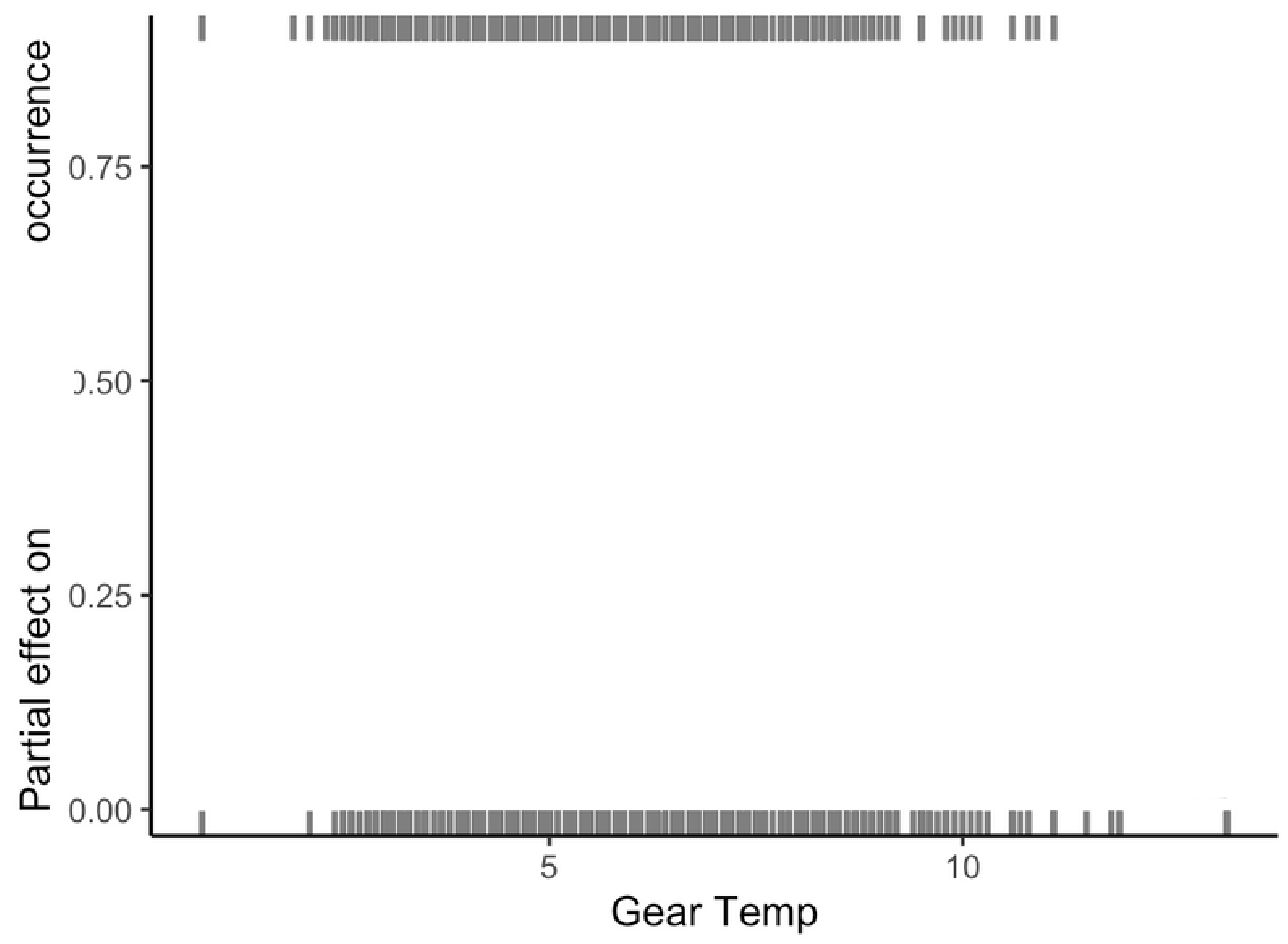

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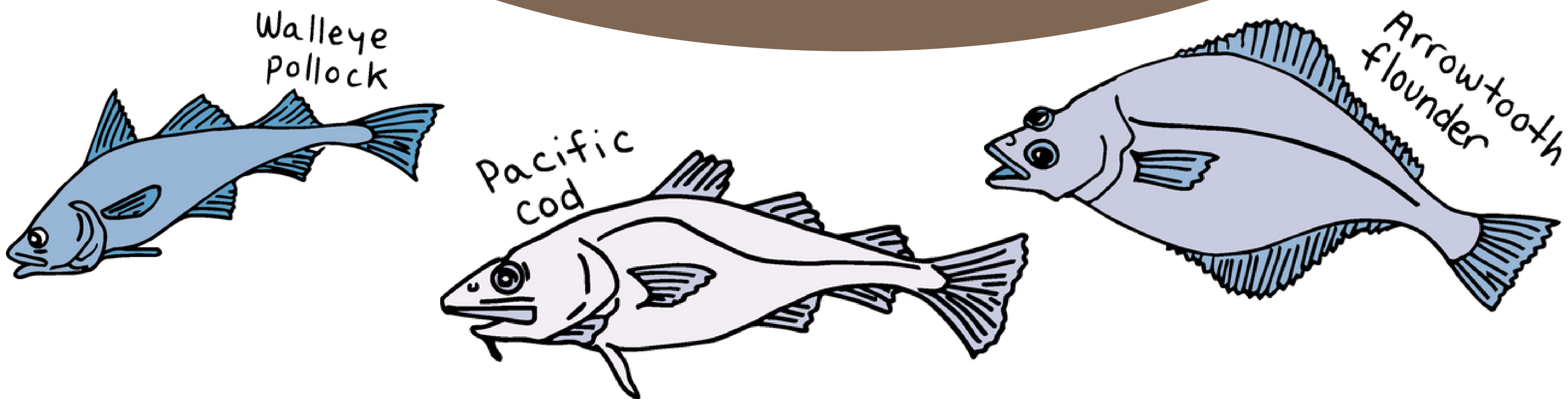

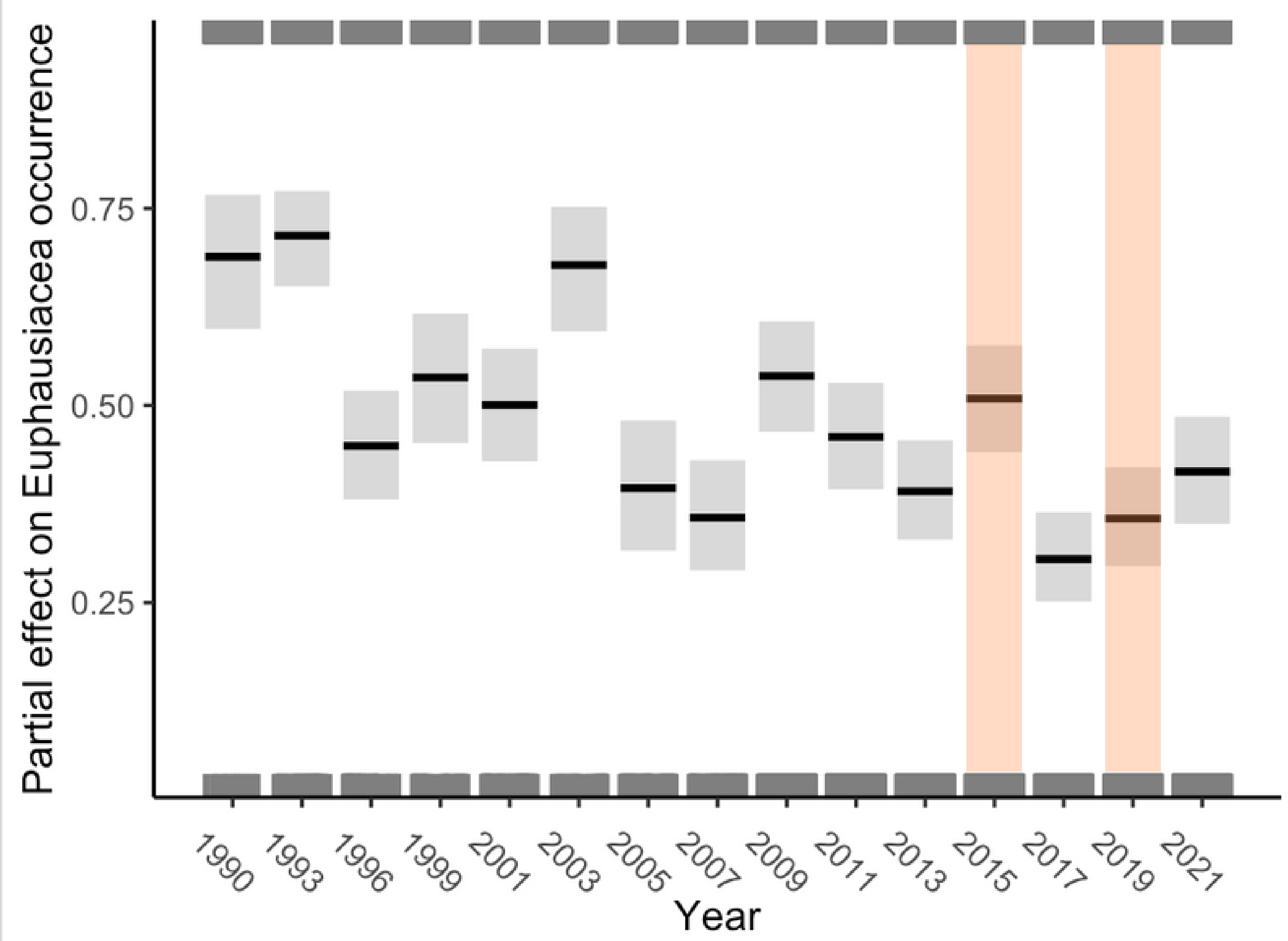

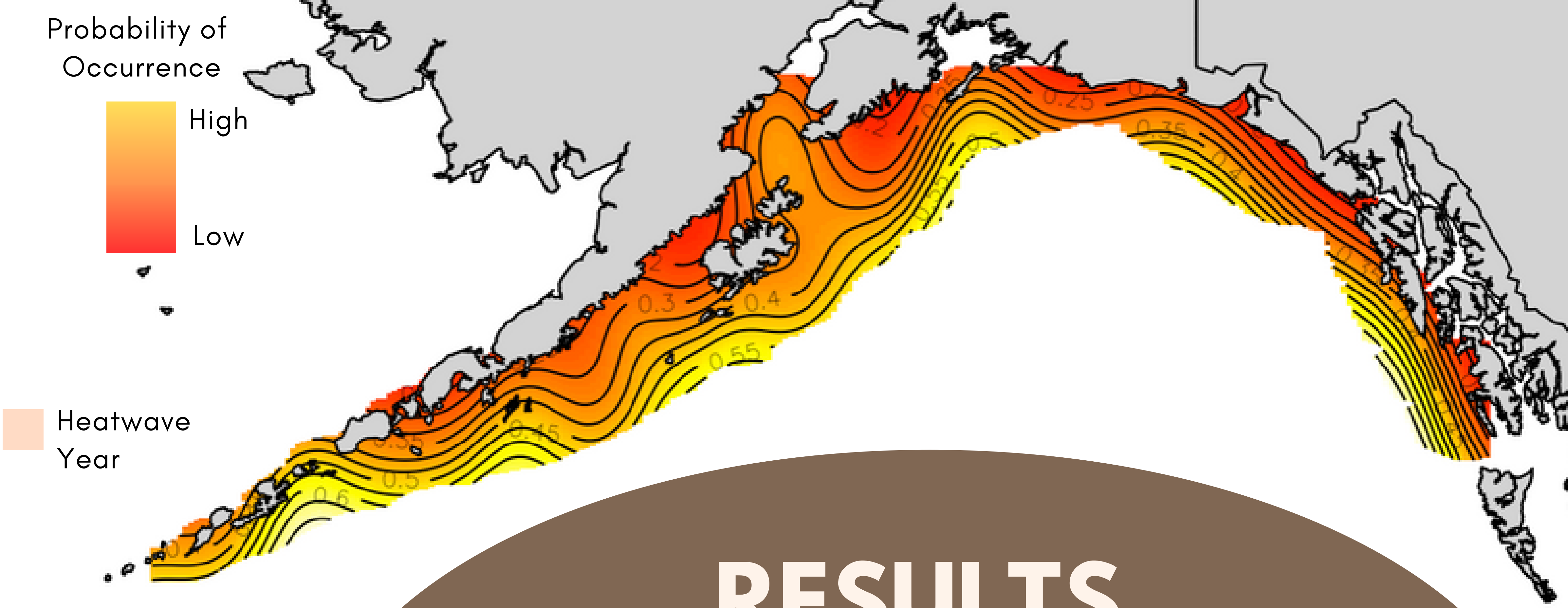

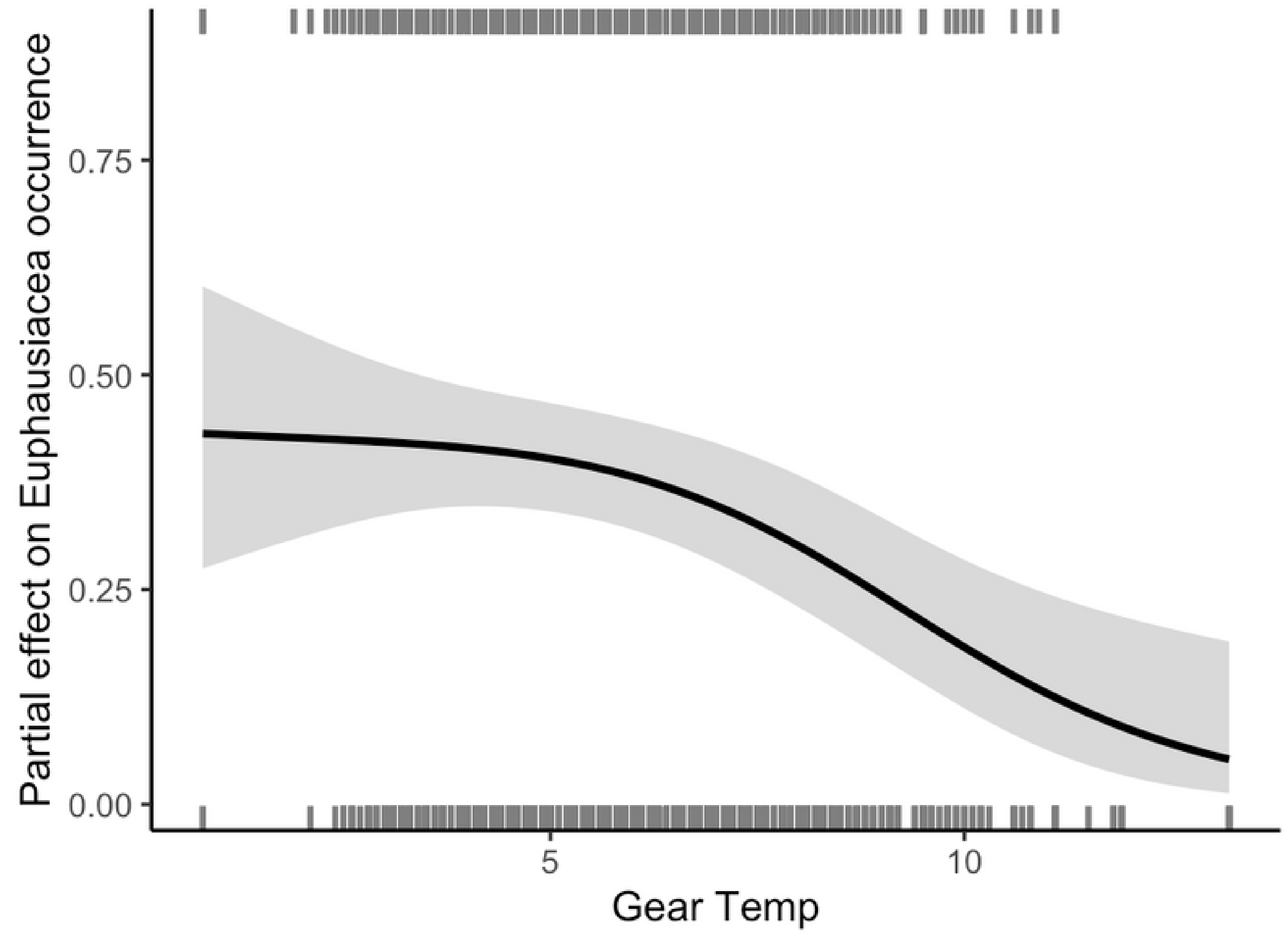

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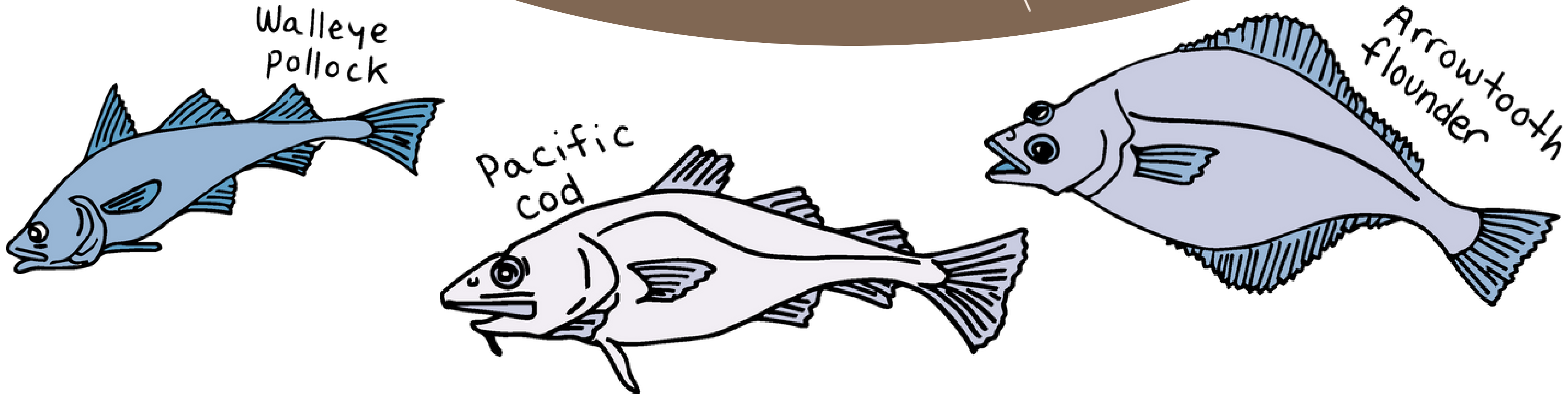

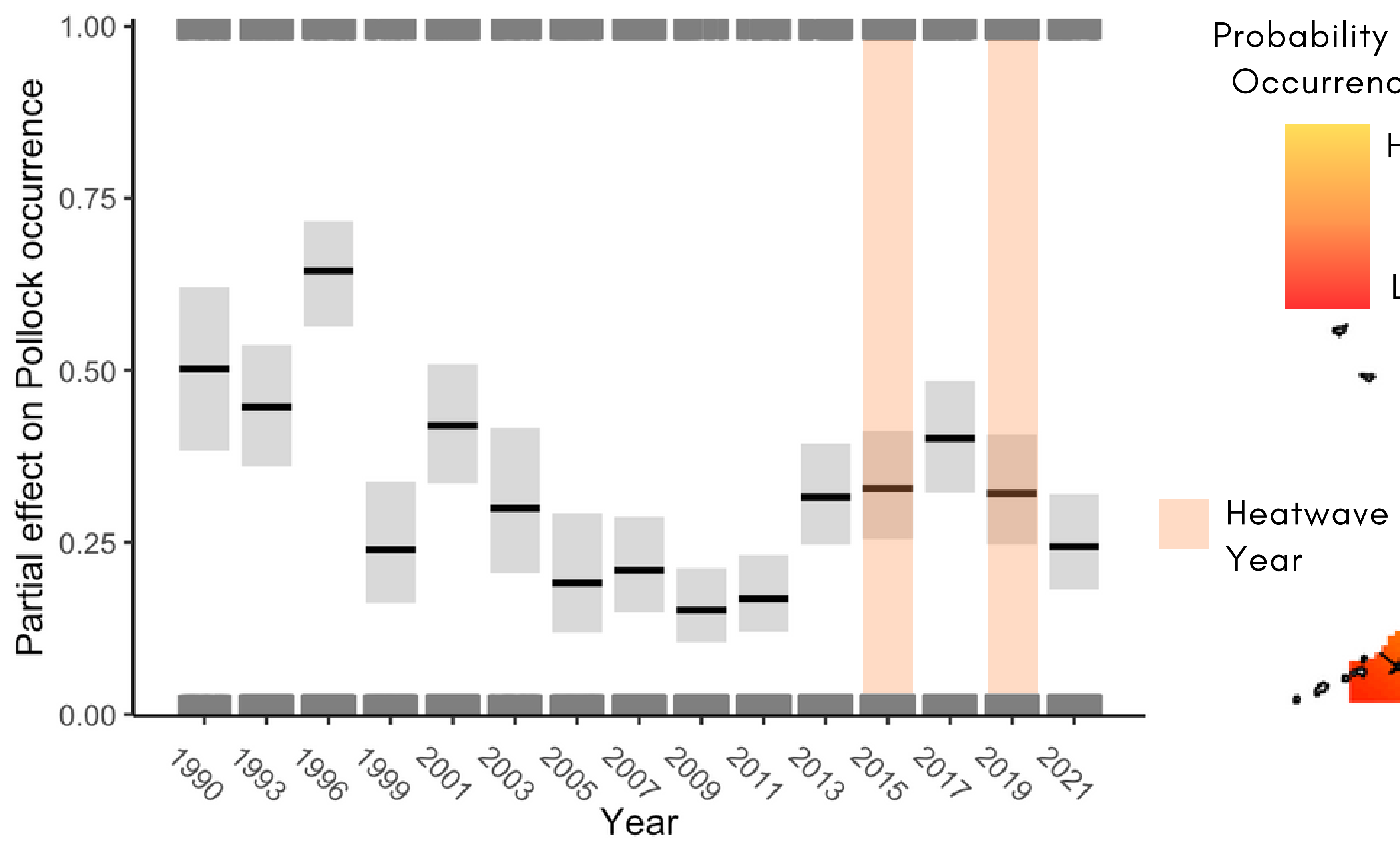

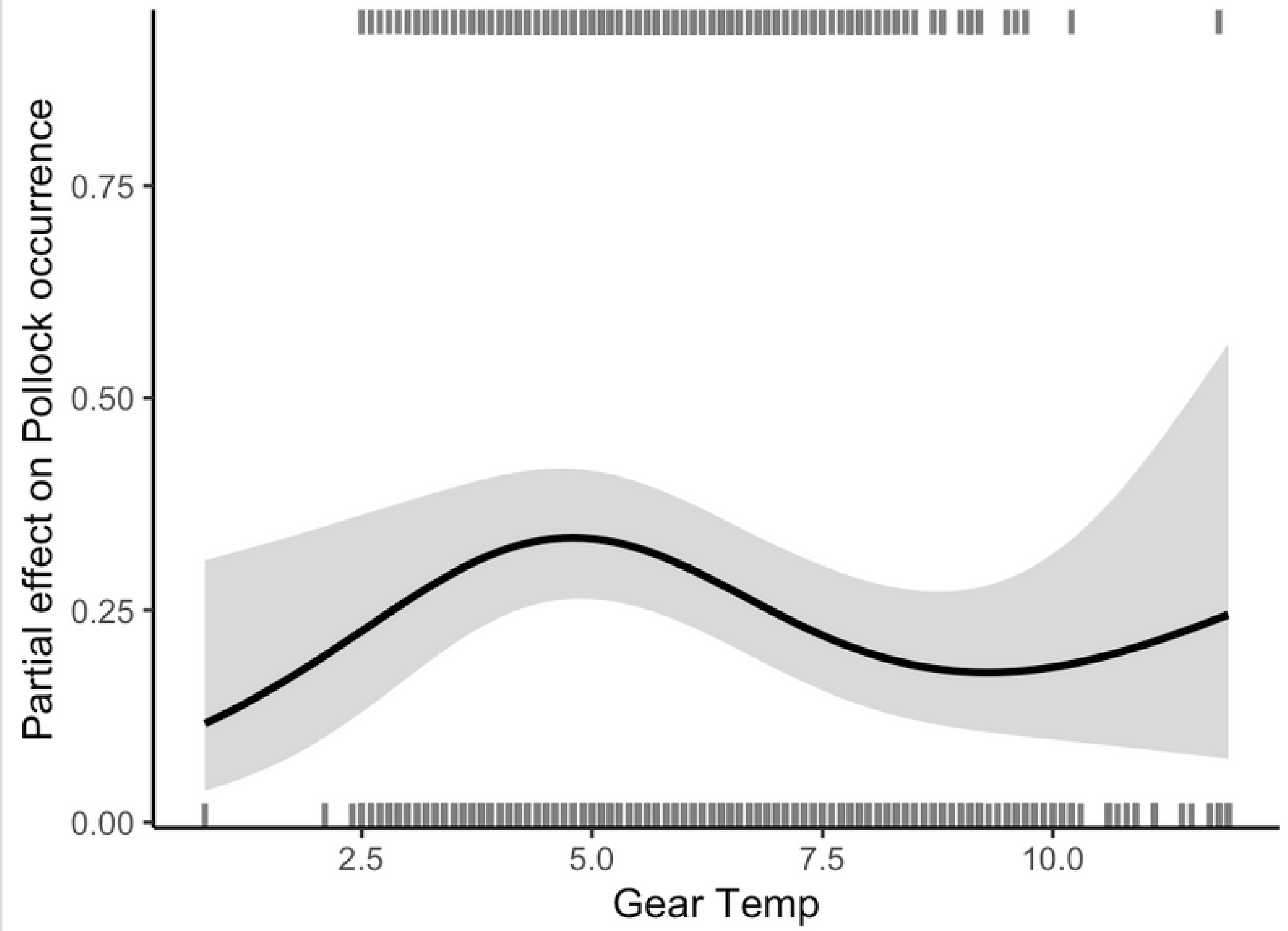

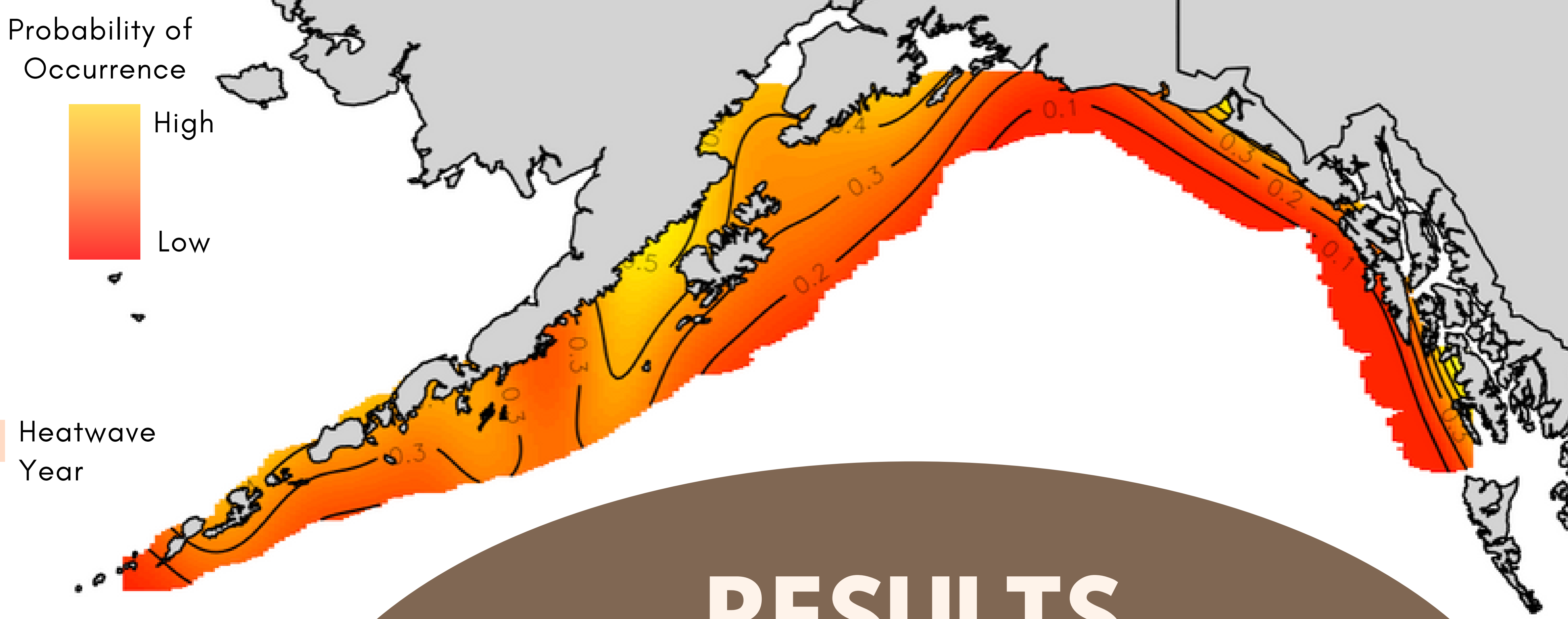

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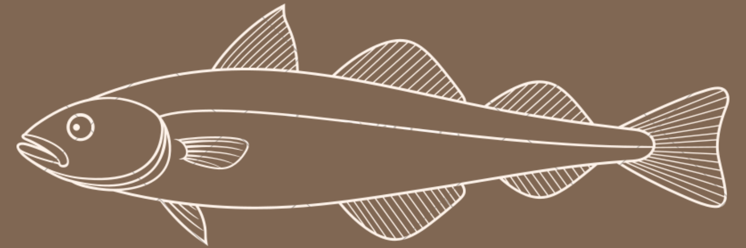
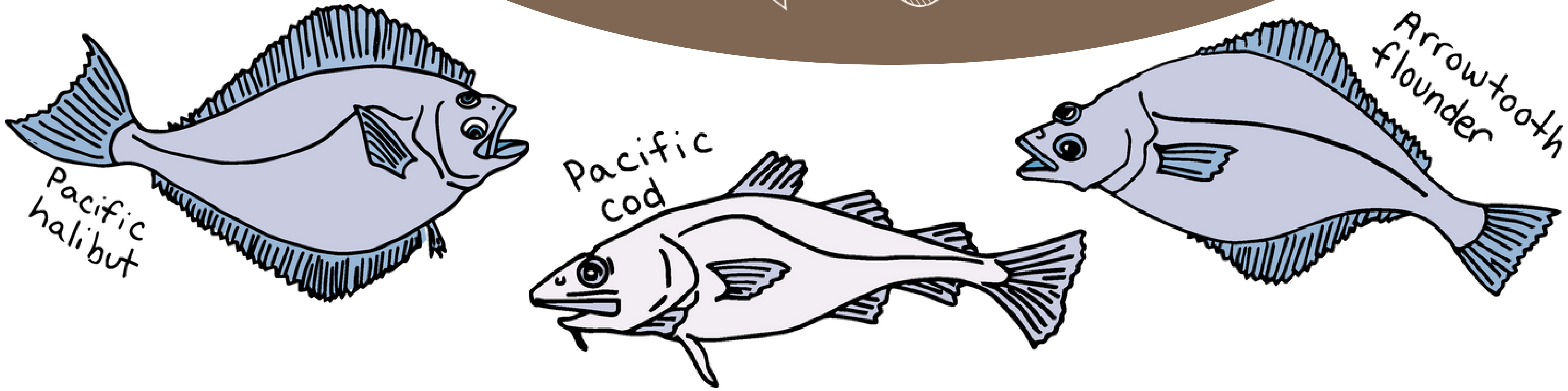
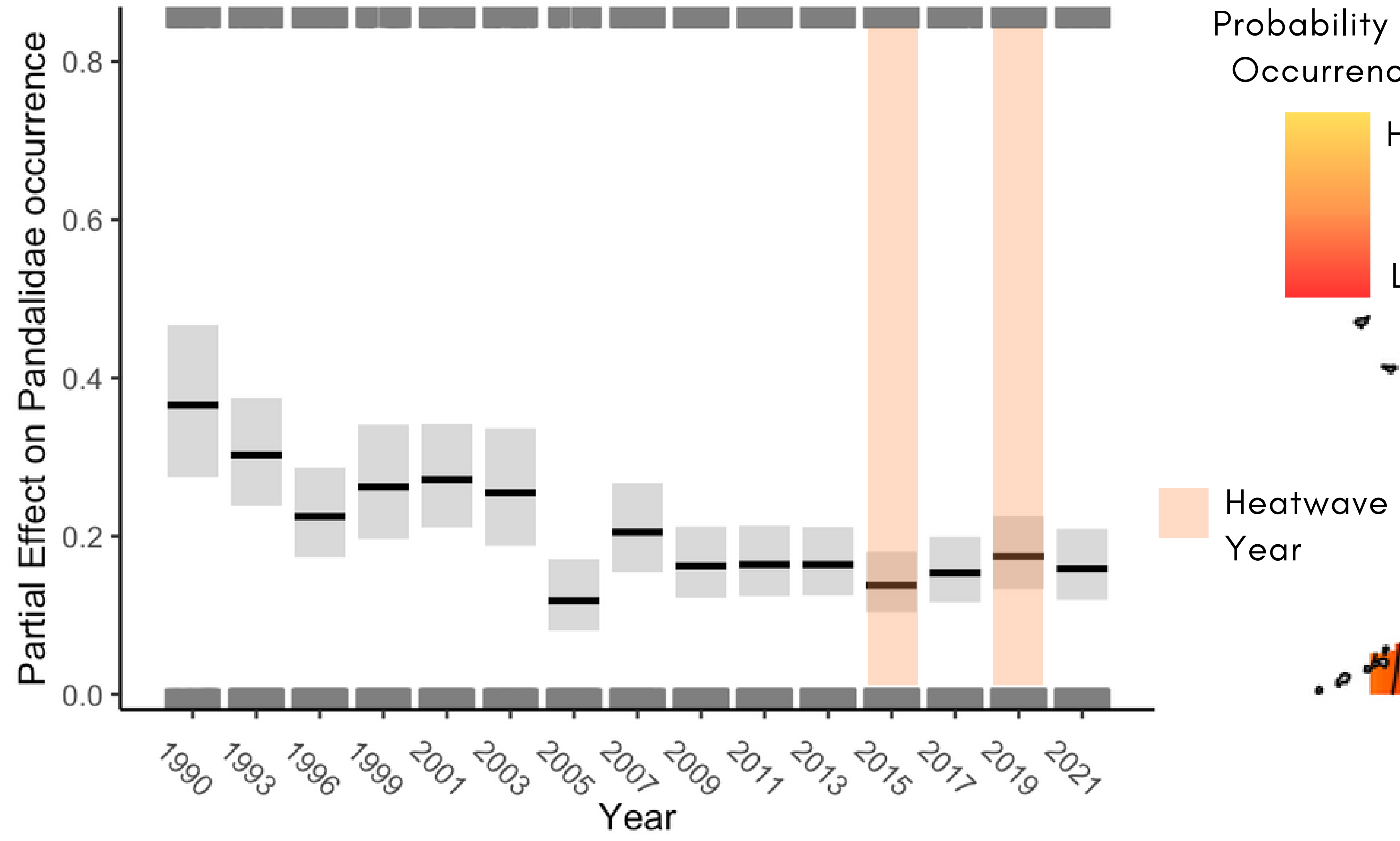
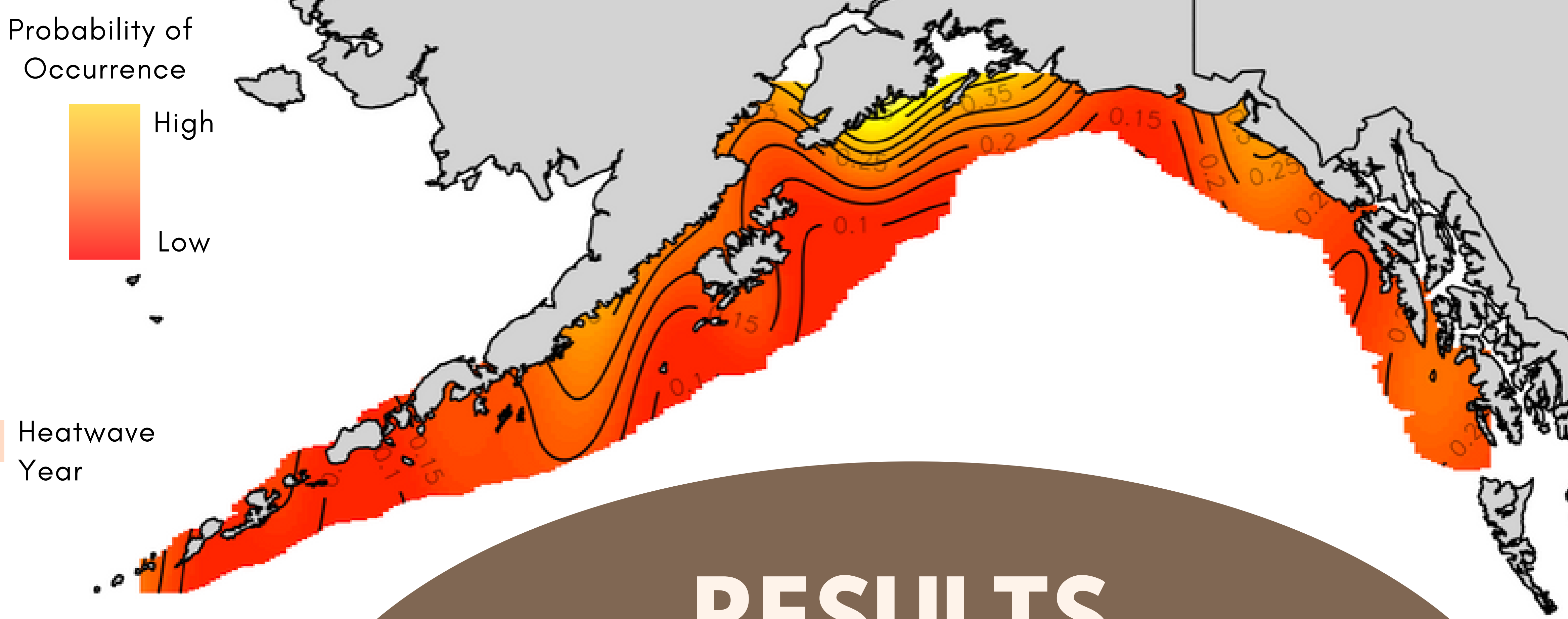
Walleye Pollock Prey Occurrence









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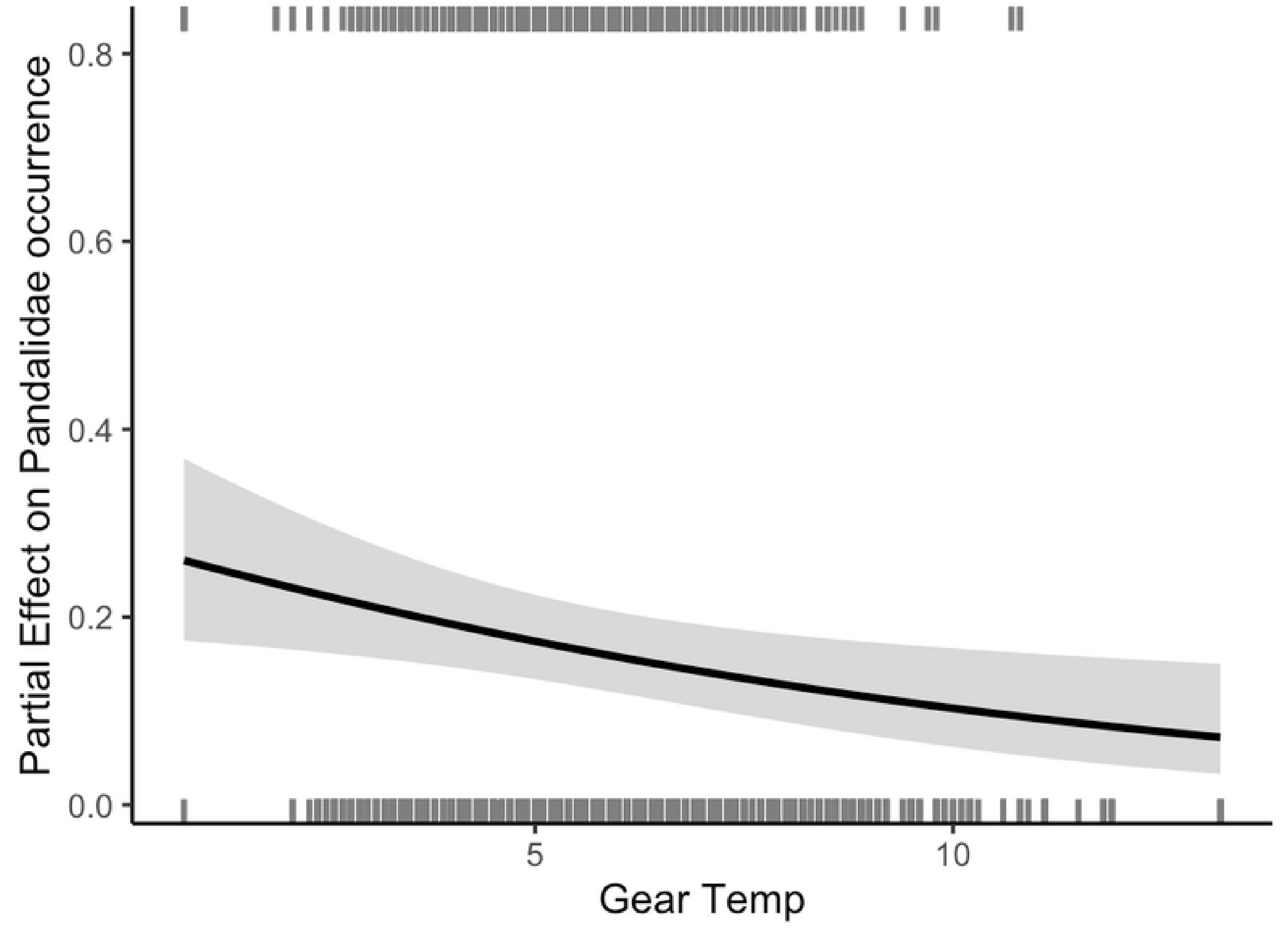
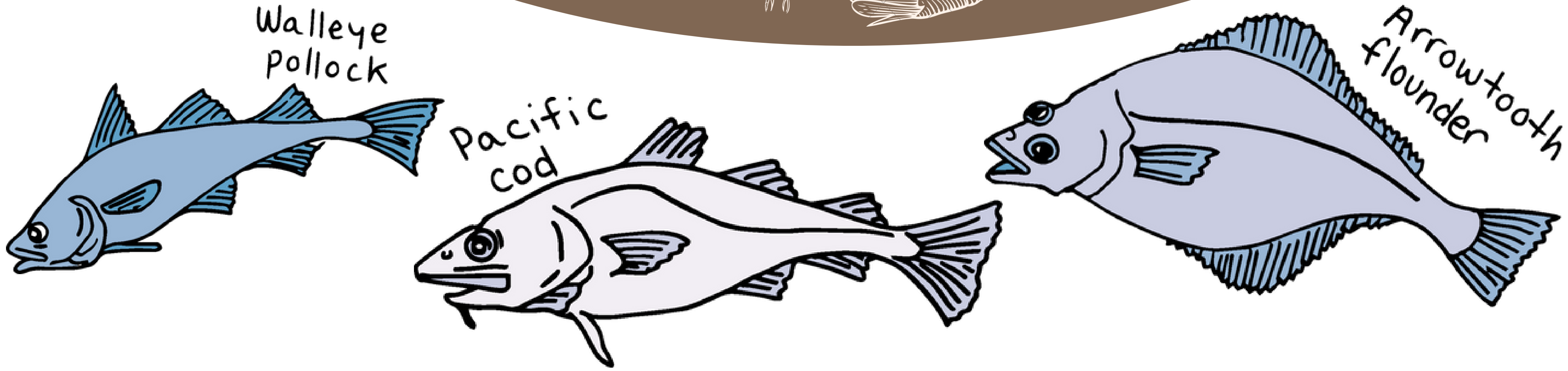
Pandalidae Prey Occurrence





DISCUSSION

Did the model results support our hypotheses?

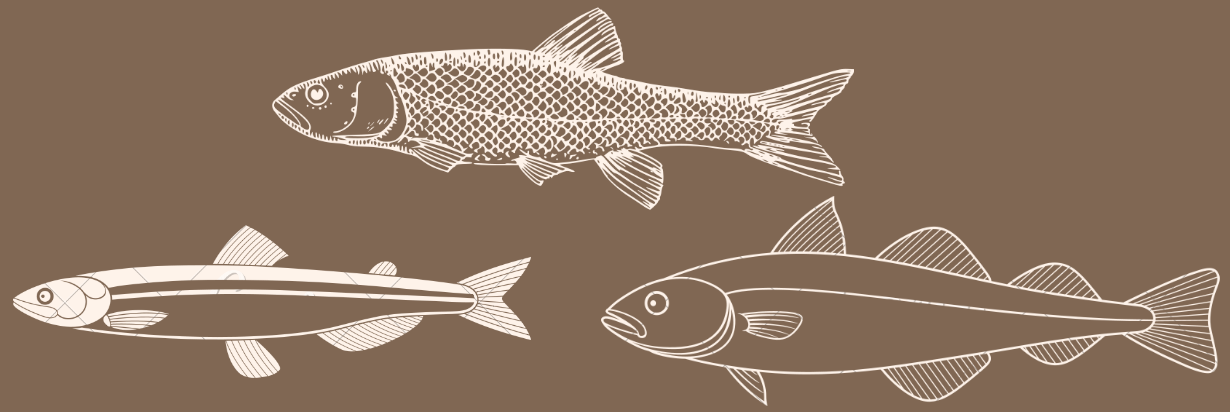
FORAGE FISH

Clupeidae/Osmeridae (-)

- No effect of temperature
- Decreased during MHW

Walleye Pollock (-) / No Effect

- Optimal temperature range, no clear linear trend
- Increased during MHW, showing cyclical trend over time



Supported Hypothesis

Partially Supported Hypothesis

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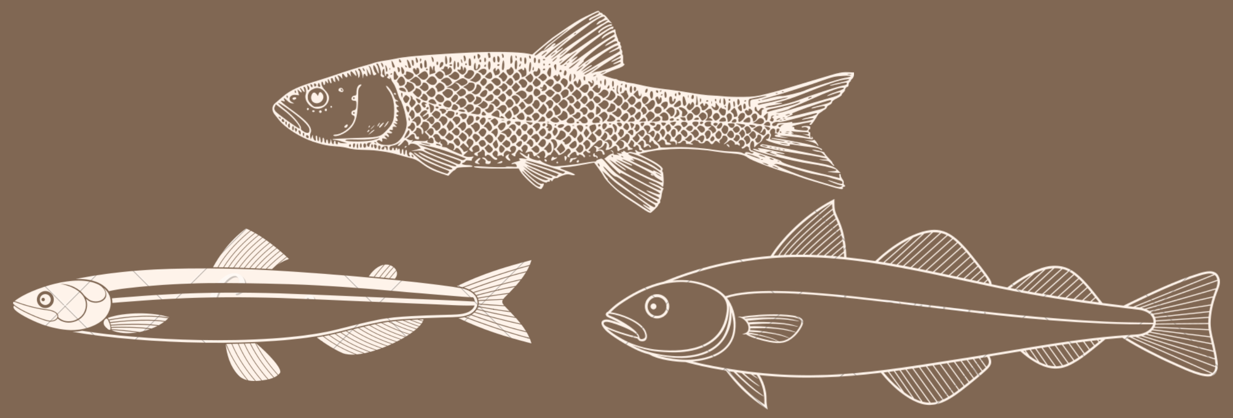

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Partially Supported Hypothesis

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Euphausiacea (-)

- Negative effect of temperature
- Decline following MHW

Tanner Crab (-)

- No effect of temperature
- Decline during MHW

Pandalidae shrimp (-)

- Negative effect of temperature
- Overall declining occurrence over time

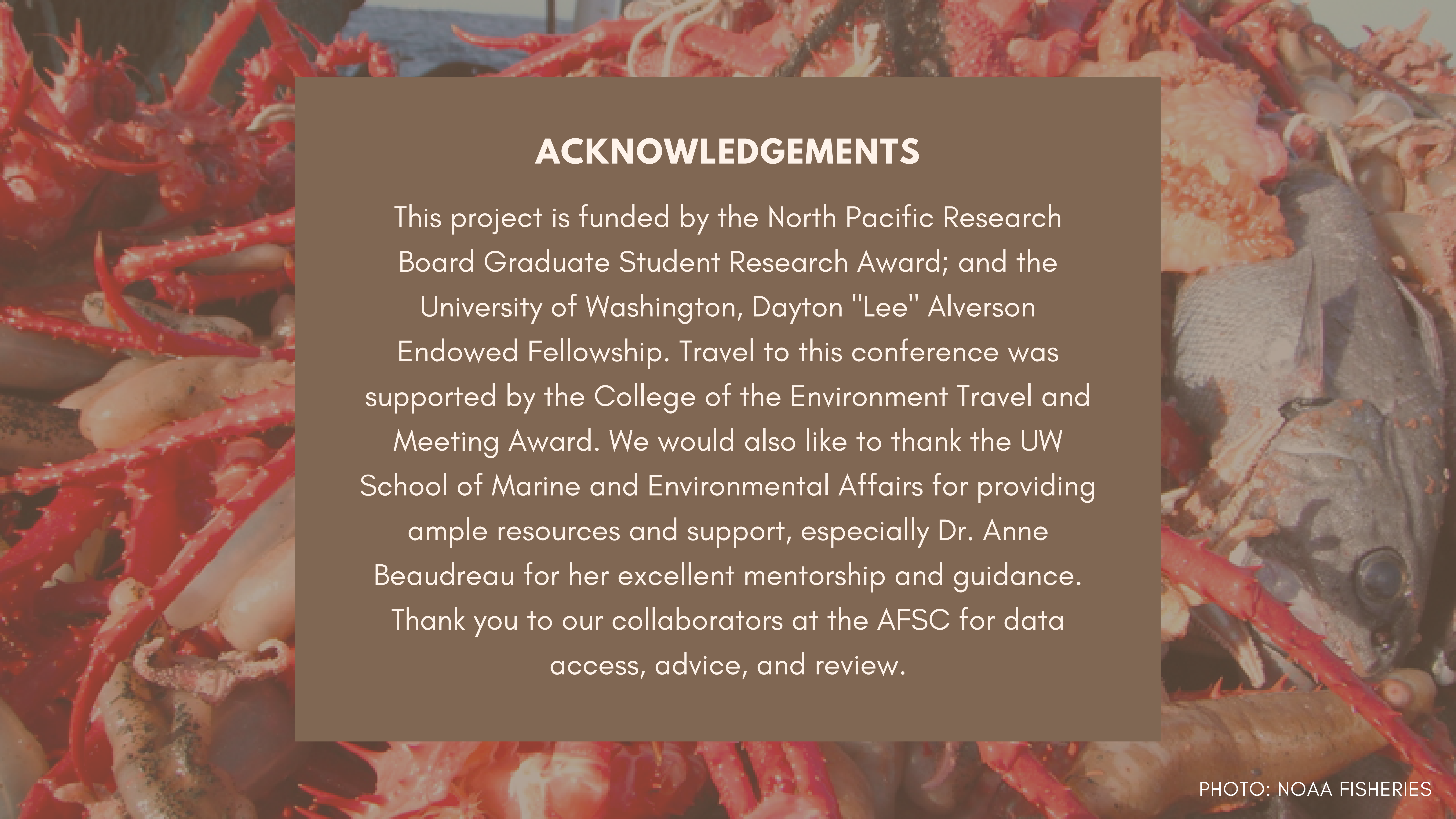
FINAL TAKEAWAYS

- We are studying the **effects of temperature** on the consumption of focal prey species.
- Euphausiids were the only prey that showed a **clear negative relationship** with temperature.
- There could be **cascading foodweb effects** that are yet to be accounted for.
- Euphausiids are a large component of pollock diets which are key prey for multiple commercial groundfish predators.

Multi-species modeling can be an effective tool for anticipating these effects.

ACKNOWLEDGEMENTS

This project is funded by the North Pacific Research Board Graduate Student Research Award; and the University of Washington, Dayton "Lee" Alverson Endowed Fellowship. Travel to this conference was supported by the College of the Environment Travel and Meeting Award. We would also like to thank the UW School of Marine and Environmental Affairs for providing ample resources and support, especially Dr. Anne Beaudreau for her excellent mentorship and guidance. Thank you to our collaborators at the AFSC for data access, advice, and review.



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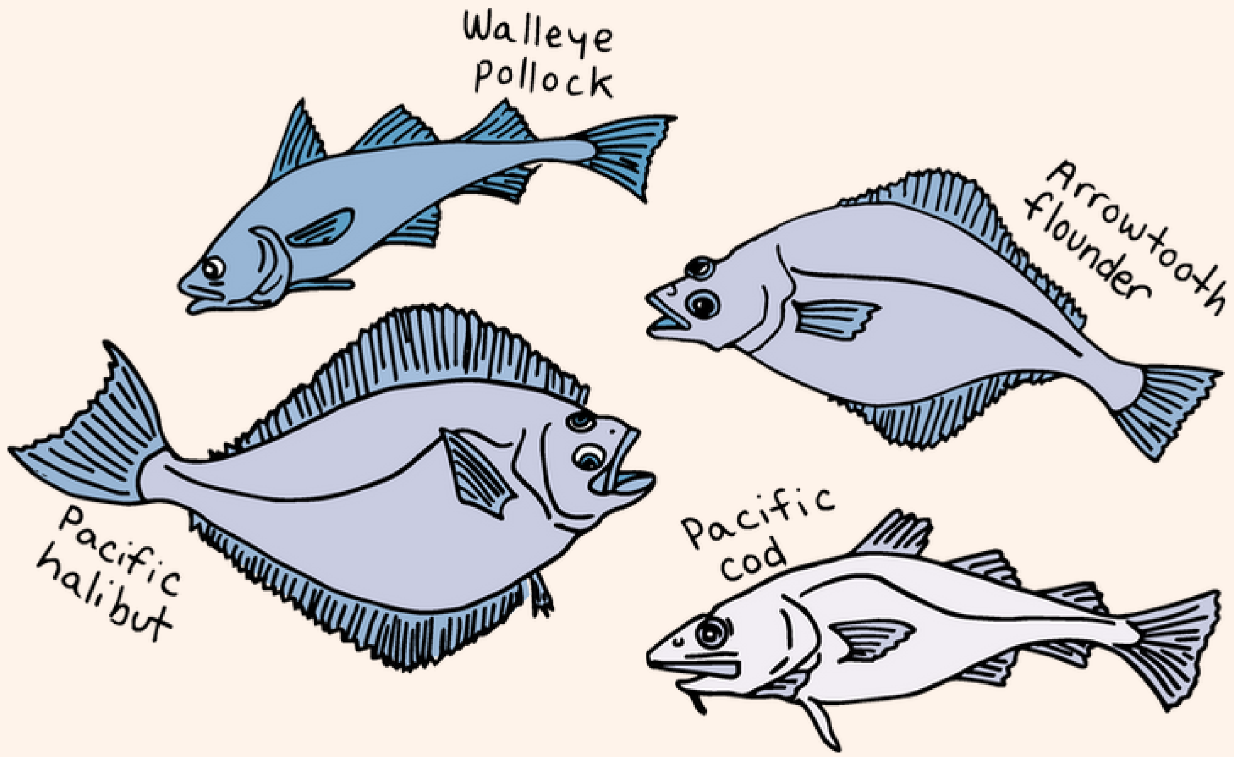
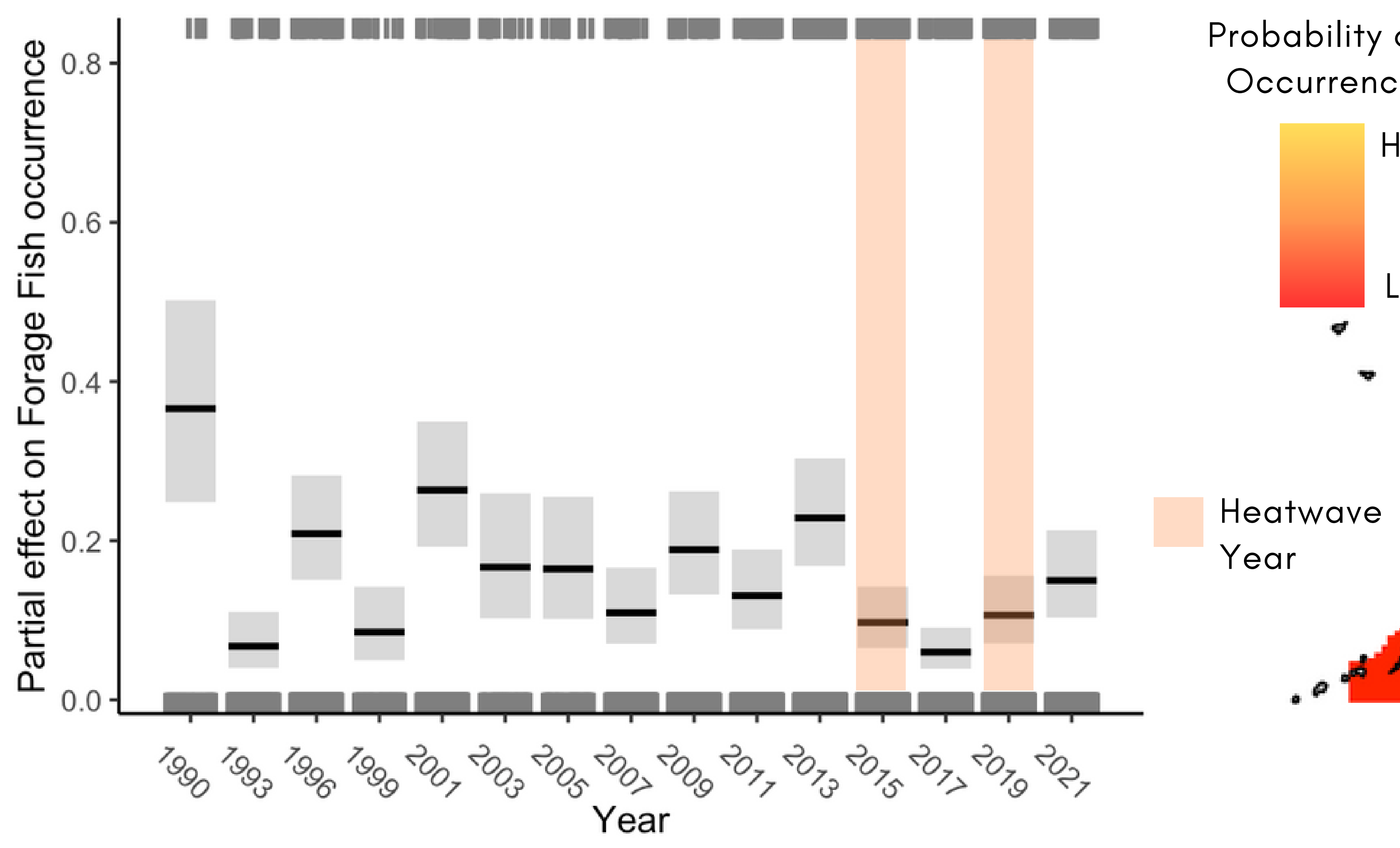


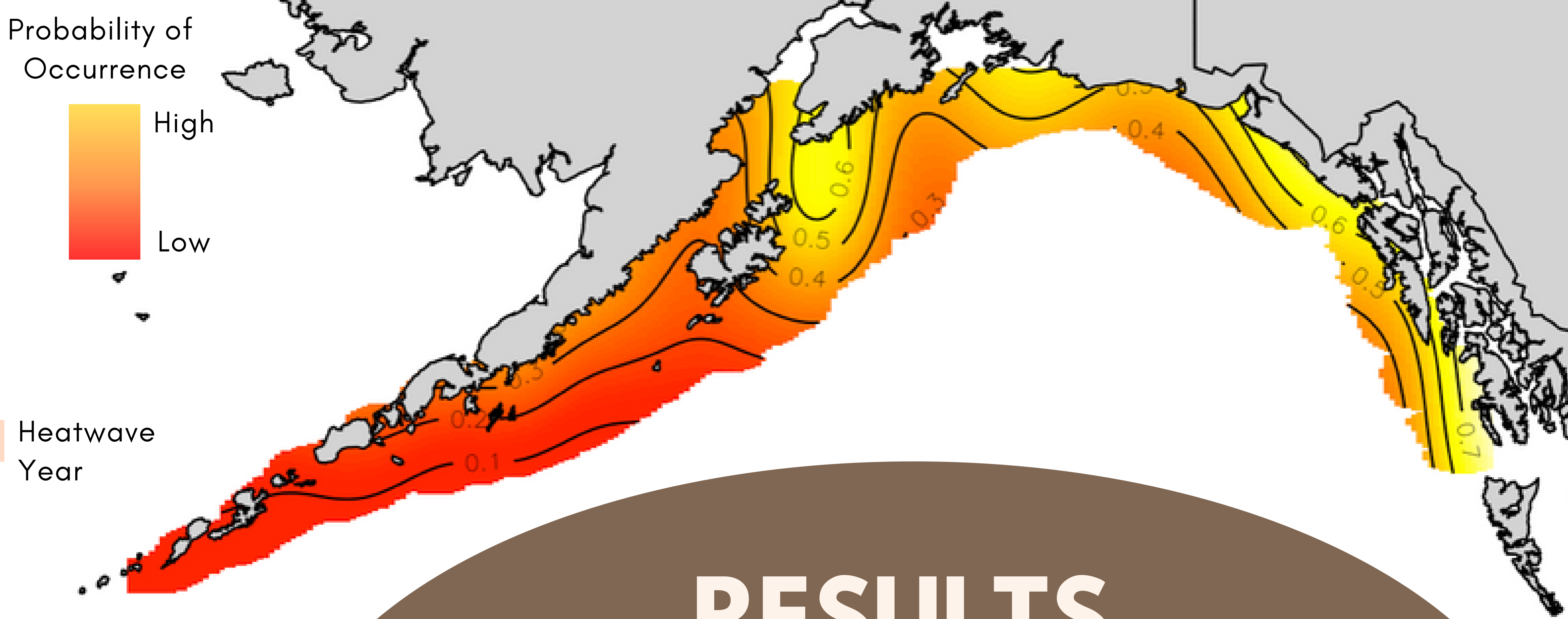
RESULTS

Akaike parameter weights

Response Variable **Predictor Variables**

Predators	Prey Group	Gear Temp	Gear Depth	Lat/Long	Year	Length	Preds
Arrowtooth flounder, Pacific cod, Walleye pollock	Euphausiacea	1.00	1.00	1.00	1.00	1.00	1.00
Arrowtooth flounder, Pacific halibut, Pacific cod	Walleye pollock	1.00	1.00	1.00	1.00	1.00	1.00
Arrowtooth flounder, Pacific halibut	Forage Fish	0.59	1.00	1.00	1.00	1.00	1.00
Pacific halibut, Pacific cod	Tanner Crab	0.28	1.00	1.00	1.00	1.00	1.00
Arrowtooth flounder, Pacific cod, Walleye pollock	Pandalidae	0.87	1.00	1.00	1.00	1.00	1.00





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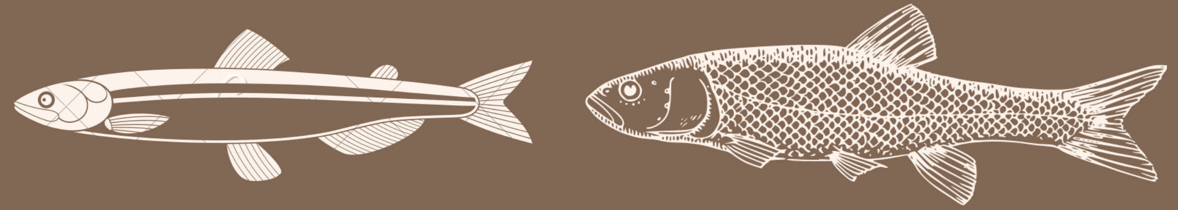
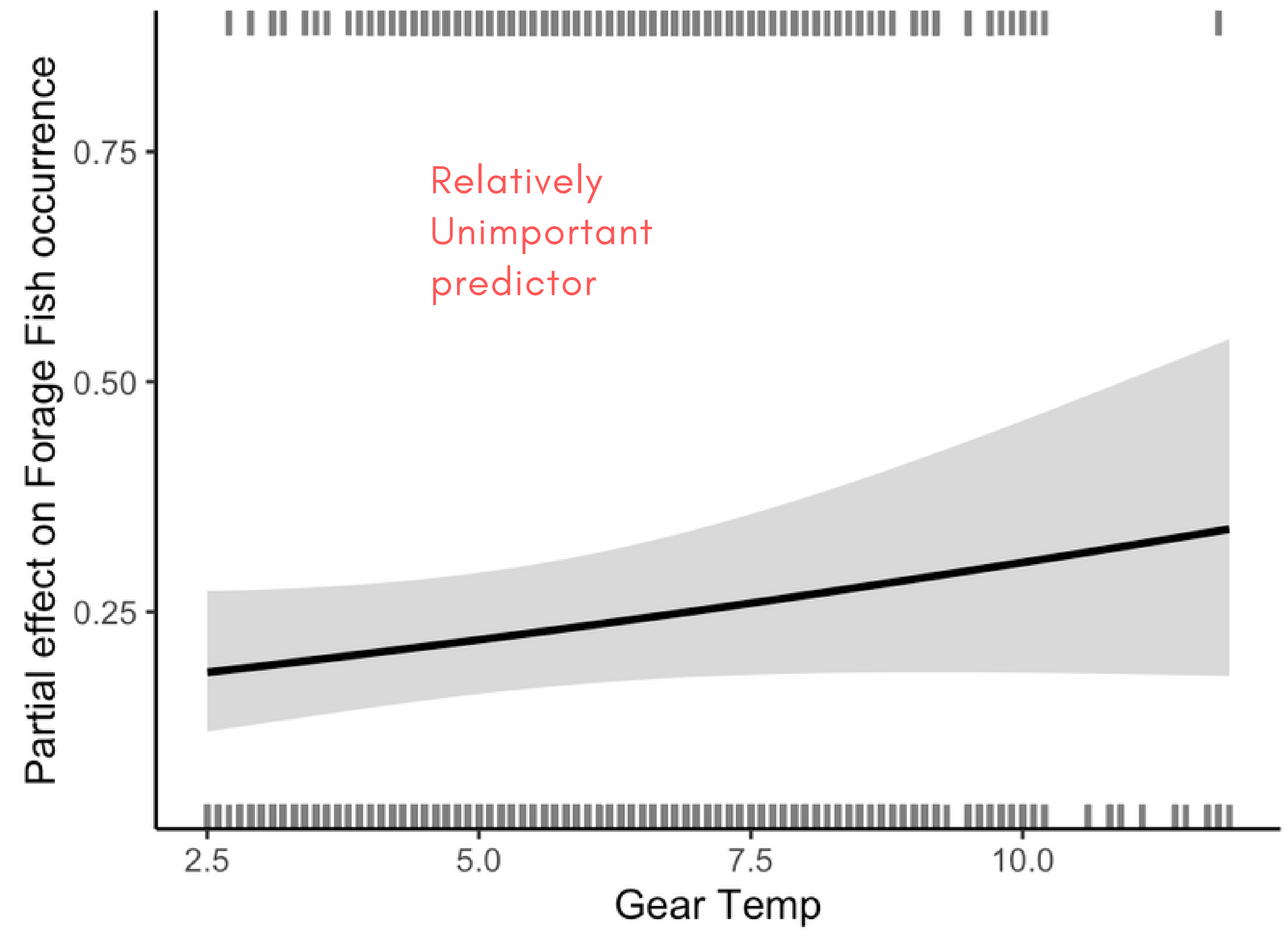
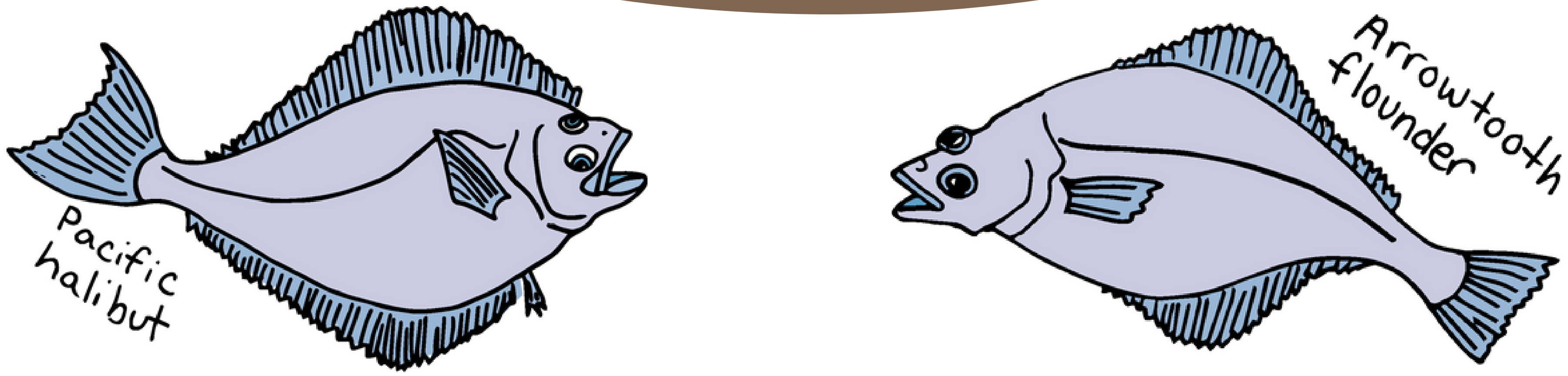
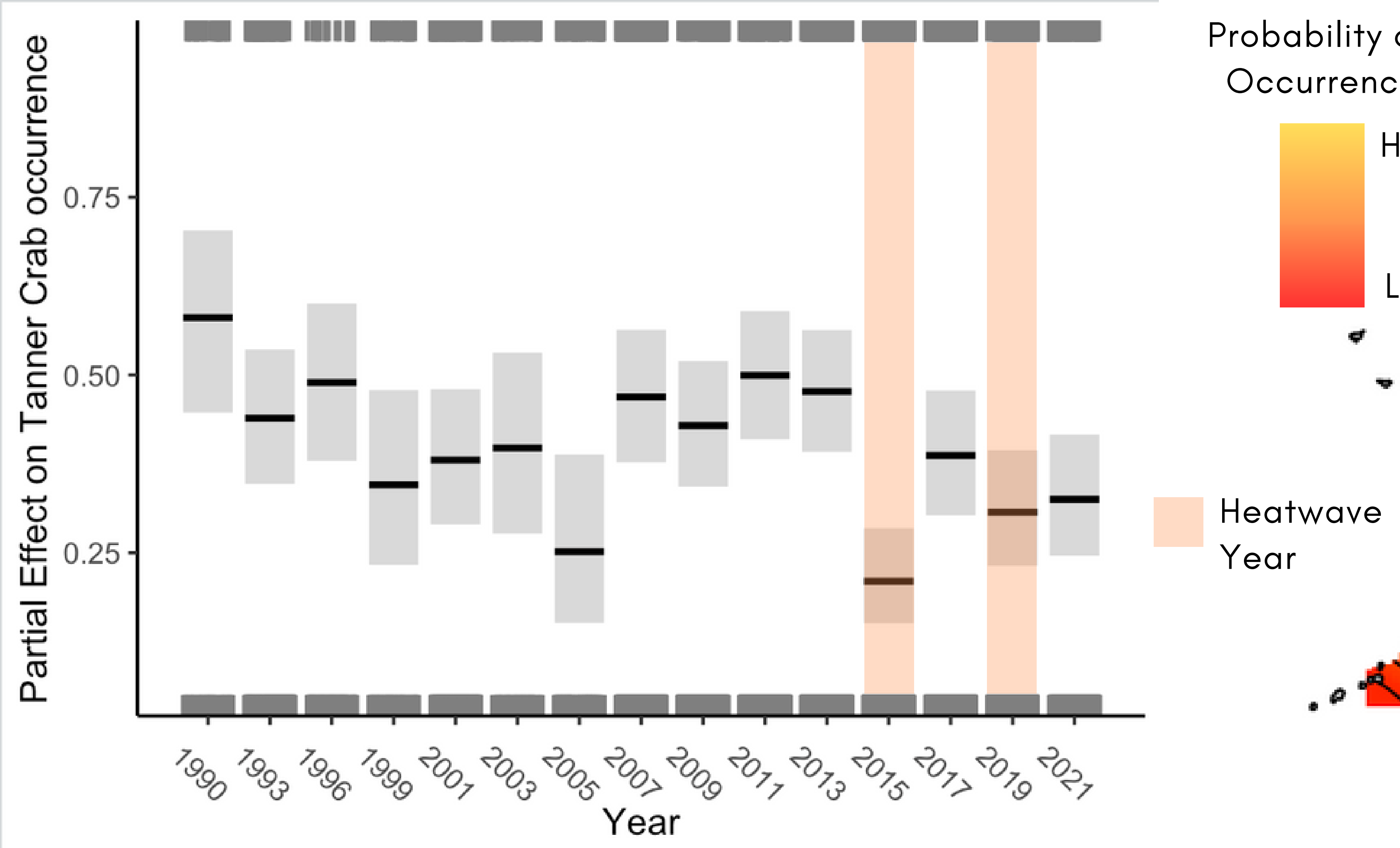
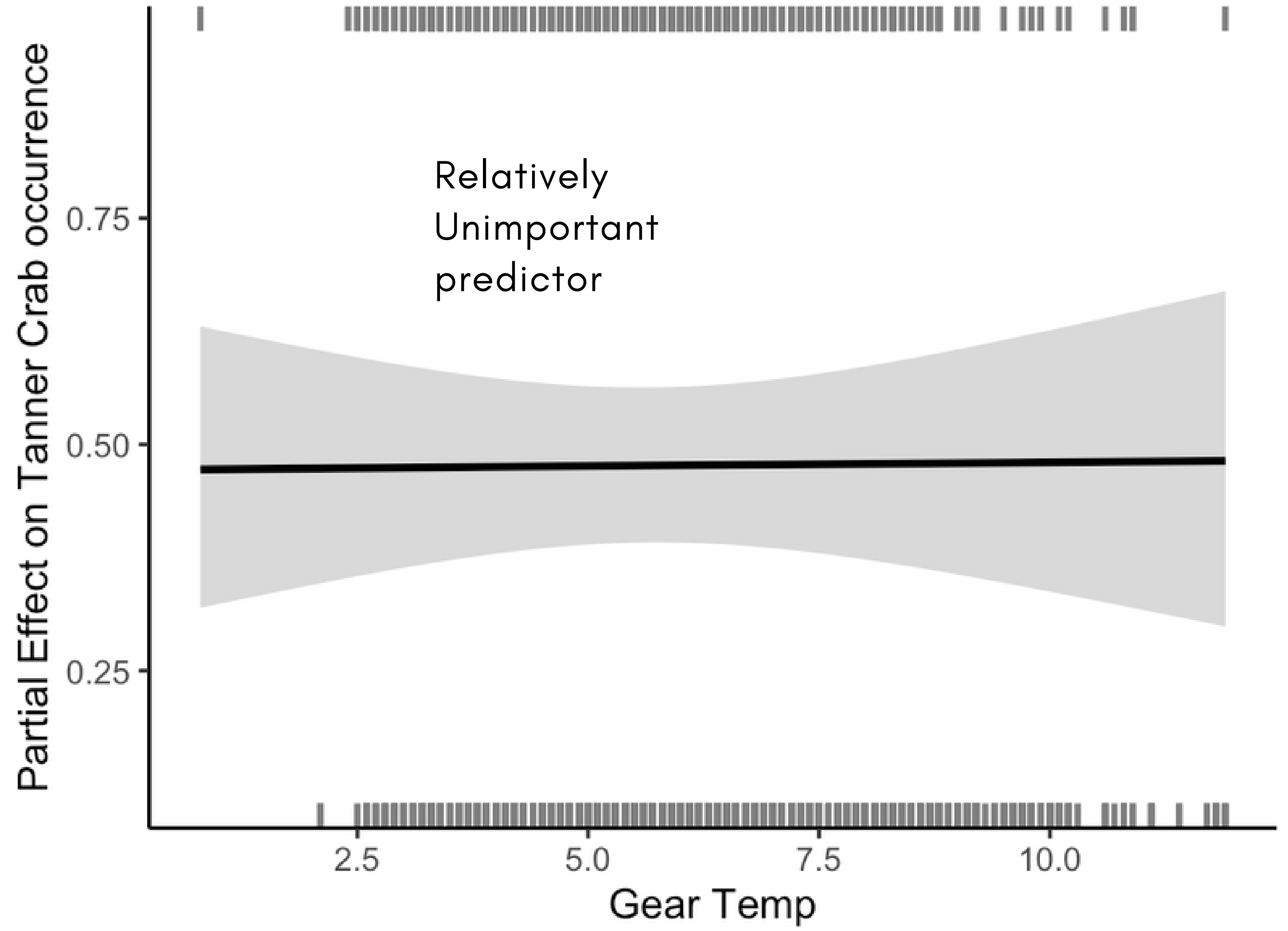
Clupeidae & Osmeridae Prey Occurrence

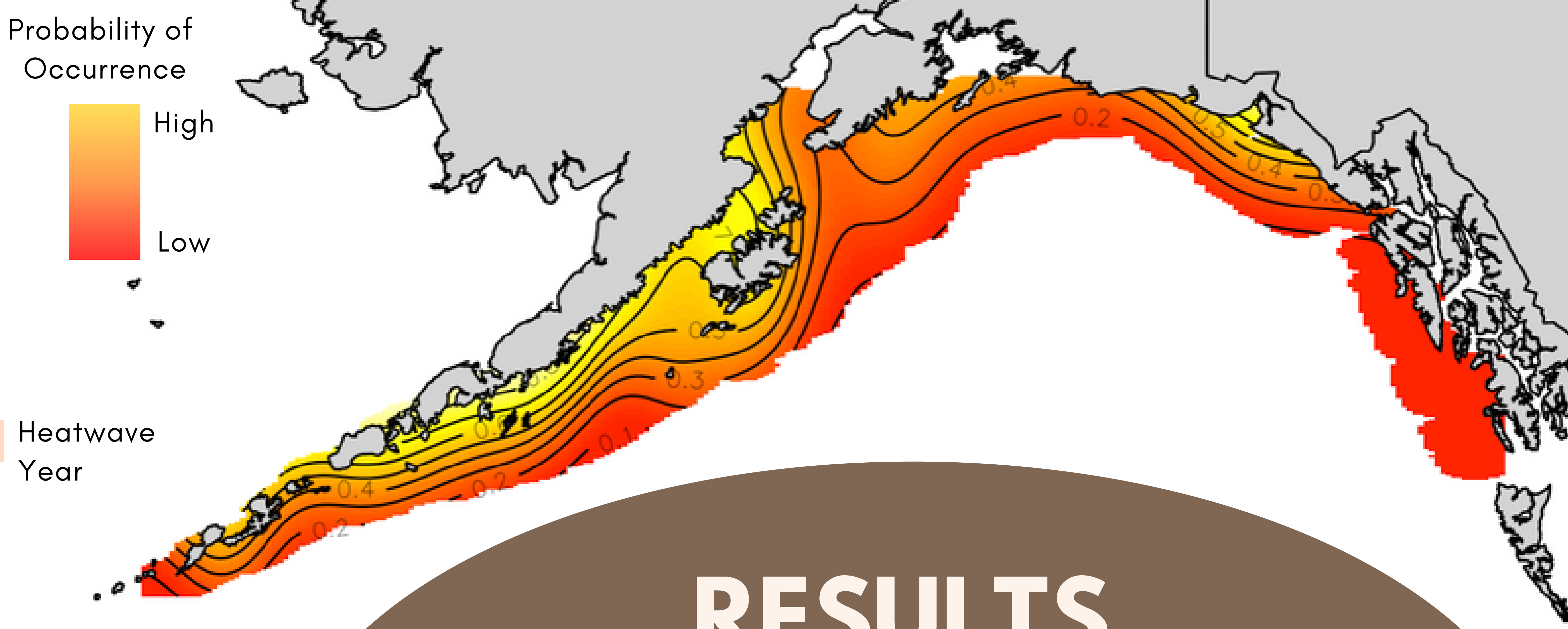






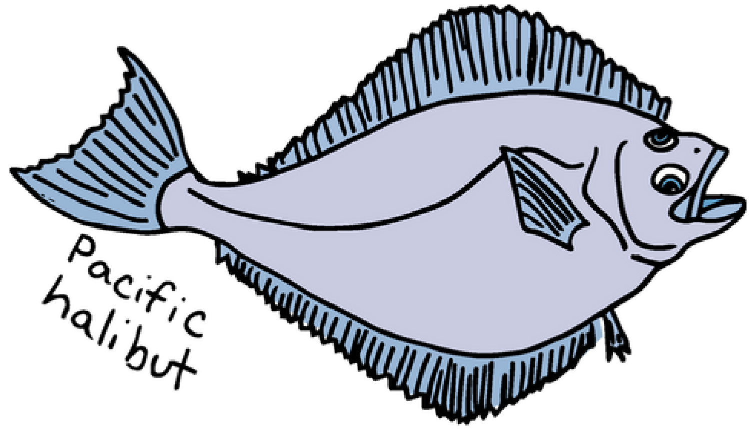


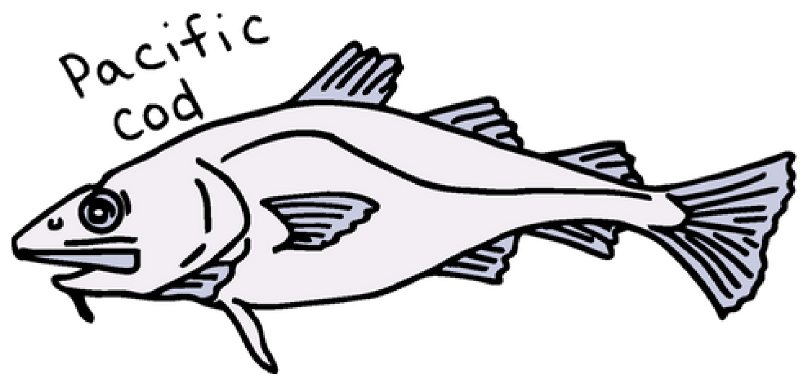




RESULTS

Tanner Crab
Prey Occurrence





METHODS

Model Fitting & Diagnostics

1. Overdispersion
    a. Compare residual deviance : df
2. Zero inflation
    a. Remove empty stomachs
3. Independence
    a. Group predators from haul
4. Multicollinearity/Concurvity
    a. Correlation matrix for numeric predictors
5. Overfitting
    a. Limit knots (k) in smooth function
6. Choosing best fit model
    a. Compare AIC from alternative models