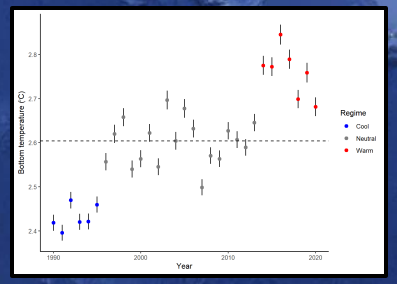
Size-specific spatial distribution of Pacific Cod in the Gulf of Alaska

Claire Rosemond, Lorenzo Ciannelli, Lauren Rogers, Pete Hulson, Kally Spalinger, Albert Hermann, and Ingrid Spies

PICES 2024

Background

Project overview



Environmental data

Survey data

Google Earth

Project overview

Project overview

Pacific Cod management areas

Pacific Cod are found in the coastal North Pacific Ocean

In the United States, Pacific Cod are assessed as four stocks

Recent genetic studies suggest there may be genetically distinct populations of Pacific Cod within management areas

Recent tagging studies suggest that individuals are moving between management areas

Pacific Cod spatial population dynamics

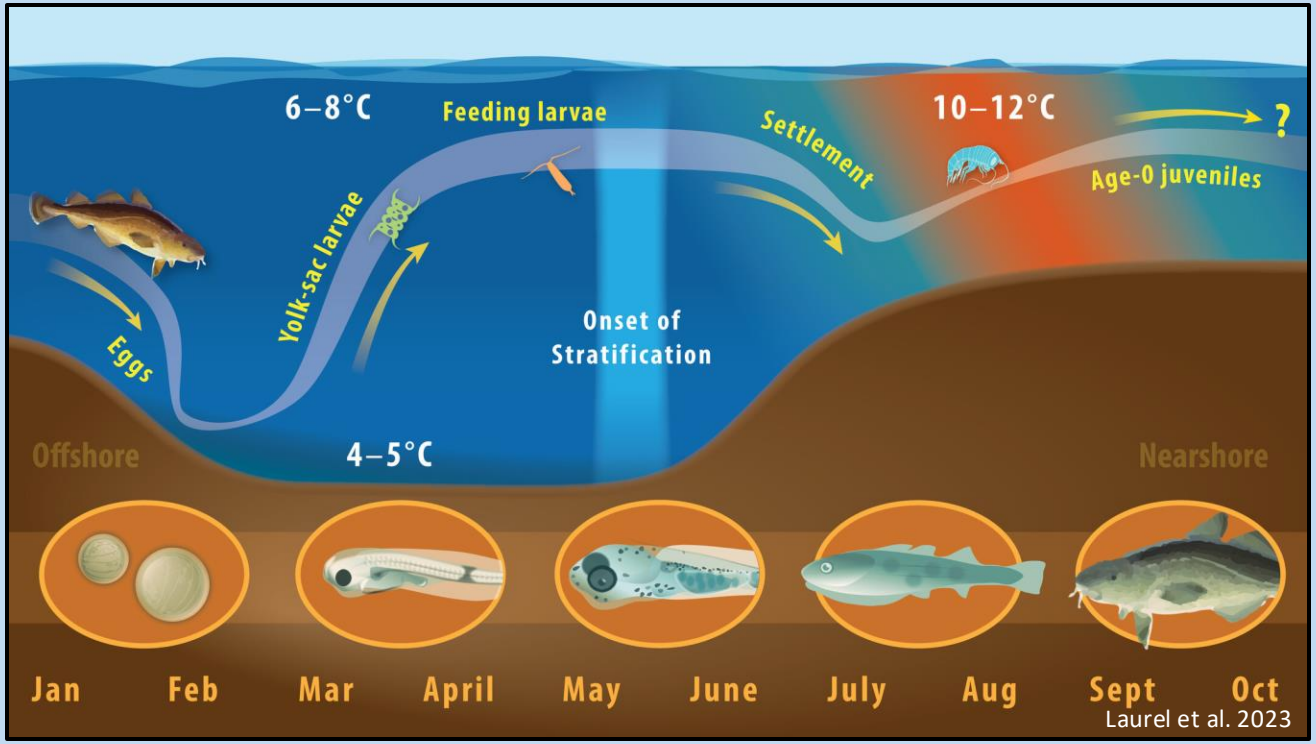
Pacific Cod move seasonally from the deeper spawning grounds in the winter to shallower feeding grounds in the summer

Pacific Cod shift habitats throughout their ontogeny:

Adults release eggs in deeper water on substrate at the bottom

Larvae are pelagic

Juveniles settle in shallow, coastal nursery areas and then transition to deeper waters as they age



Laurel et al. 2023

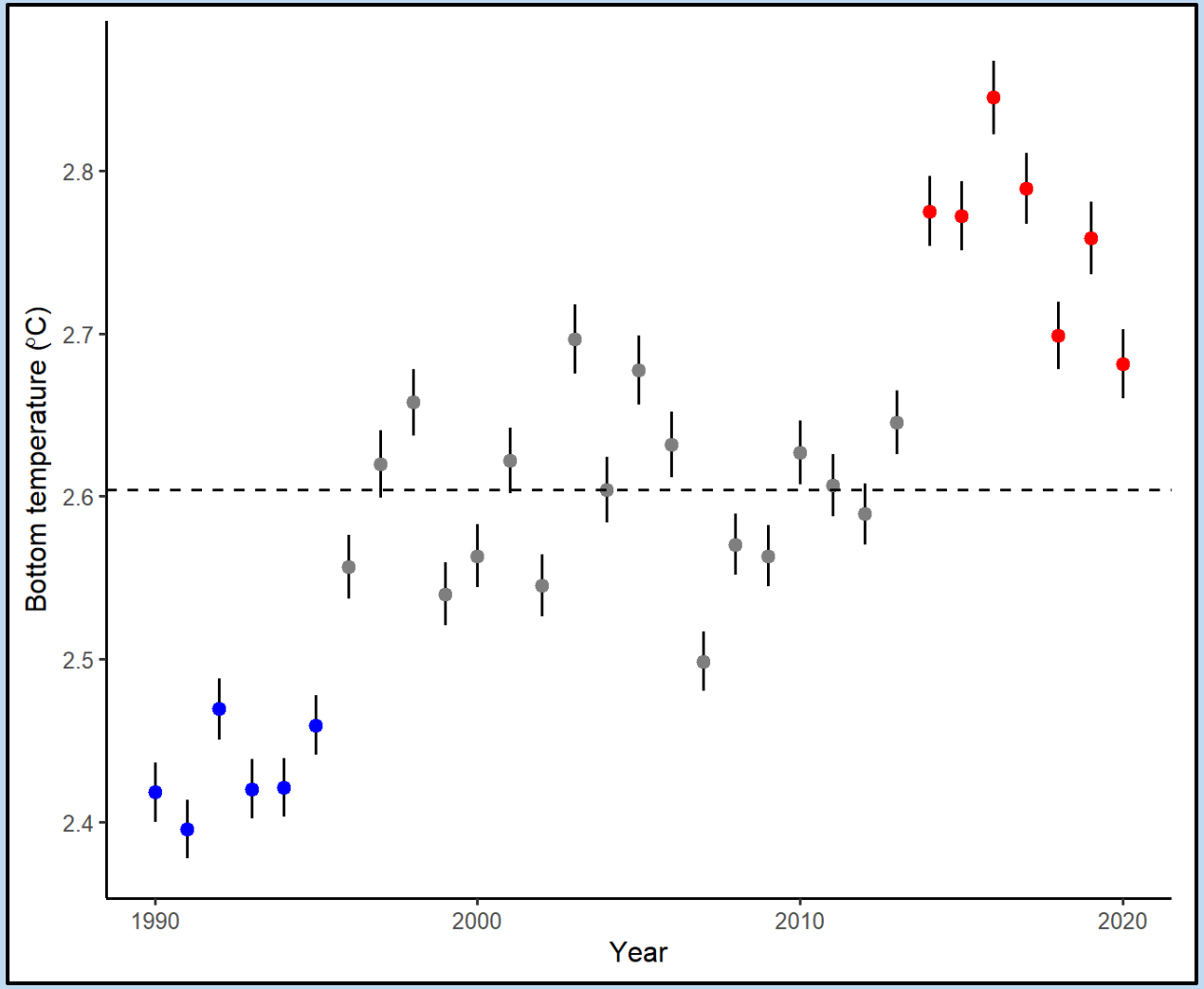
Winter

Summer

Ecological shifts in the GOA

Summer bottom temperature has increased over the last three decades

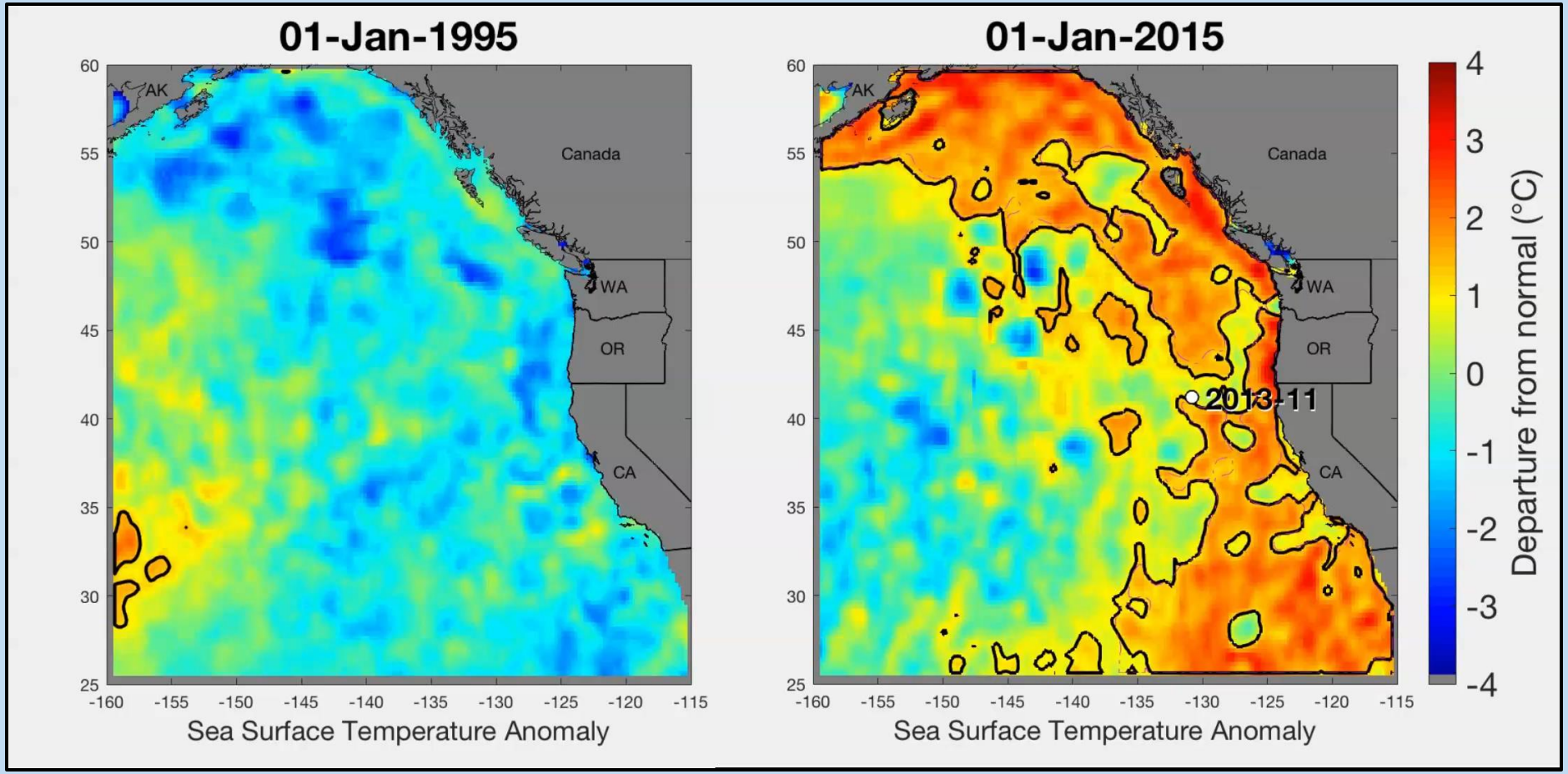
Regimes characterized by cooler, neutral, and warmer temperatures



Ecological shifts in the GOA

Cool regime

Warm regime

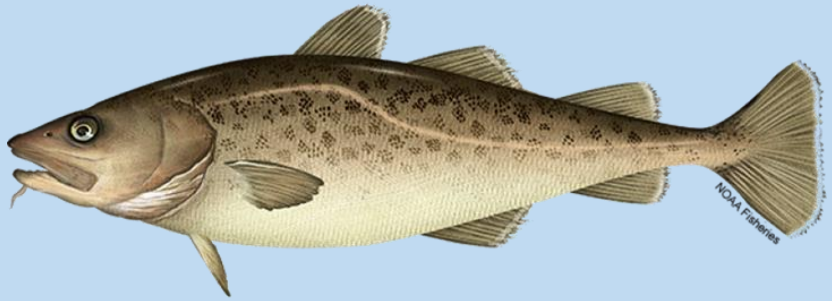


Videos: NOAA California Current Marine Heatwave Tracker

Impacts of ecological change on Pacific Cod

Adults:

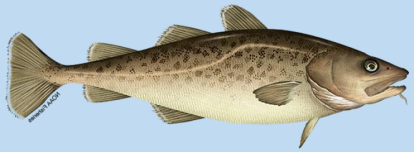
Decline in adult biomass led to the closure (in 2020) of fishery in the Gulf of Alaska



Early life history stages (larvae, juveniles):

Compression of potential spawning habitat (Laurel & Rogers 2020)

Larvae hatched earlier (Almeida et al. 2024; Miller et al. 2024)



Potential juvenile nursery habitat increased and shifted offshore (Laurel et al. 2023)

Fewer juveniles arriving to the nearshore (Abookire et al. 2021; Almeida et al. 2024)

Research questions

How do environmental conditions and habitat affinity influence the **spatial and temporal dynamics of Pacific Cod biomass density** at multiple life history stages?

When deciding how to **define a stock boundary** for assessment and management, how can we account for spatial and temporal population dynamics?

Methods

Pacific Cod catch per unit effort (CPUE) data

Fishery-independent survey data:

NOAA NMFS Groundfish Bottom Trawl Survey

ADF&G Large-mesh Bottom Trawl Survey

NOAA NMFS/ADF&G Small-mesh Bottom Trawl Survey

Pacific Cod catch per unit effort (CPUE) data

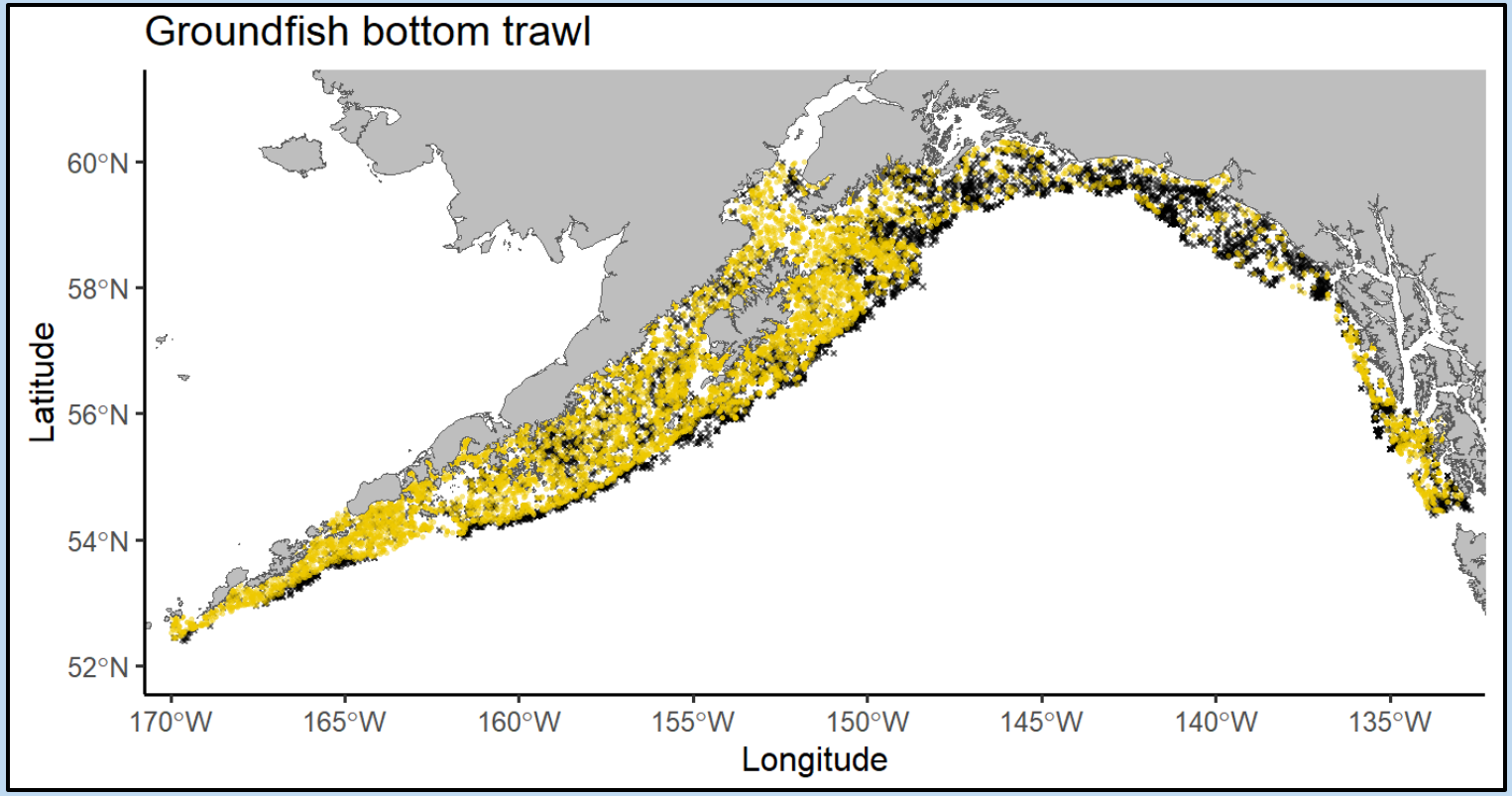
Fishery-independent survey data:

NOAA AFSC Groundfish Bottom Trawl Survey

- **Stratified random sampling along the continental shelf and upper slope**

ADF&G Large-mesh Bottom Trawl Survey

NOAA AFSC/ADF&G Small-mesh Bottom Trawl Survey



Pacific Cod catch per unit effort (CPUE) data

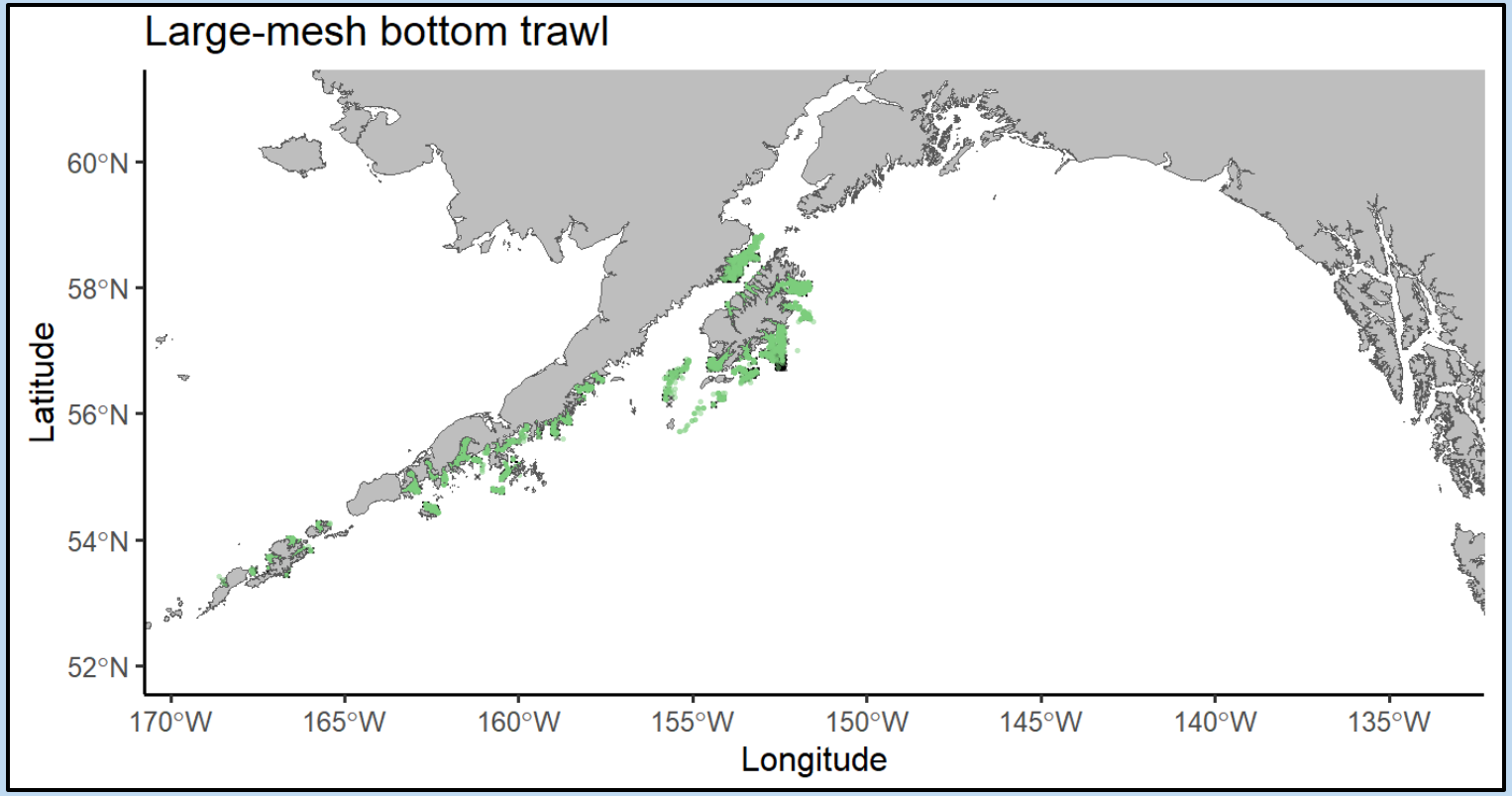
Fishery-independent survey data:

NOAA AFSC Groundfish Bottom Trawl Survey

ADF&G Large-mesh Bottom Trawl Survey

- **Target known Tanner crab habitat**

NOAA AFSC/ADF&G Small-mesh Bottom Trawl Survey



Pacific Cod catch per unit effort (CPUE) data

Fishery-independent survey data:

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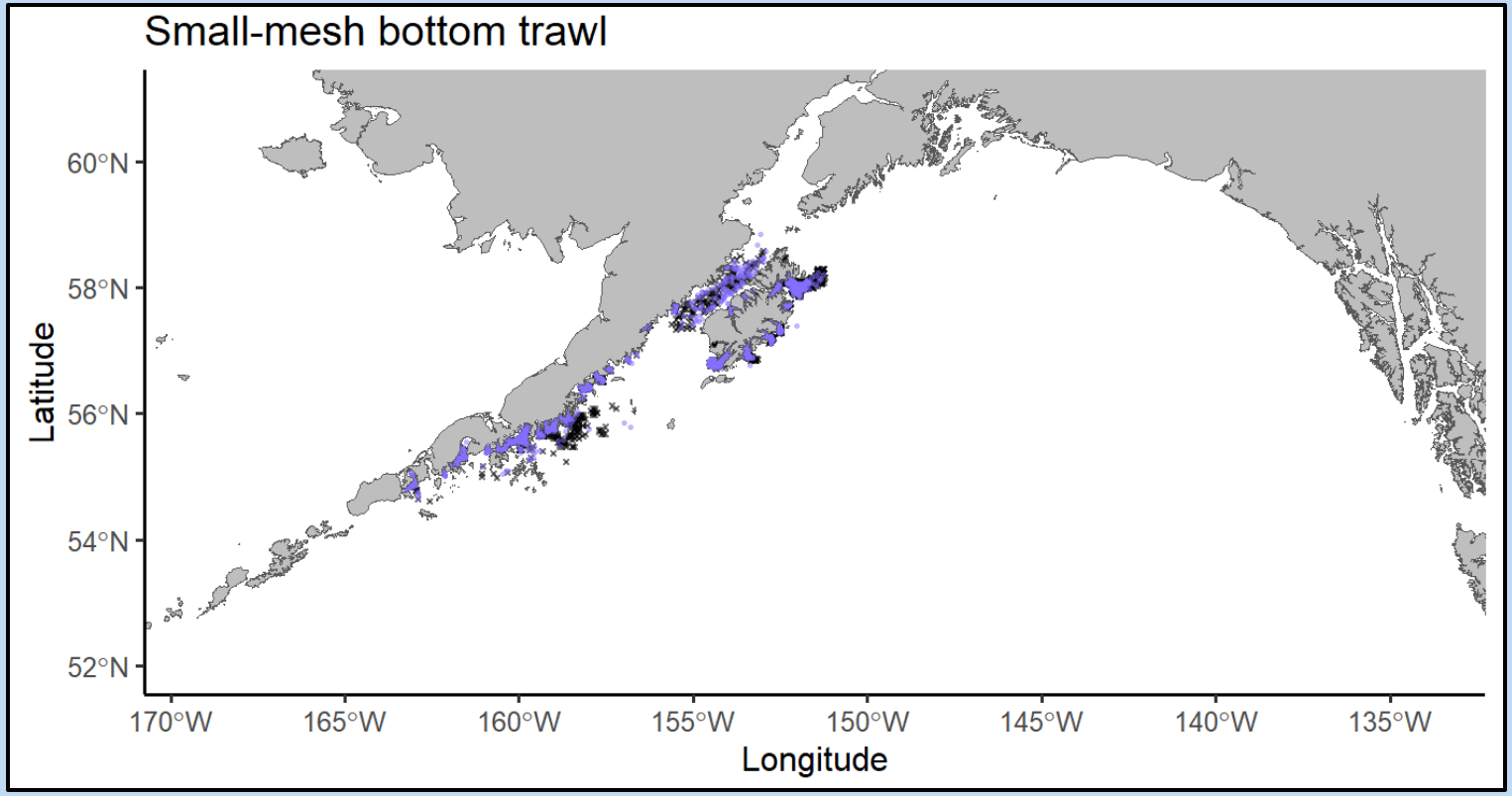
ADF&G Large-mesh Bottom Trawl Survey

NOAA AFSC/ADF&G Small-mesh Bottom Trawl Survey

- **Target known shrimp habitat**

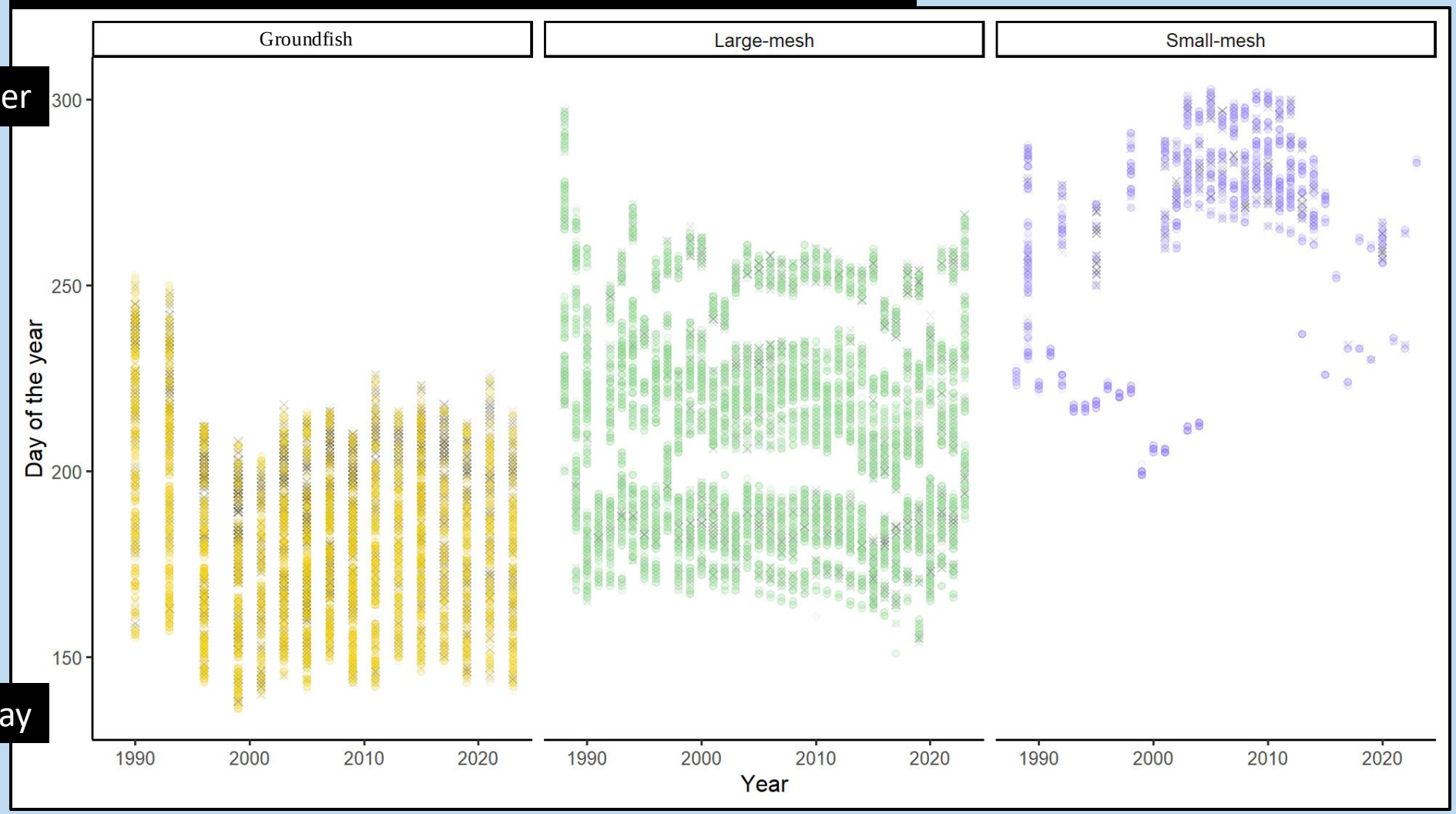


Pacific Cod catch per unit effort (CPUE) data

Seasonal temporal coverage (1990 to 2020)

late October

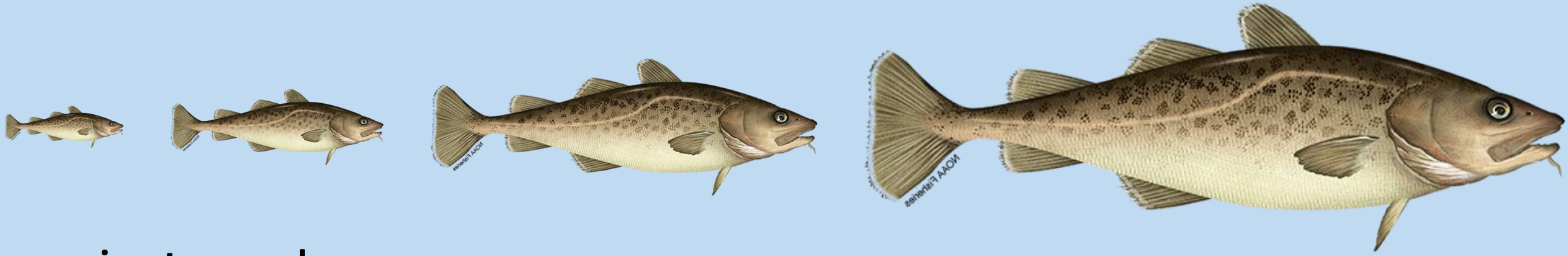
mid-May



Pacific Cod catch per unit effort (CPUE) data

Size bins:

< 10 cm | 10 - 20 cm | 20 - 42 cm | > 42 cm

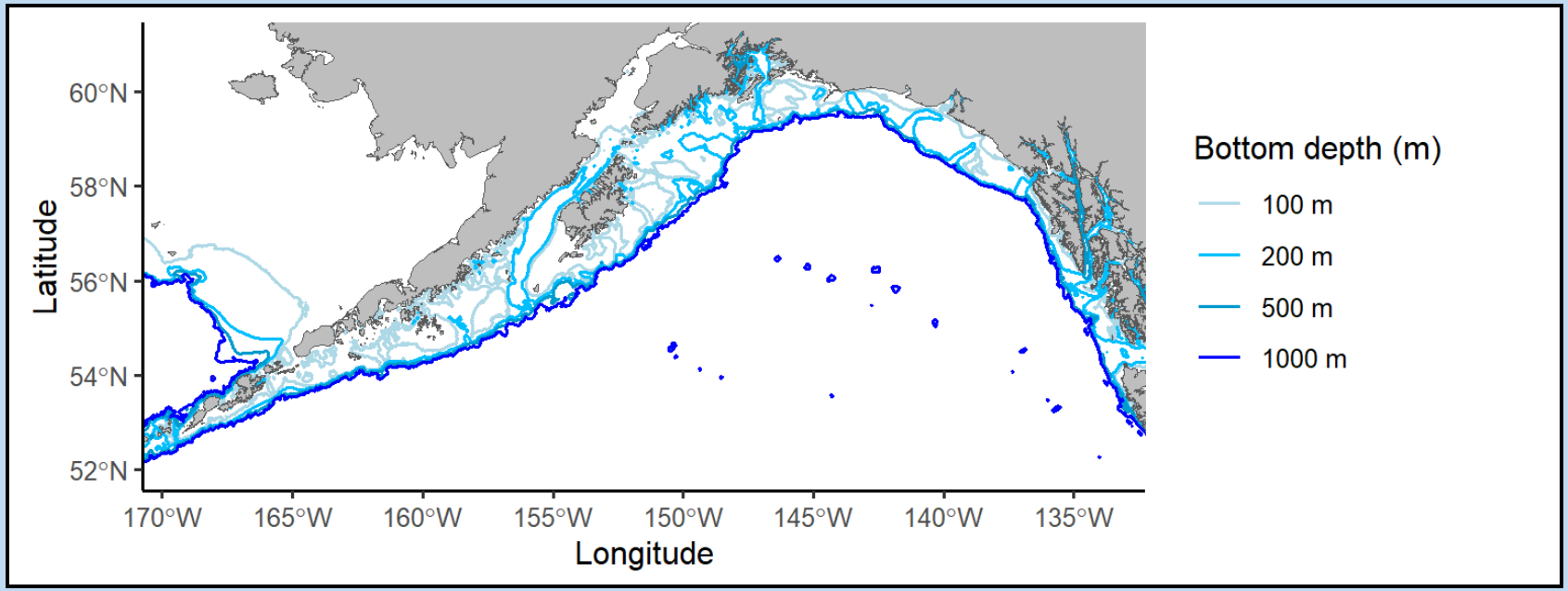


Approximate age classes:

~ Age 0 | ~ Age 1 | ~ Age 2 | ~ Age 3+

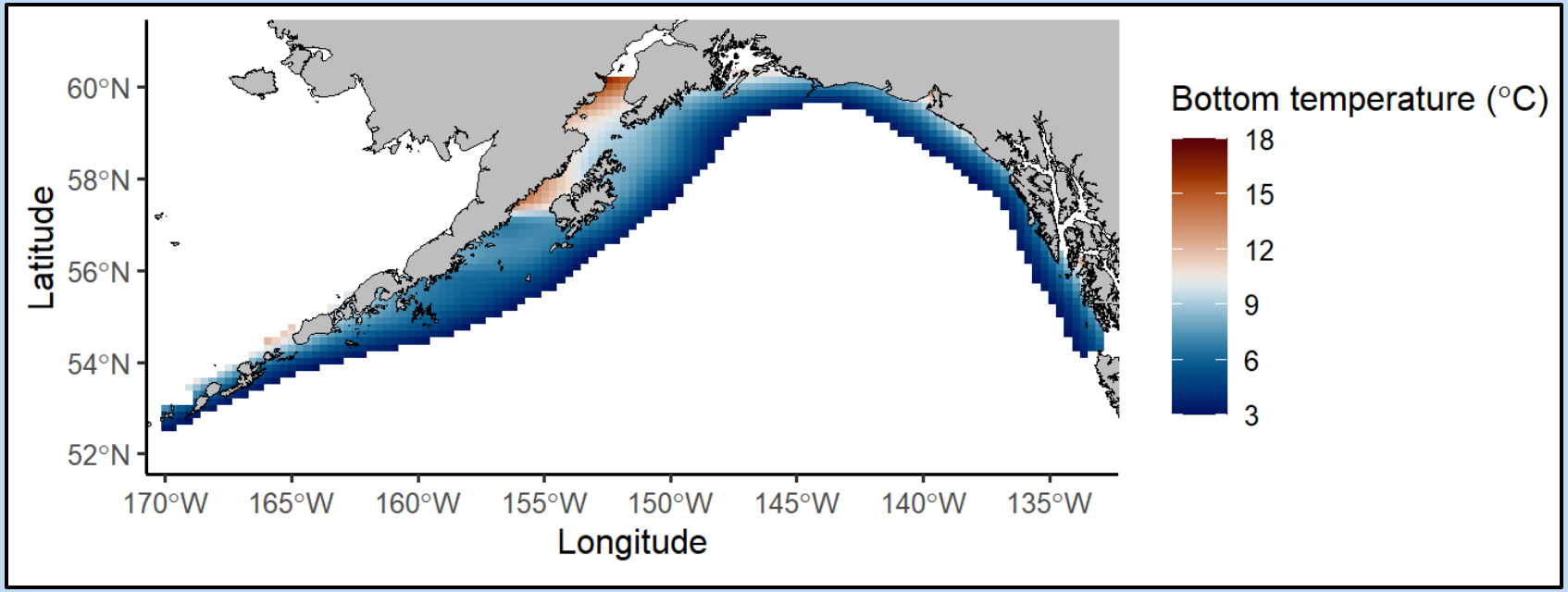
Habitat data and environmental data

Habitat data

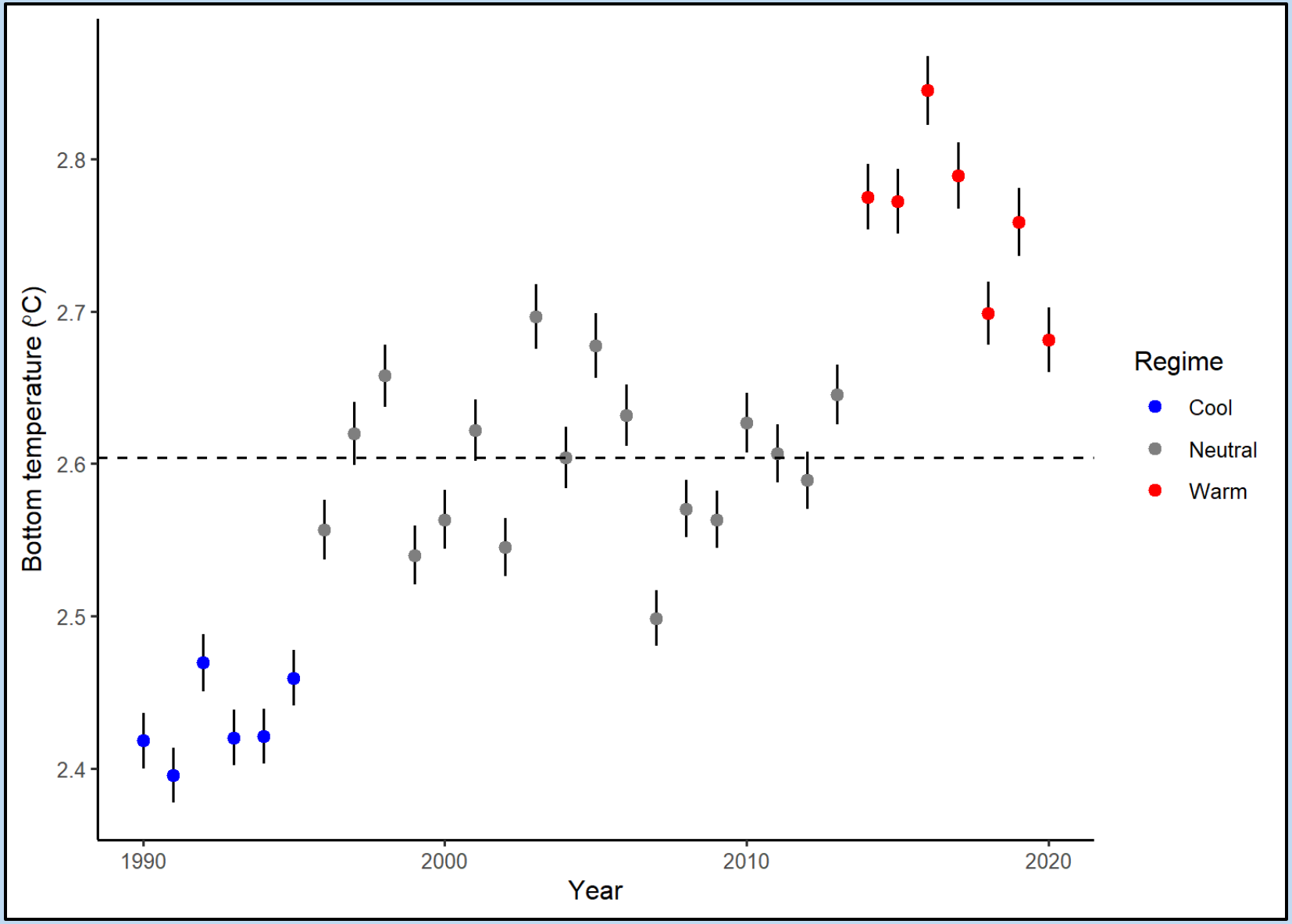


Environmental data

nep 10 km hindcast



Regimes


Bottom temperature (°C)
2.8
2.7
2.6
2.5
2.4
1990
2000
2010
2020
Year
Regime
Cool
Neutral
Warm

Model parameterization

Generalized additive model (GAM)

Response:

ln(CPUE + 1)

Linear term:

Size class * Regime

Random effects:

Year

Survey * Size class

Smooth terms:

Latitude, Longitude * Size class * Regime

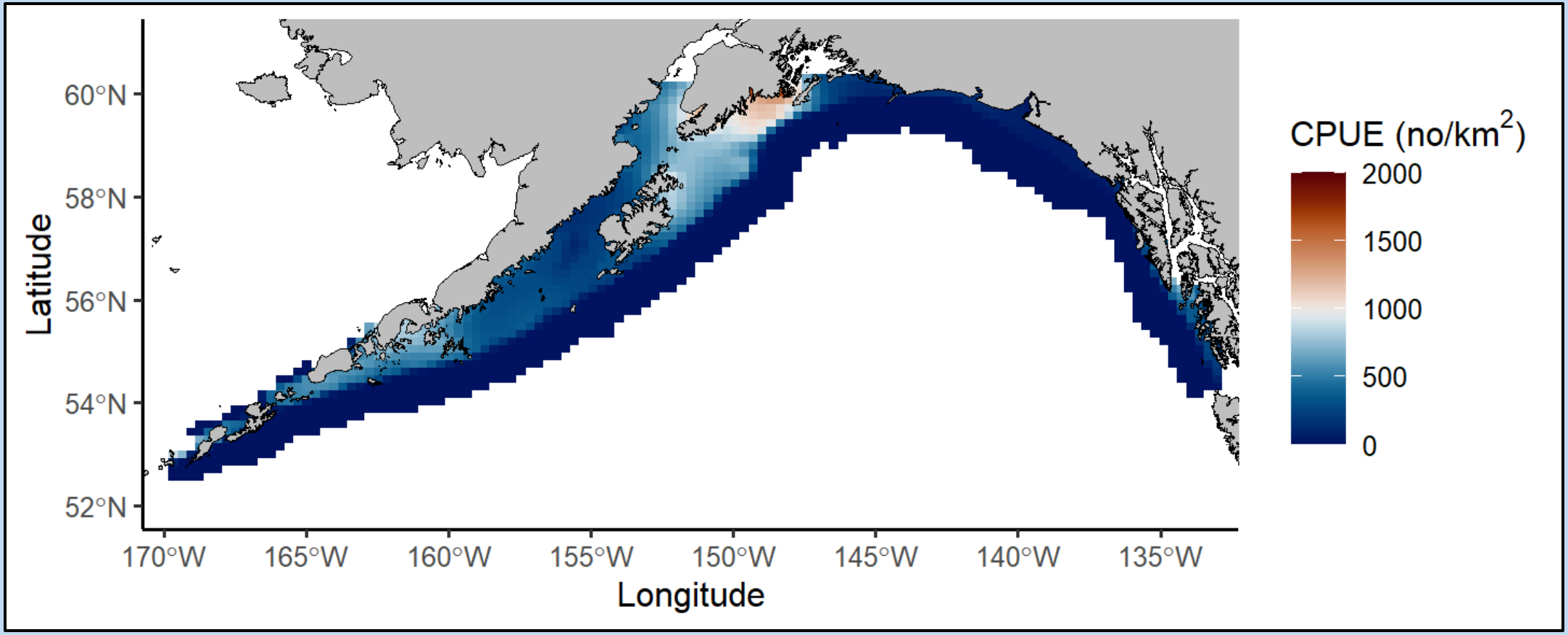
Bottom depth * Size class * Regime

Day of year * Size class

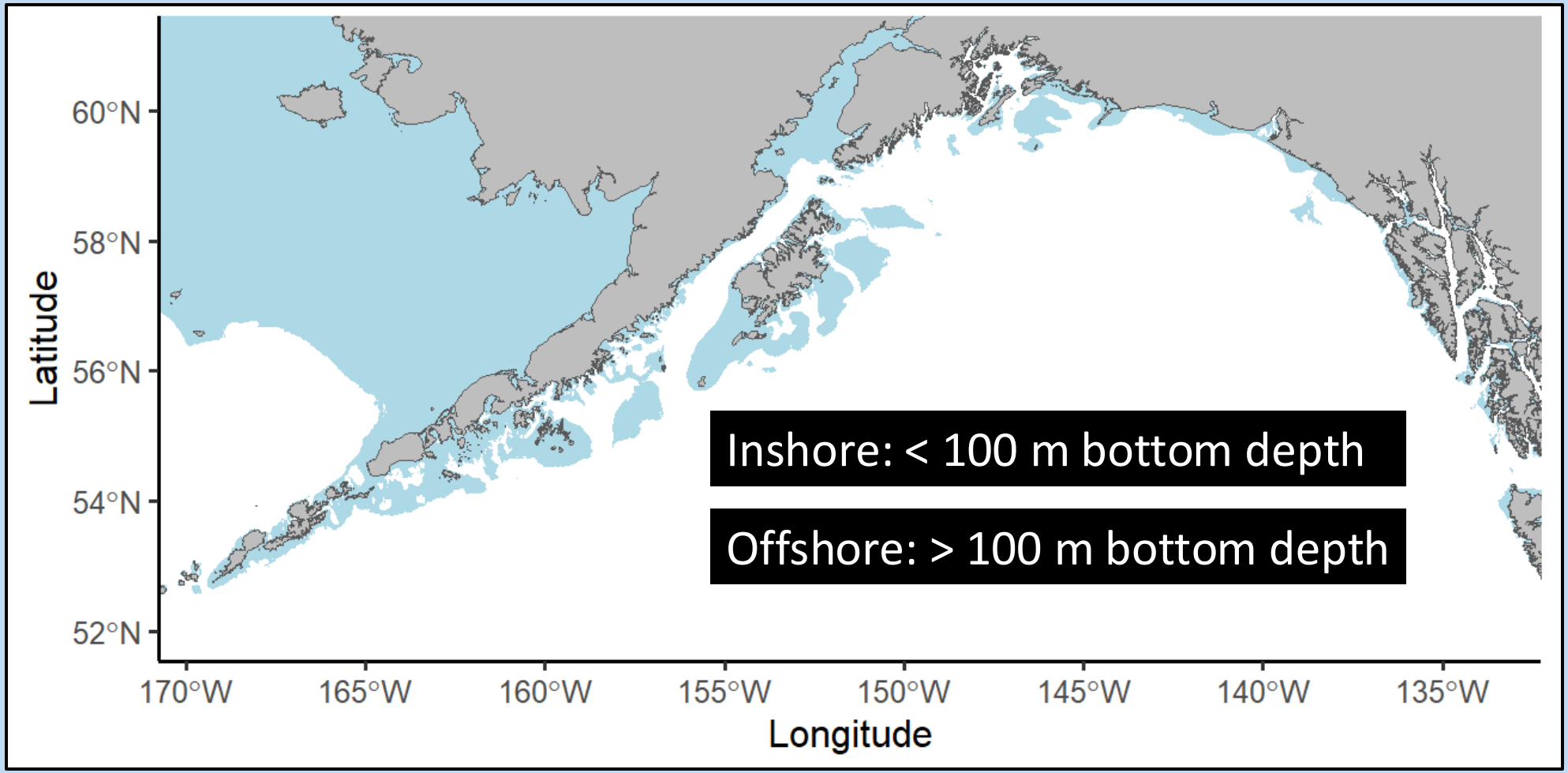
Bottom temperature * Size class

Deviance explained: 66.4%

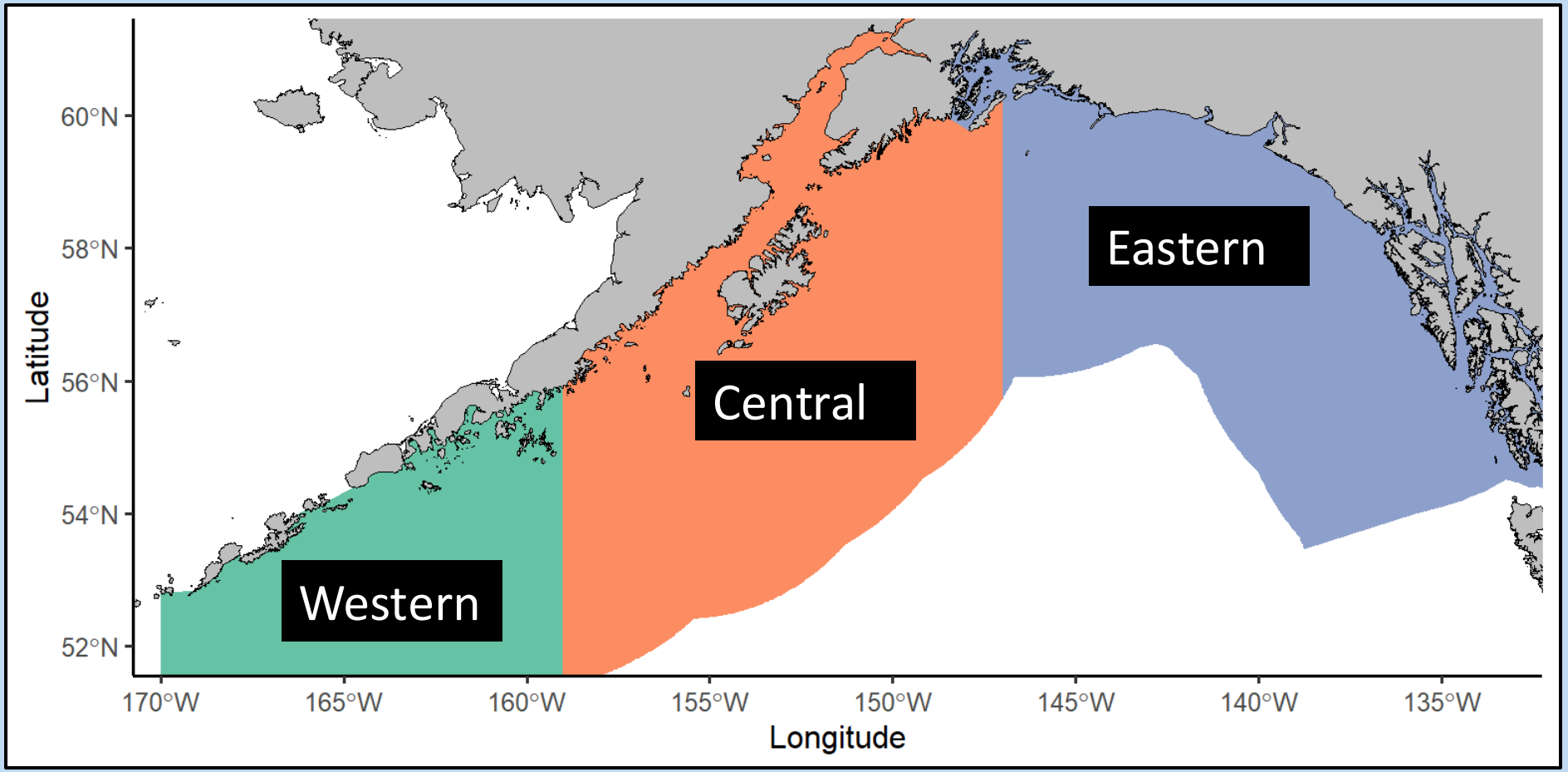
Model predictions



Habitat affinity



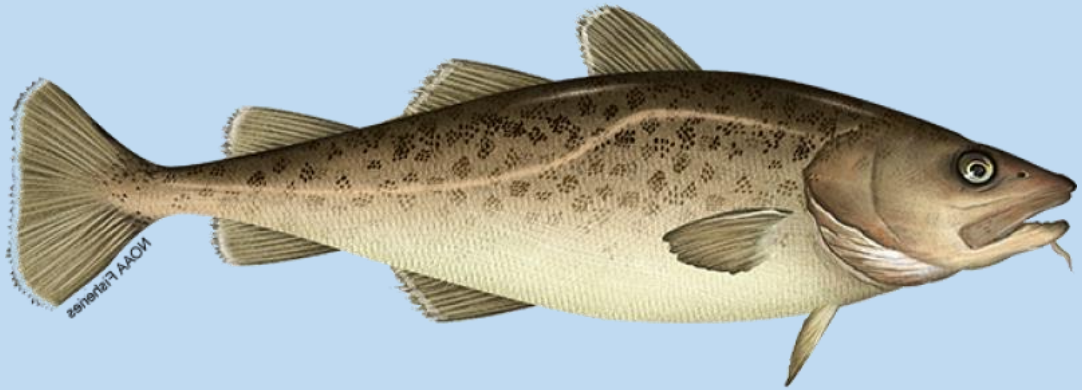
Spatial distribution across the GOA



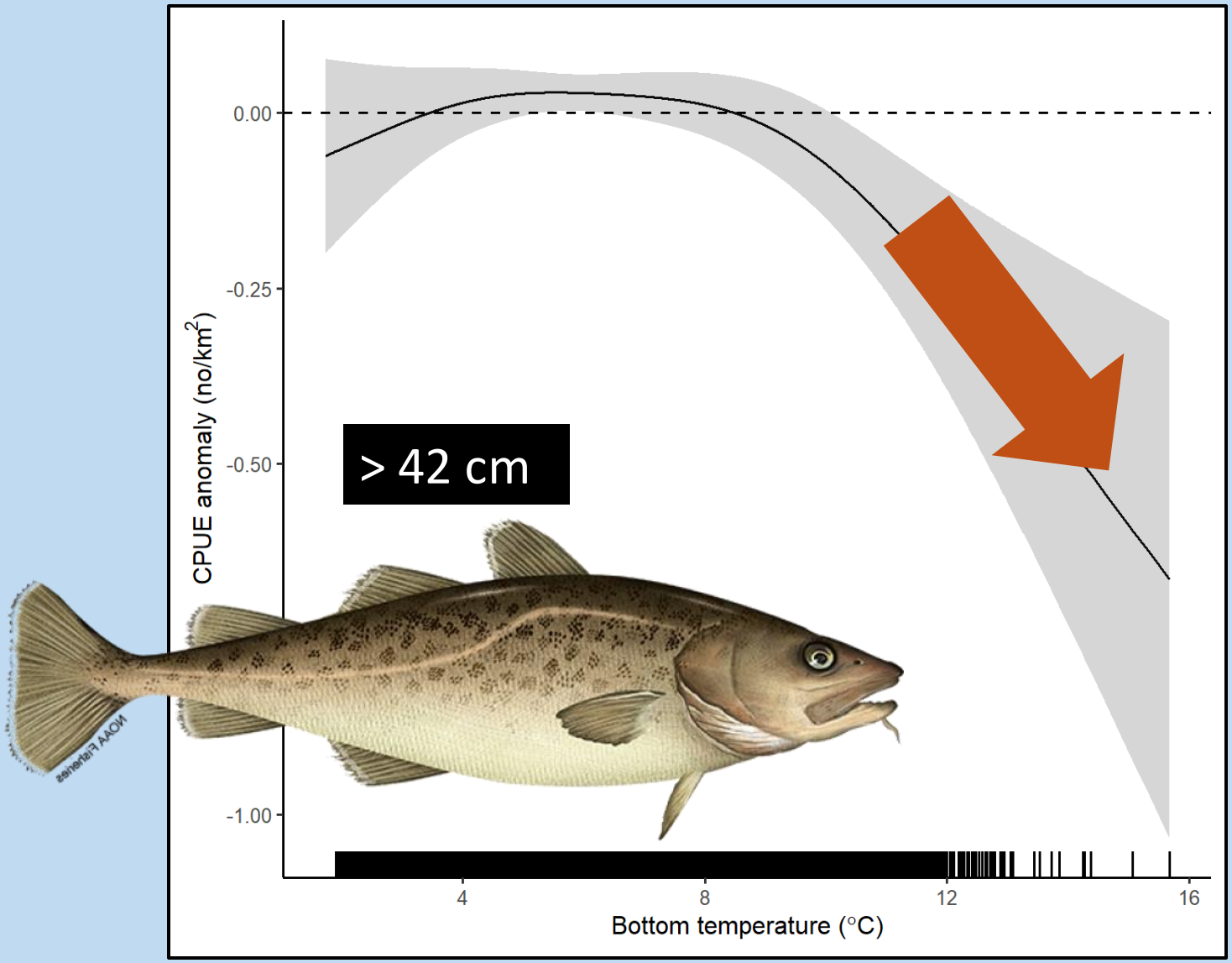
Preliminary Results

Largest size class

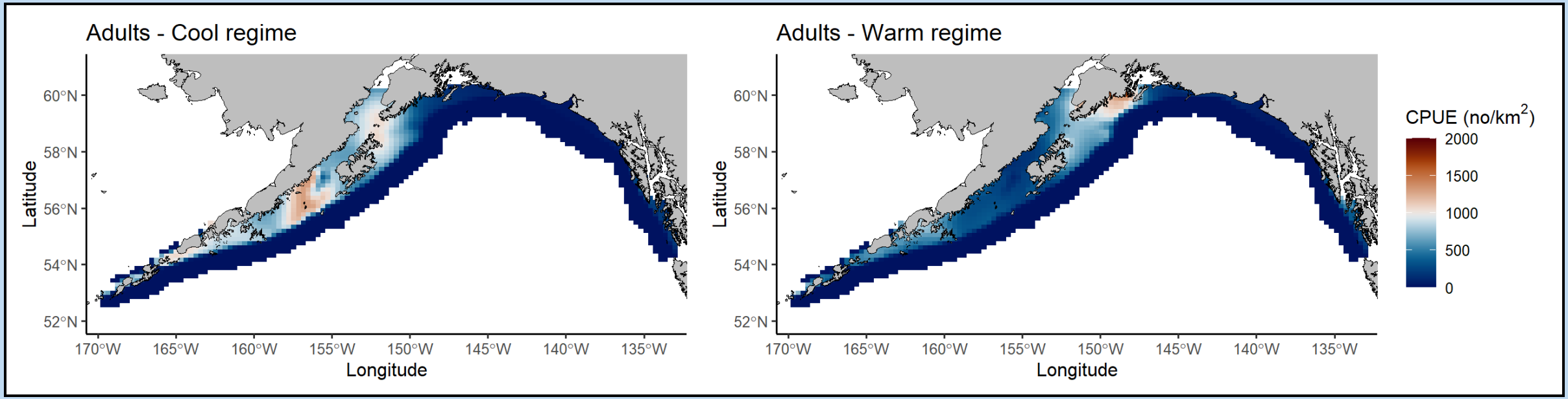
> 42 cm



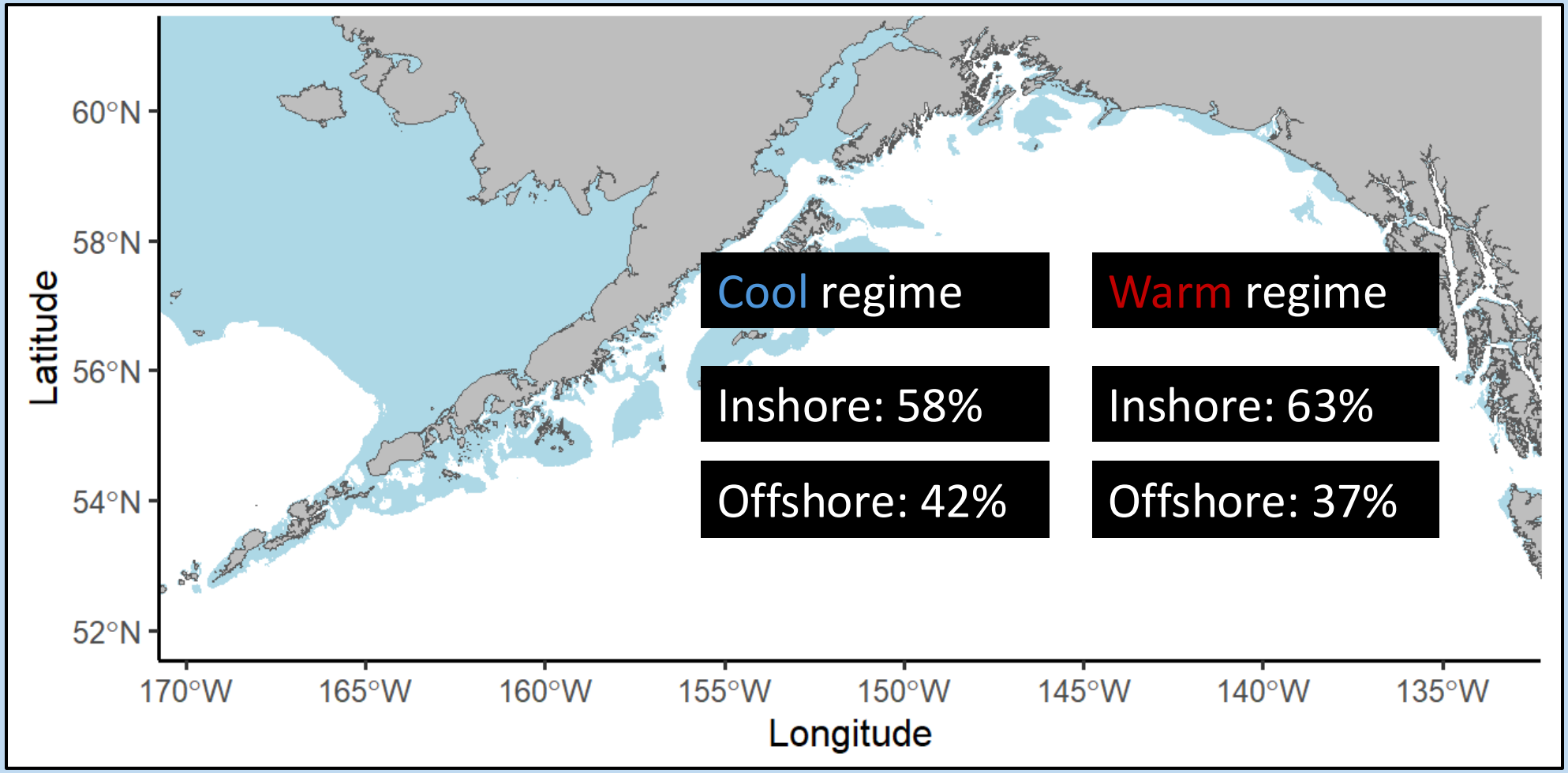
Response to temperature: largest size class



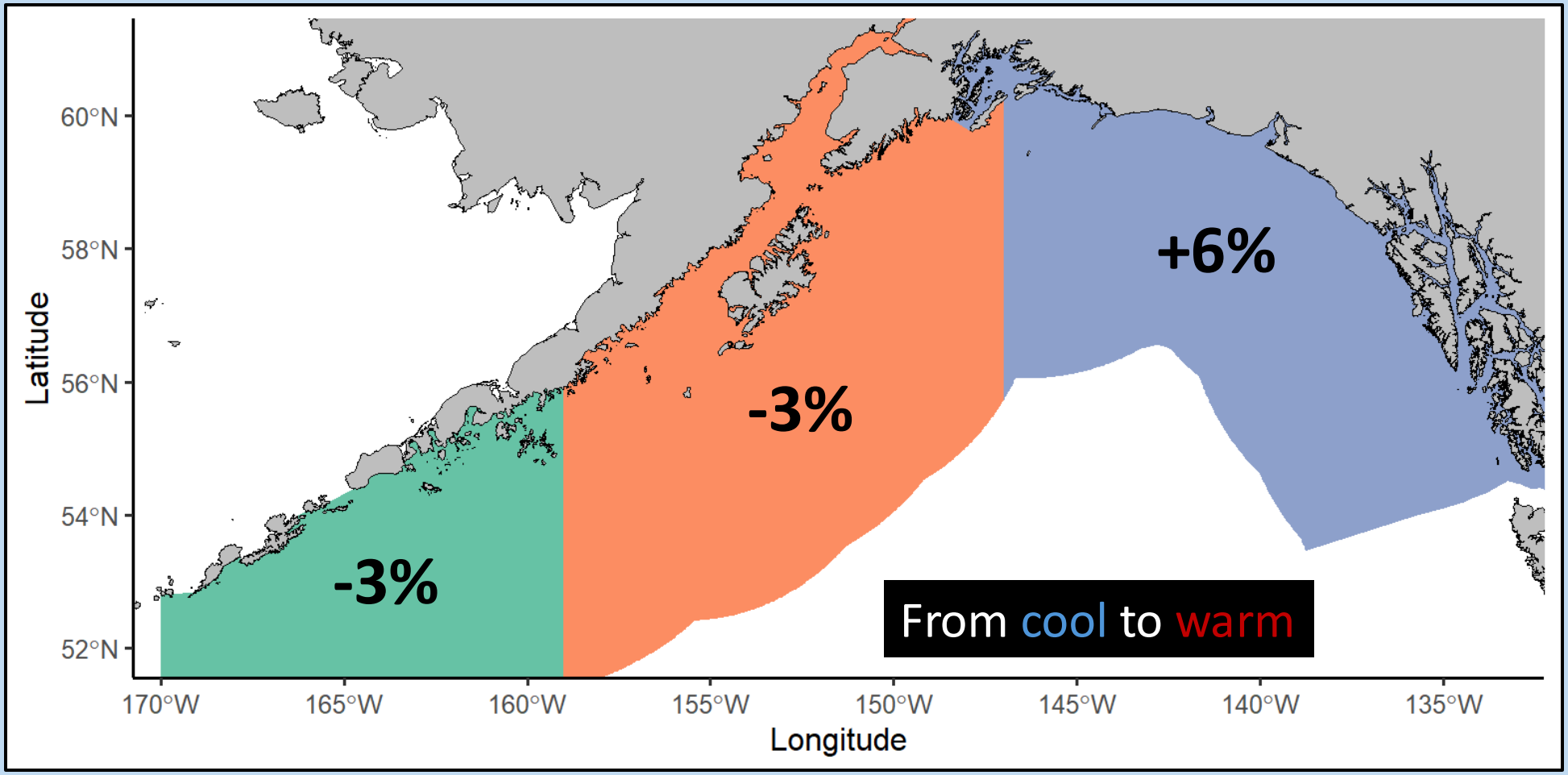
Spatial distribution: largest size class



Habitat affinity: largest size class



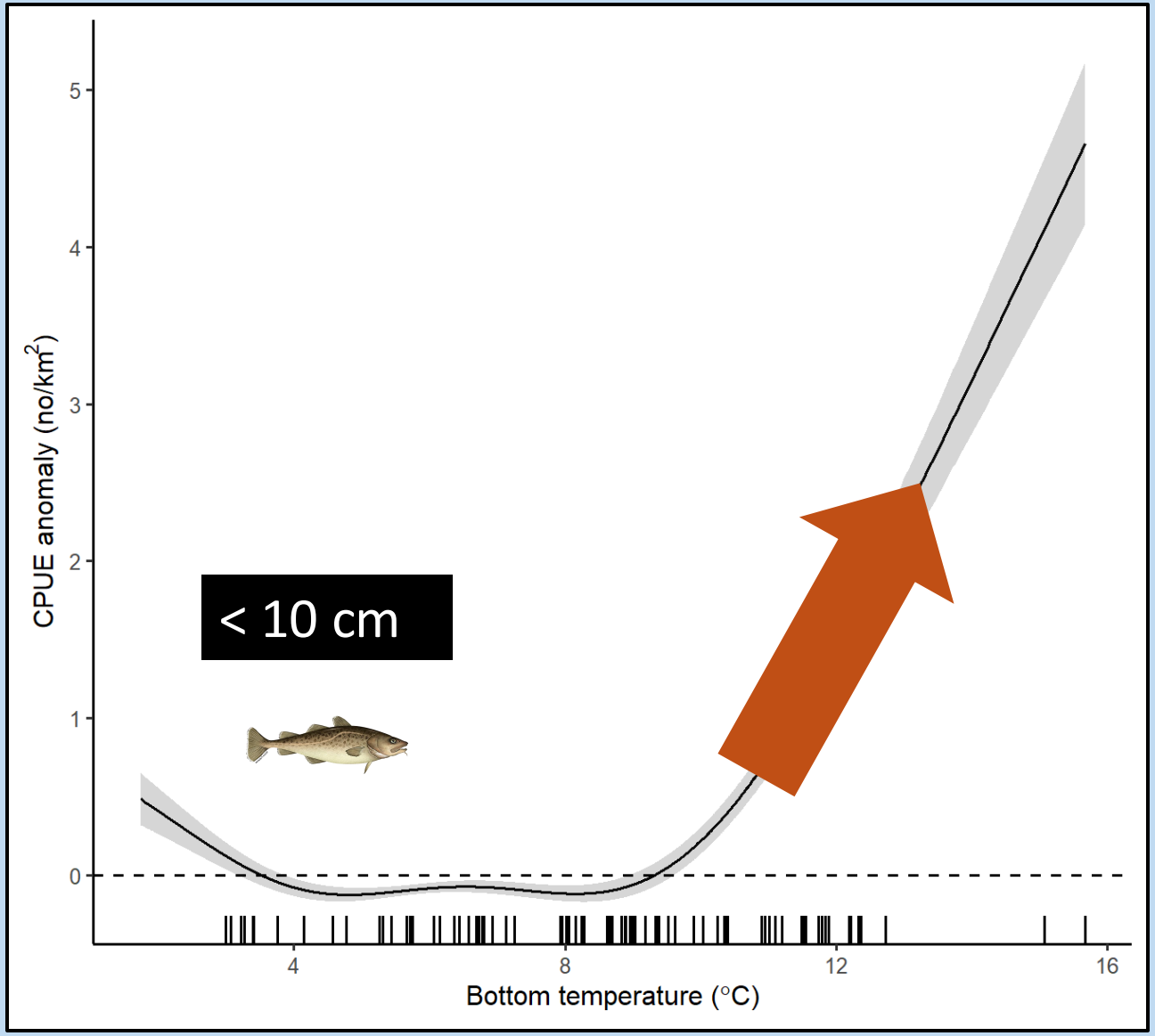
Across the GOA: largest size class



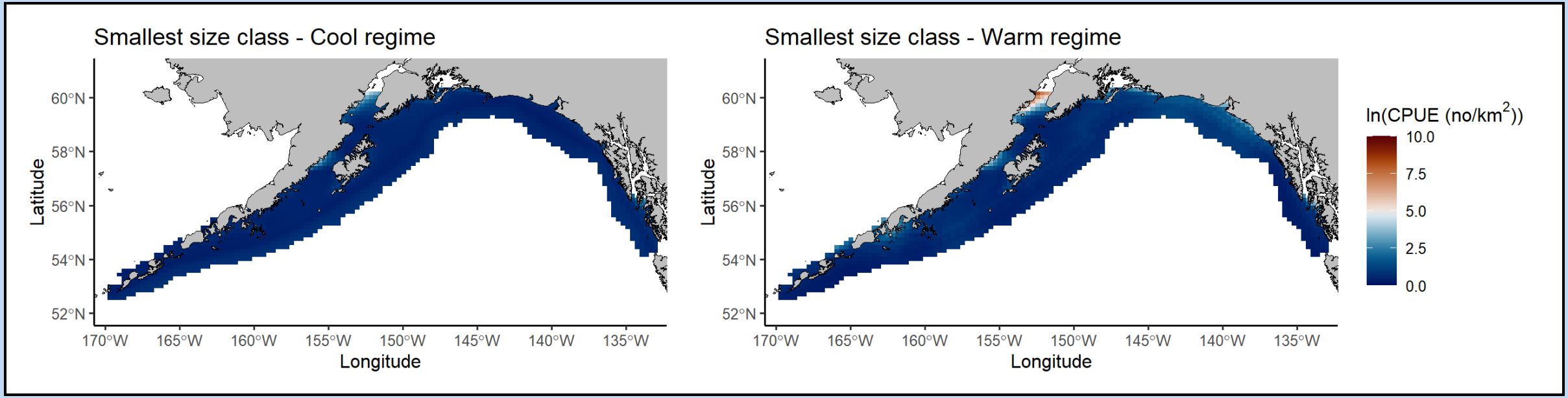
Smallest size class

< 10 cm

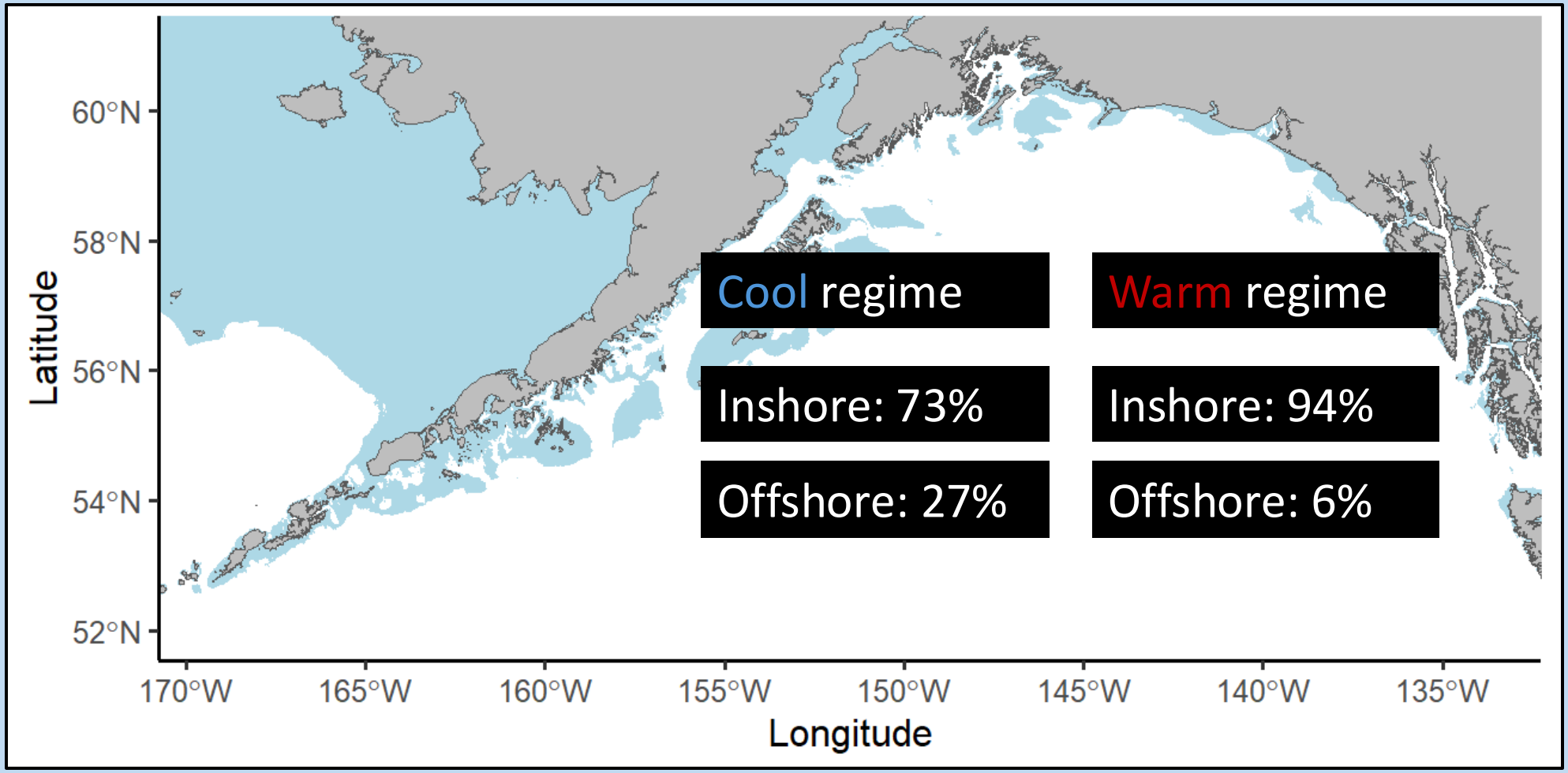
Response to temperature: smallest size class



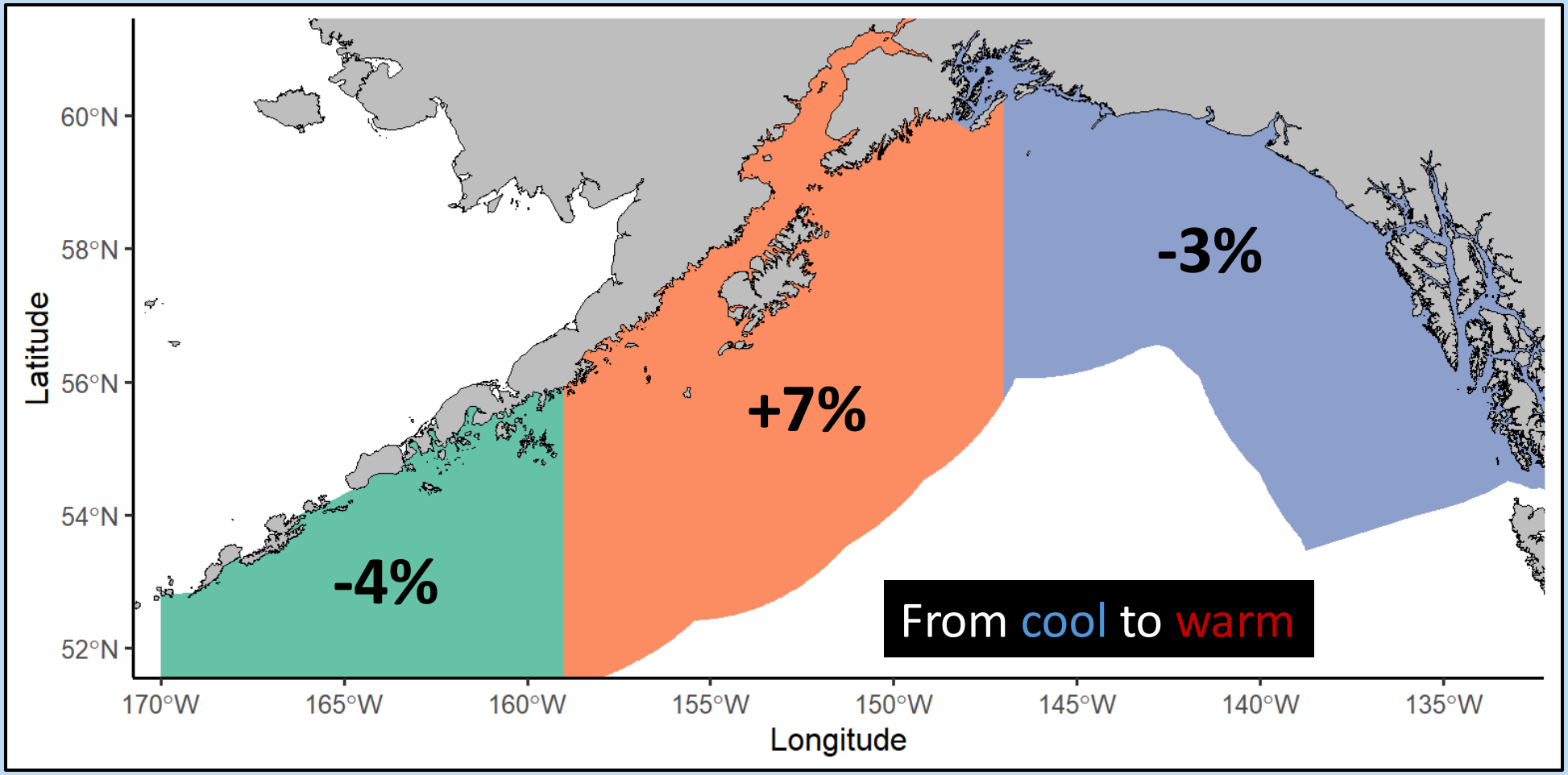
Spatial distribution: smallest size class



Habitat affinity: smallest size class



Across the GOA: smallest size class



Discussion

Research questions

How do environmental conditions and habitat affinity influence the **spatial and temporal dynamics of Pacific Cod biomass density** at multiple life history stages?

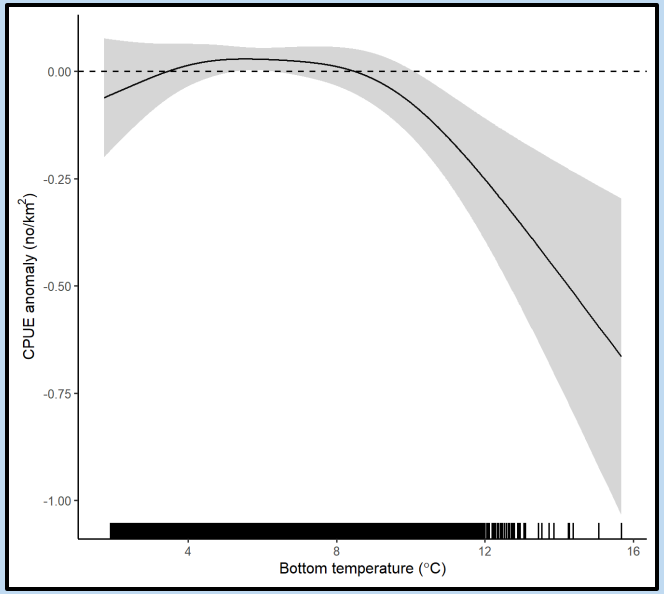
When deciding how to **define a stock boundary** for assessment and management, how can we account for spatial and temporal population dynamics?

Research questions

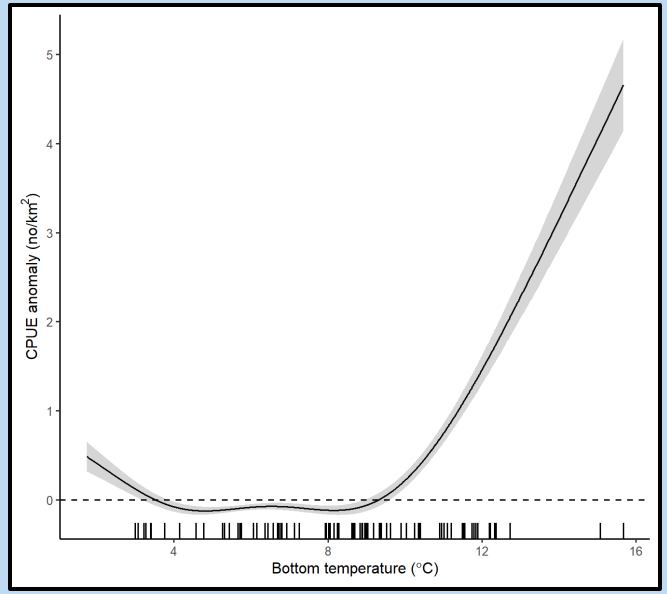
How do environmental conditions and habitat affinity influence the **spatial and temporal dynamics of Pacific Cod biomass density** at multiple life history stages?

- Response in biomass density to temperature differed between life history stages

Largest size class



Smallest size class

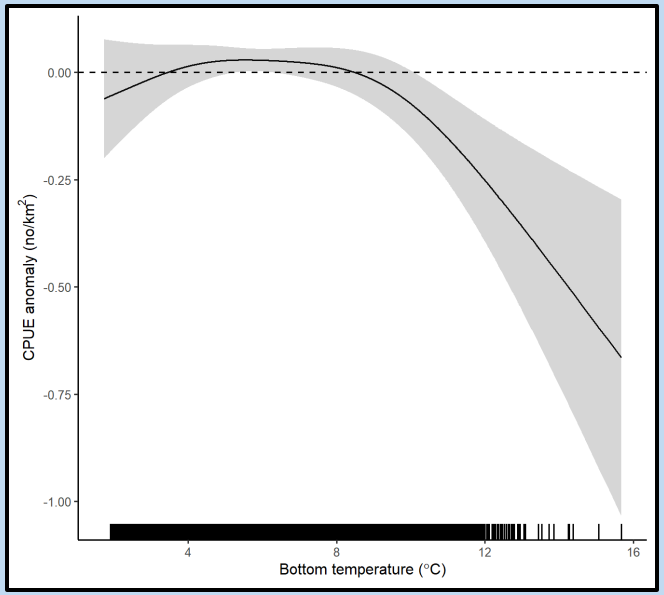


Research questions

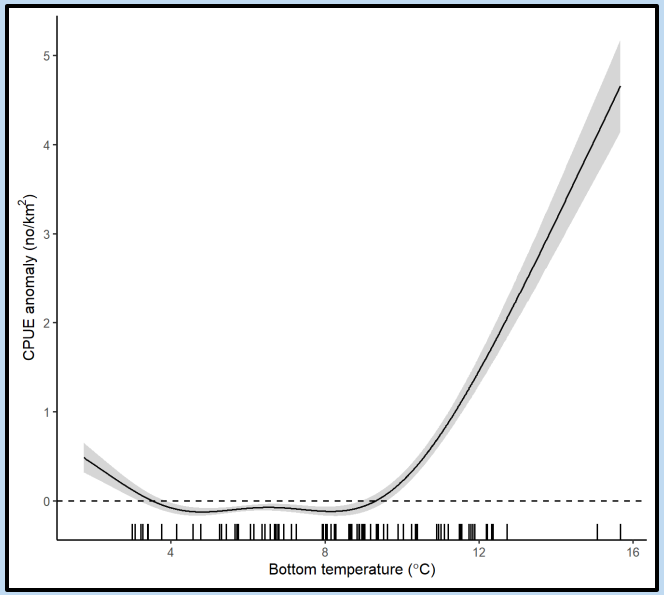
How do environmental conditions and habitat affinity influence the **spatial and temporal dynamics of Pacific Cod biomass density** at multiple life history stages?

- Important for predicting stock status and future recruitment to the fishery

Largest size class



Smallest size class



Research questions

How do environmental conditions and habitat affinity influence the **spatial and temporal dynamics of Pacific Cod biomass density** at multiple life history stages?

- Biomass density moved closer inshore during the warm regime

Largest size class	
Cool regime	Warm regime
Inshore: 58%	Inshore: 63%
Offshore: 42%	Offshore: 37%

Smallest size class	
Cool regime	Warm regime
Inshore: 73%	Inshore: 94%
Offshore: 27%	Offshore: 6%

Research questions

How do environmental conditions and habitat affinity influence the **spatial and temporal dynamics of Pacific Cod biomass density** at multiple life history stages?

- Evidence of habitat compression during the warm regime or a decline in an offshore segment of the population

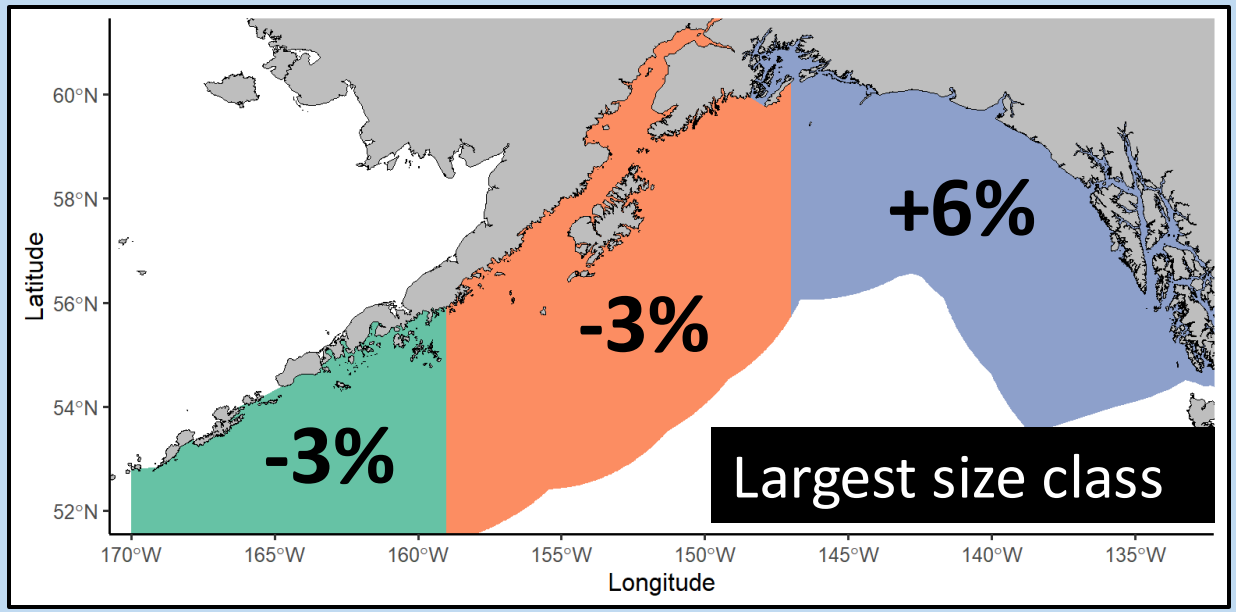
Largest size class	
Cool regime	Warm regime
Inshore: 58%	Inshore: 63%
Offshore: 42%	Offshore: 37%

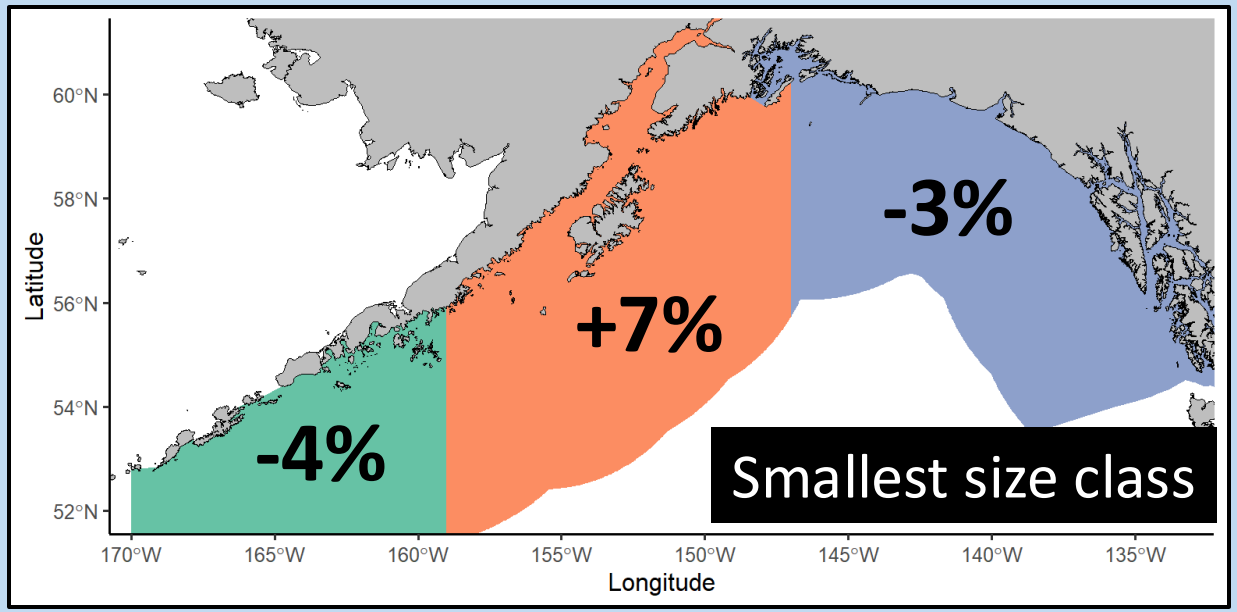
Smallest size class	
Cool regime	Warm regime
Inshore: 73%	Inshore: 94%
Offshore: 27%	Offshore: 6%

Research questions

When deciding how to **define a stock boundary** for assessment and management, how can we account for spatial and temporal population dynamics?

- Biomass density shifted across the Gulf of Alaska from the cool to the warm regime and patterns differed between life history stages

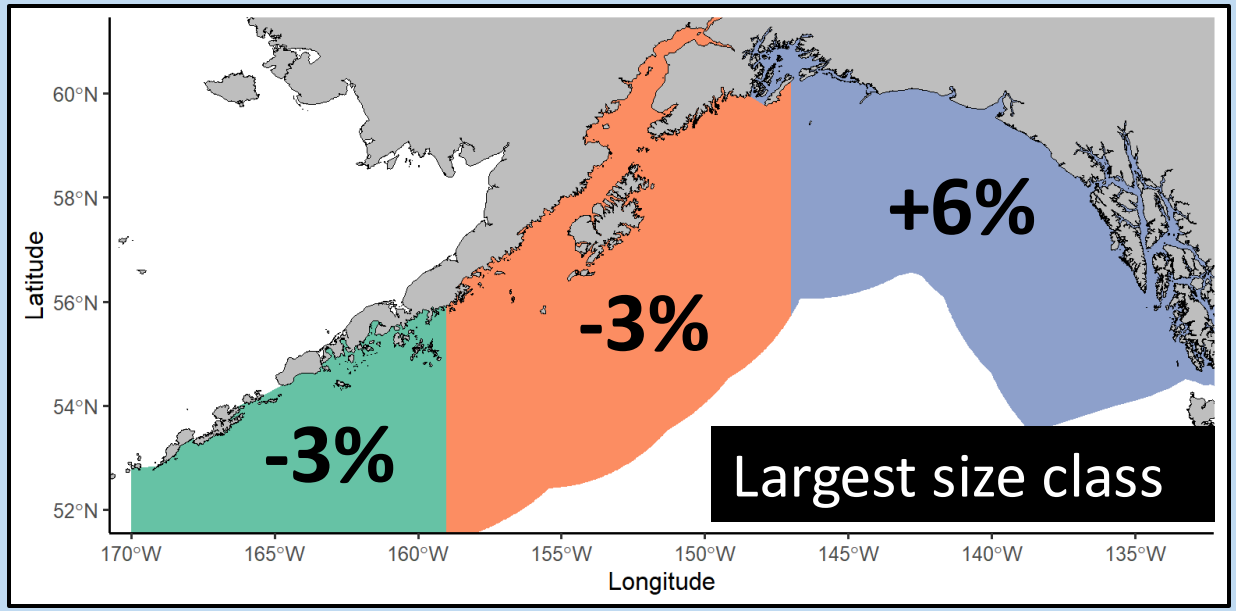


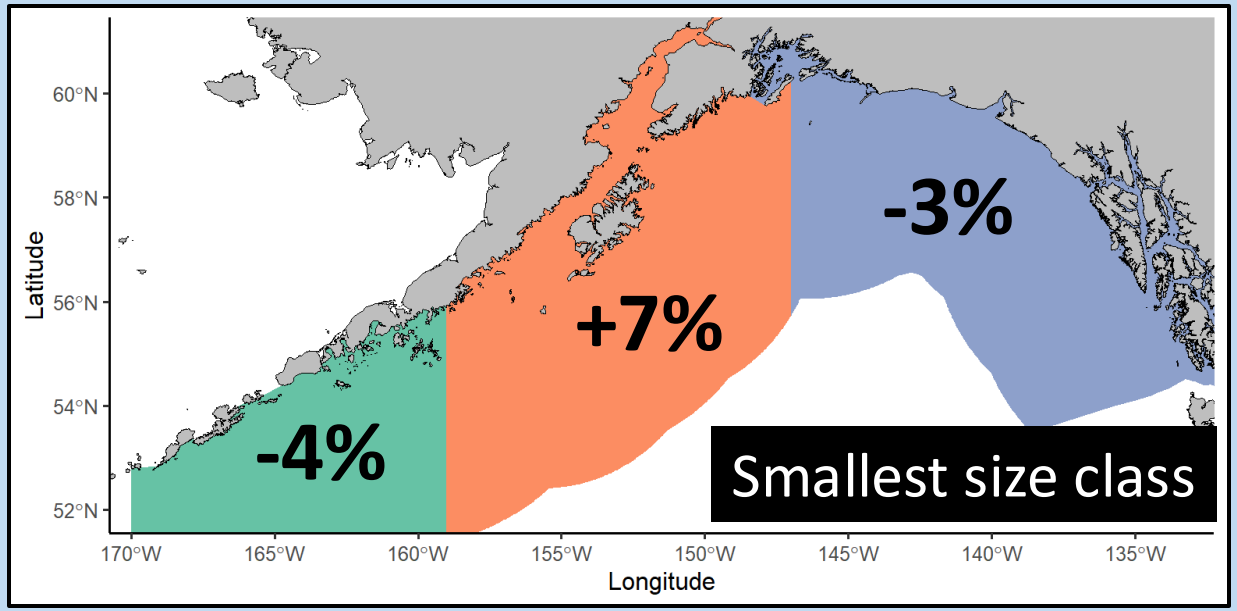


Research questions

When deciding how to **define a stock boundary** for assessment and management, how can we account for spatial and temporal population dynamics?

- Could allocate catch quota based on region-specific changes in biomass density

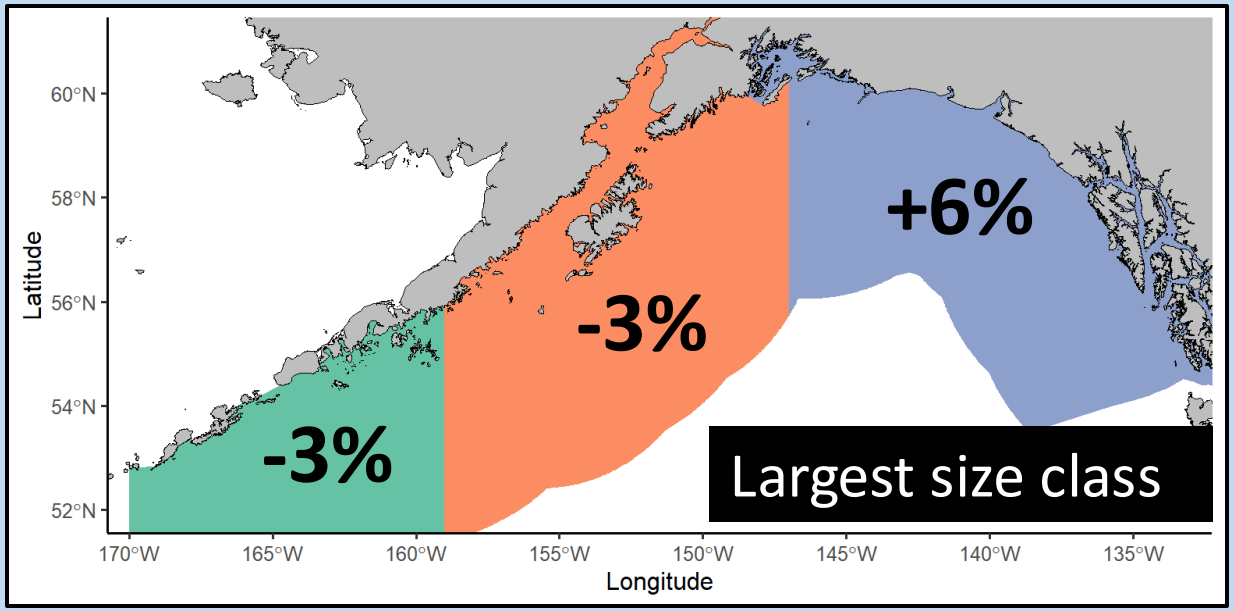


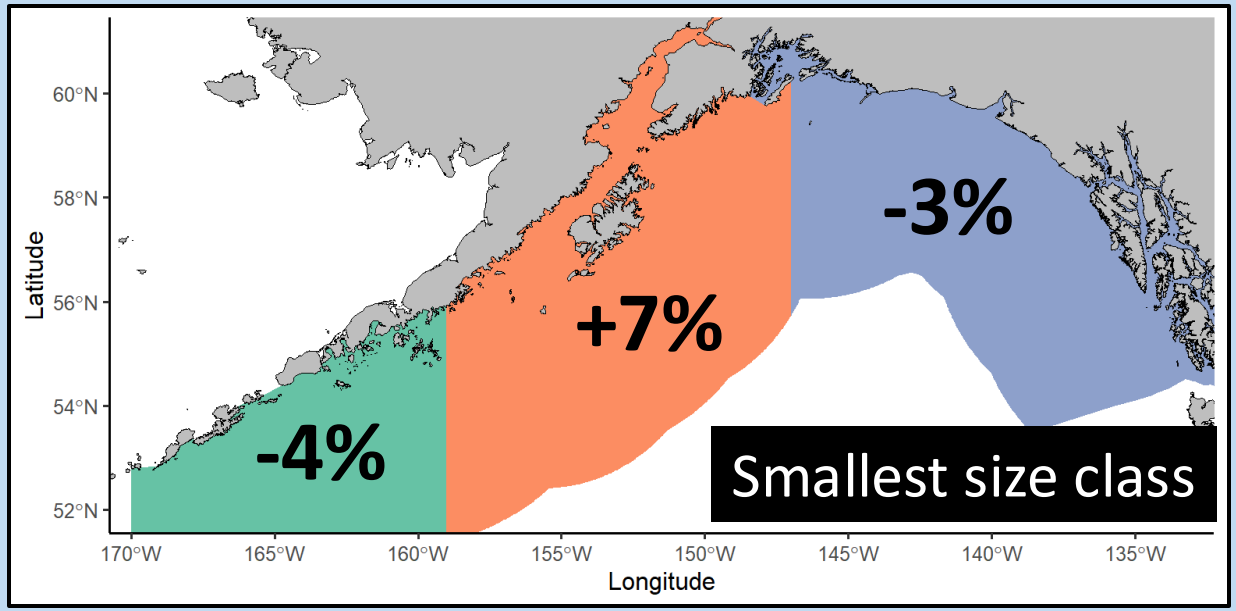


Next steps

When deciding how to **define a stock boundary** for assessment and management, how can we account for spatial and temporal population dynamics?

- Management strategy evaluation of different spatial stock configurations





Acknowledgments

Project collaborators:

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Please contact me with additional questions!

claire.rosemond@oregonstate.edu

@SeaRosemond

Claire Rosemond