Disentangling complex dynamics of Pacific hake biomass distribution in the California Current Ecosystem

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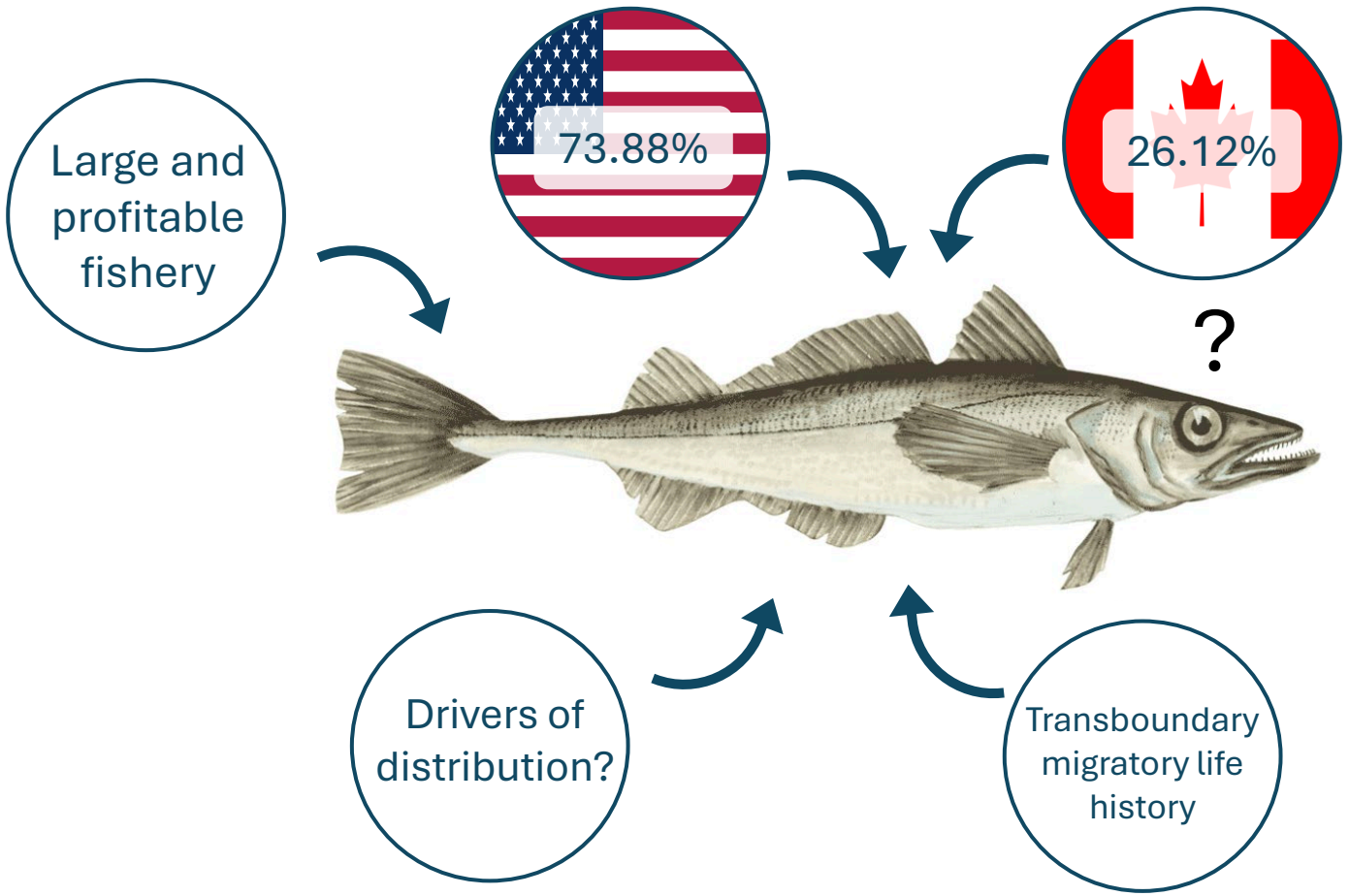
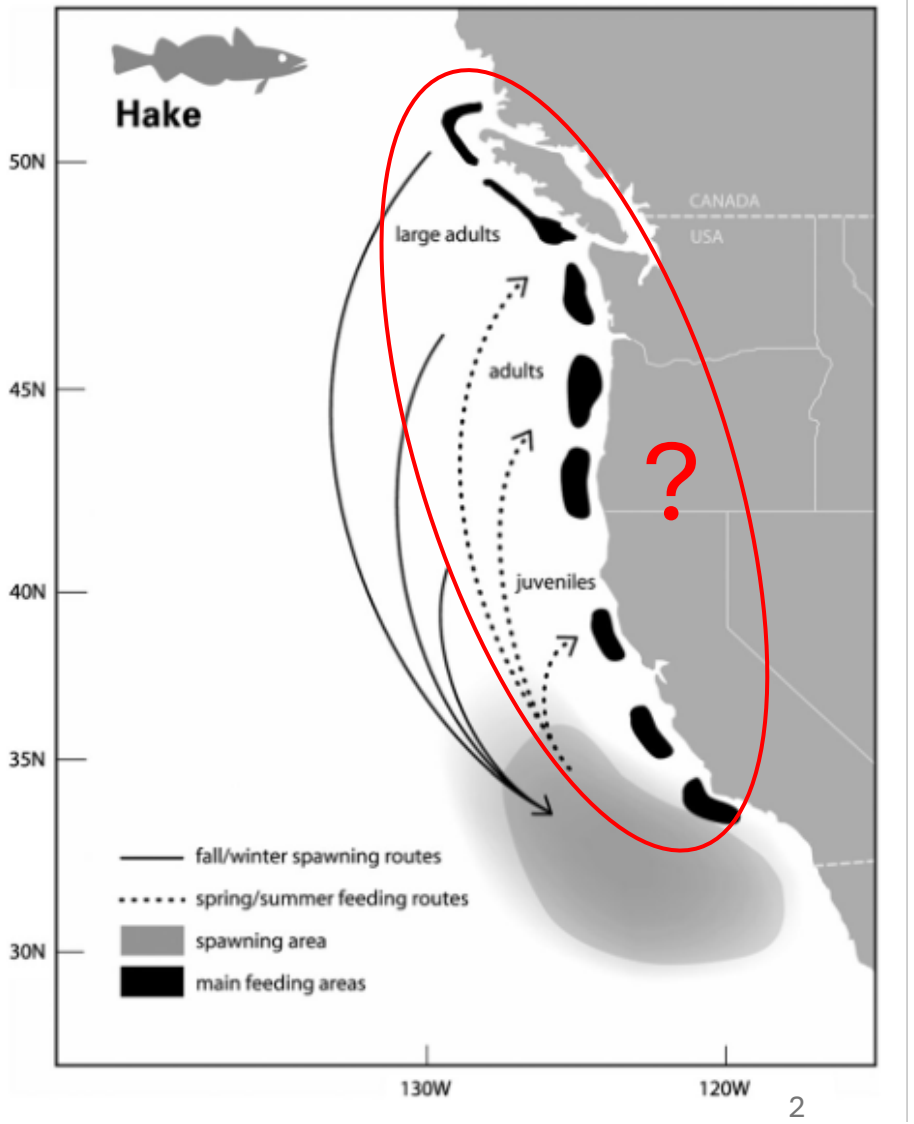
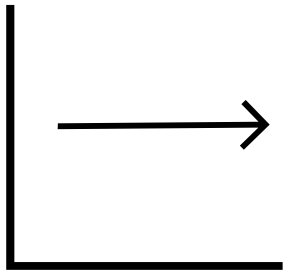
Pacific hake are ecologically and economically important





Distribution shifts may compromise fair treaty allocations

Stock assessment estimates



Hake in Canada





Gemini Prompt: Create an image of a Pacific hake straddling the US CAN border just off the west coast. Color hake in opposite Country flags.

Is It Time to Rethink the Pacific Whiting Treaty?



Steve Martell
Published Jun 20, 2026

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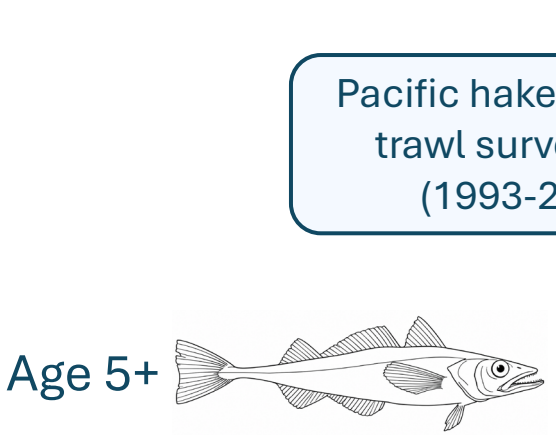
Complex species require adequately complex model structures



Pacific hake acoustic trawl survey data (1993-2023)

Spatial random field

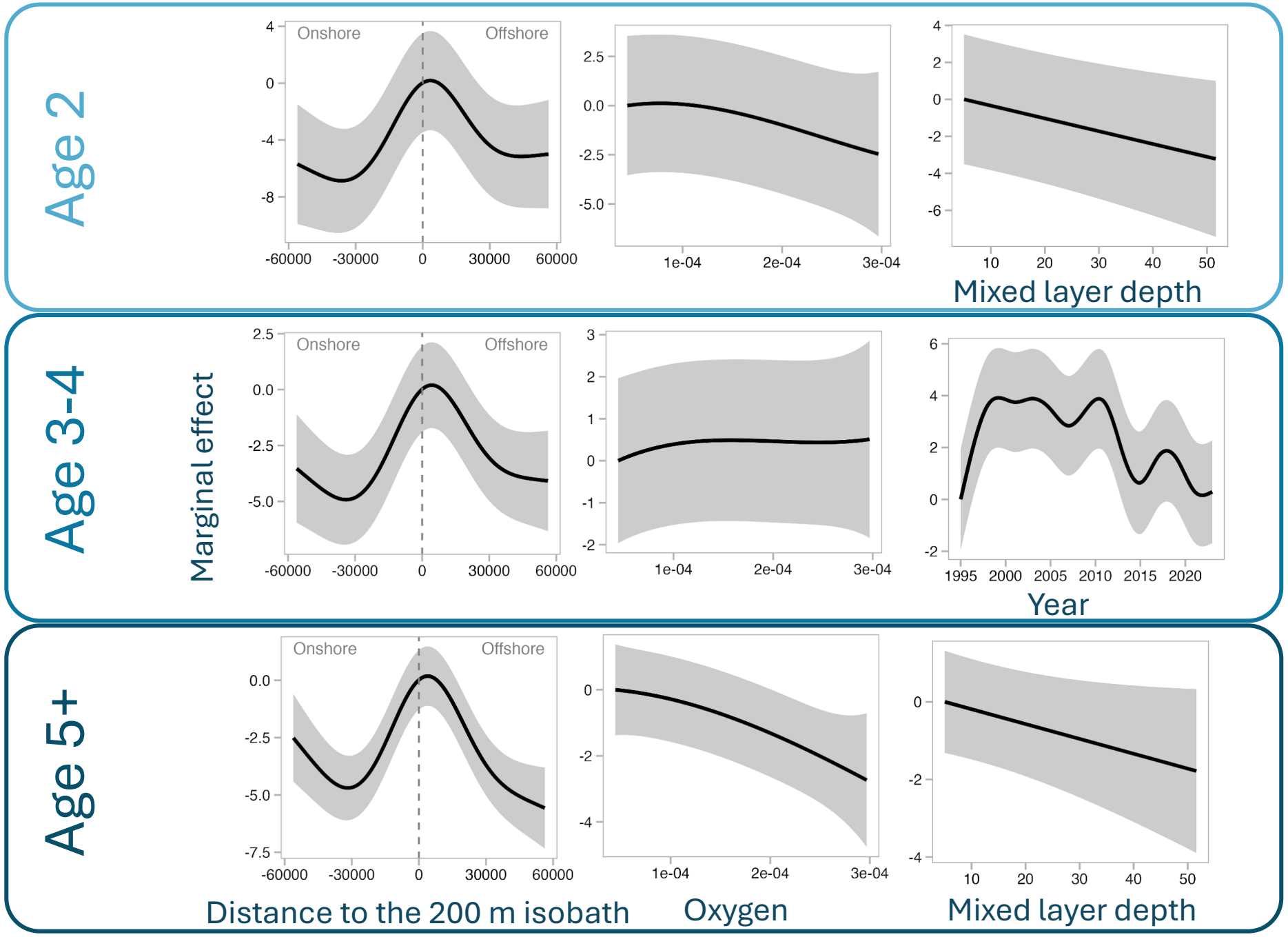
Spatiotemporal random field

Flexible spatiotemporal model

Environmental drivers

- ✓ Fixed effects
- ✓ Spatially varying effects

Fixed effects

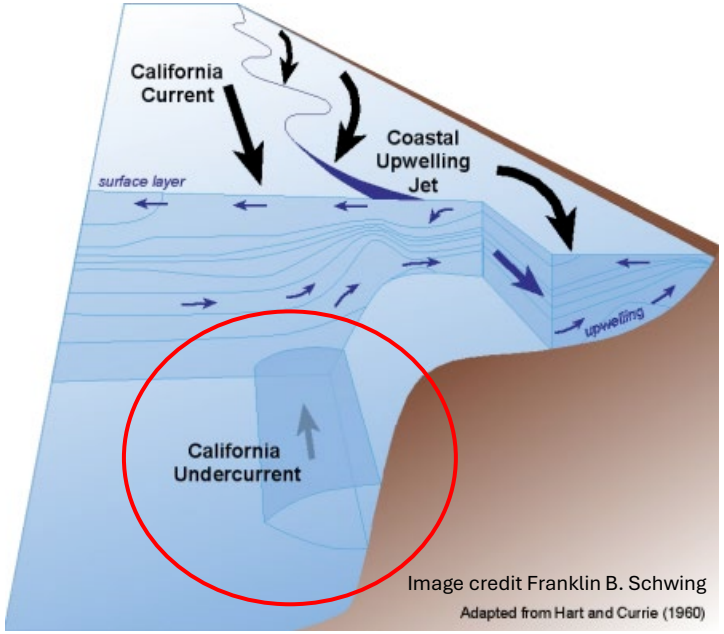


Spatially varying effects

Mechanistic drivers

Mystery drivers

Age 2
CU maximum strength



Age 5+
Prey standing stock index

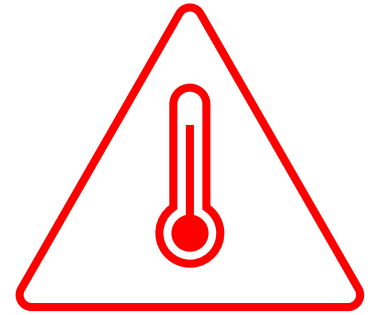


Age 3-4
Regime

Pre 2013

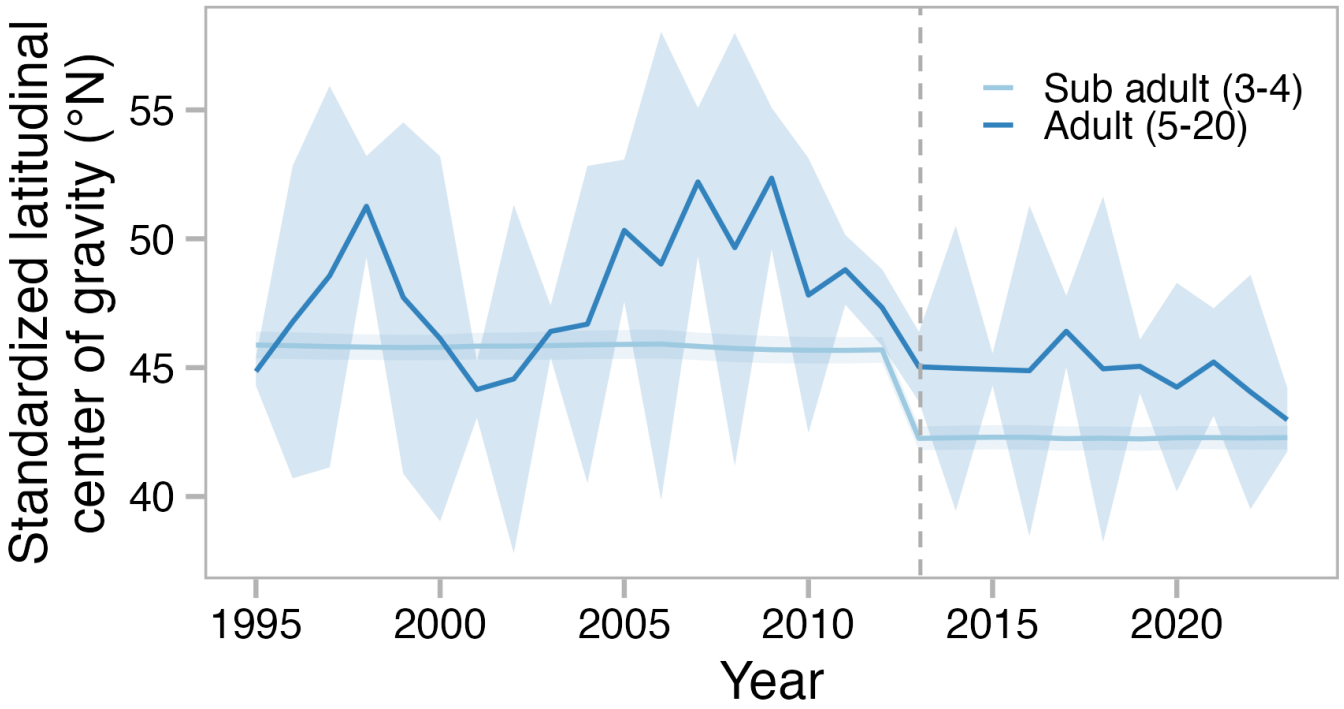


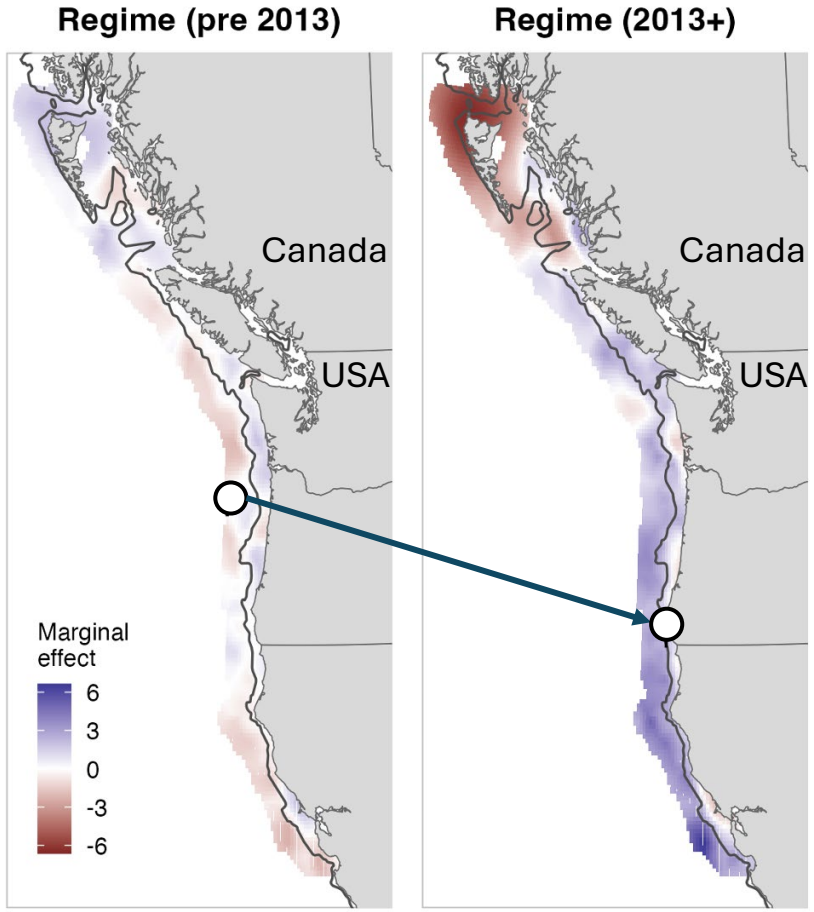
Post 2013



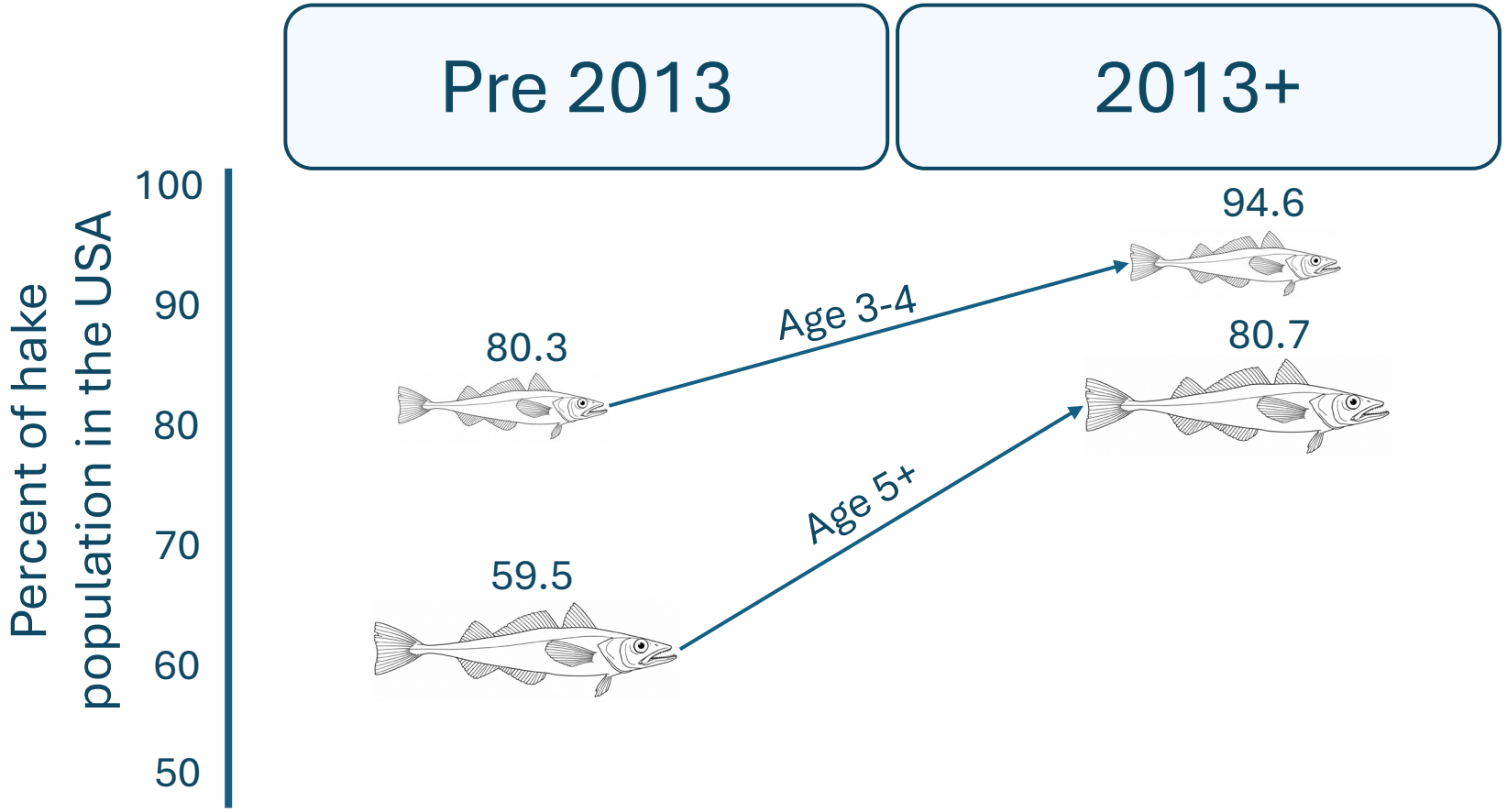
Pacific hake have shifted nearly 400 km South since 2013

Biomass-weighted latitudinal center of gravity





The proportion of hake in the USA has increased by >20 percentage points since 2013



Predicting hake distribution can support transboundary fisheries management

Our work identified:

- Hake distribution shifted nearly 400 km south since 2013
- Novel age specific environmental drivers

Future directions

- Annual model-based estimates of the proportion of hake in each country
  - Inform stock assessment
  - Inform adjustments to fixed allocations
- Apply our modeling approach to other species facing similar challenges

Collaborators

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Thank you!

Photo by John Pohl

Supplementary slides

What drives Pacific hake biomass distribution?

Physical drivers

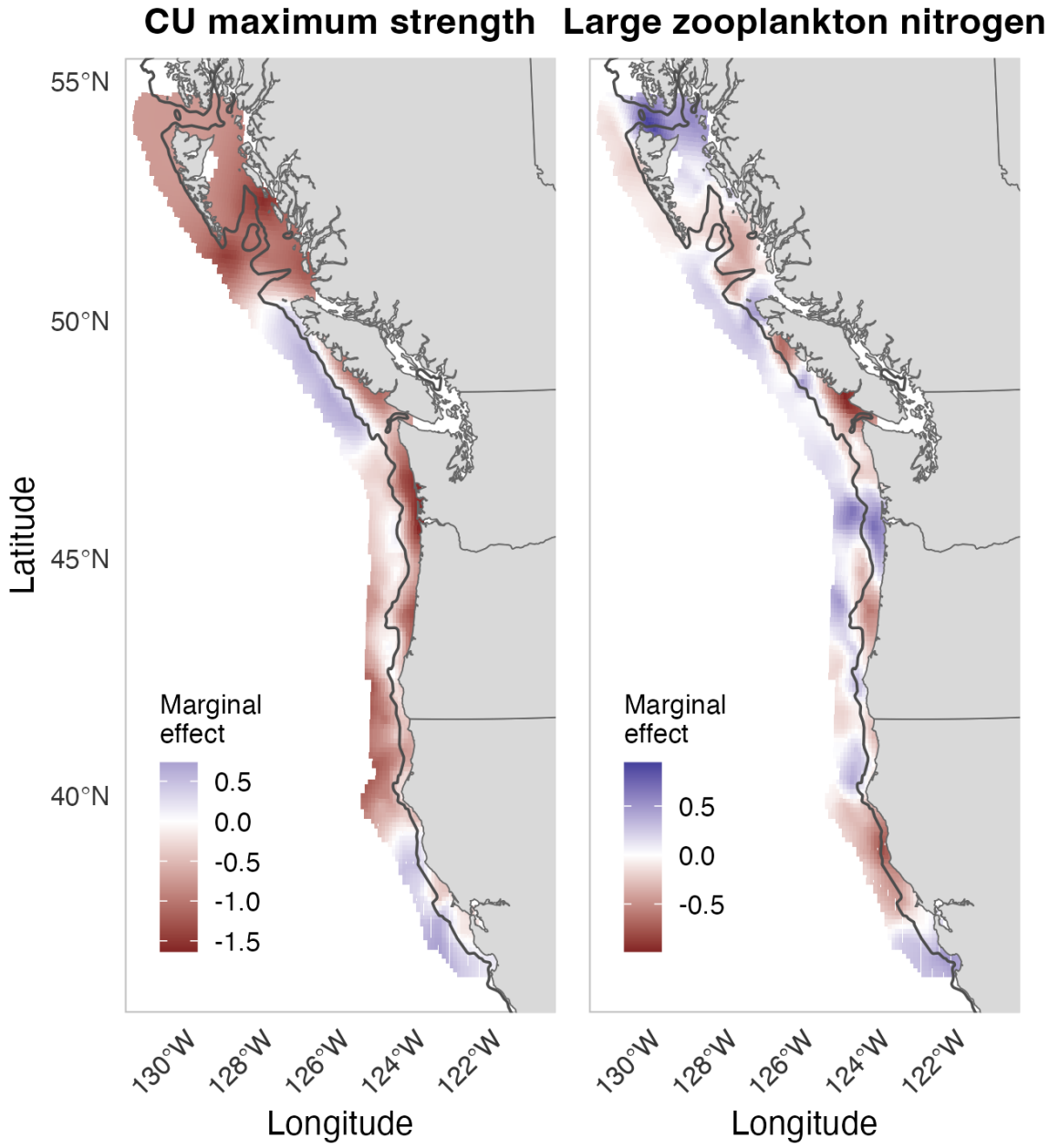
- Temperature at depth
- Onshore current velocity
- Characteristics of the California Undercurrent
- Bottom depth
- Distance to the 200 m isobath
- Mixed layer depth
- Temperature anomaly at ~100 m

Biogeochemical drivers

- Oxygen at depth
- Prey standing stock index
- Chlorophyll concentration

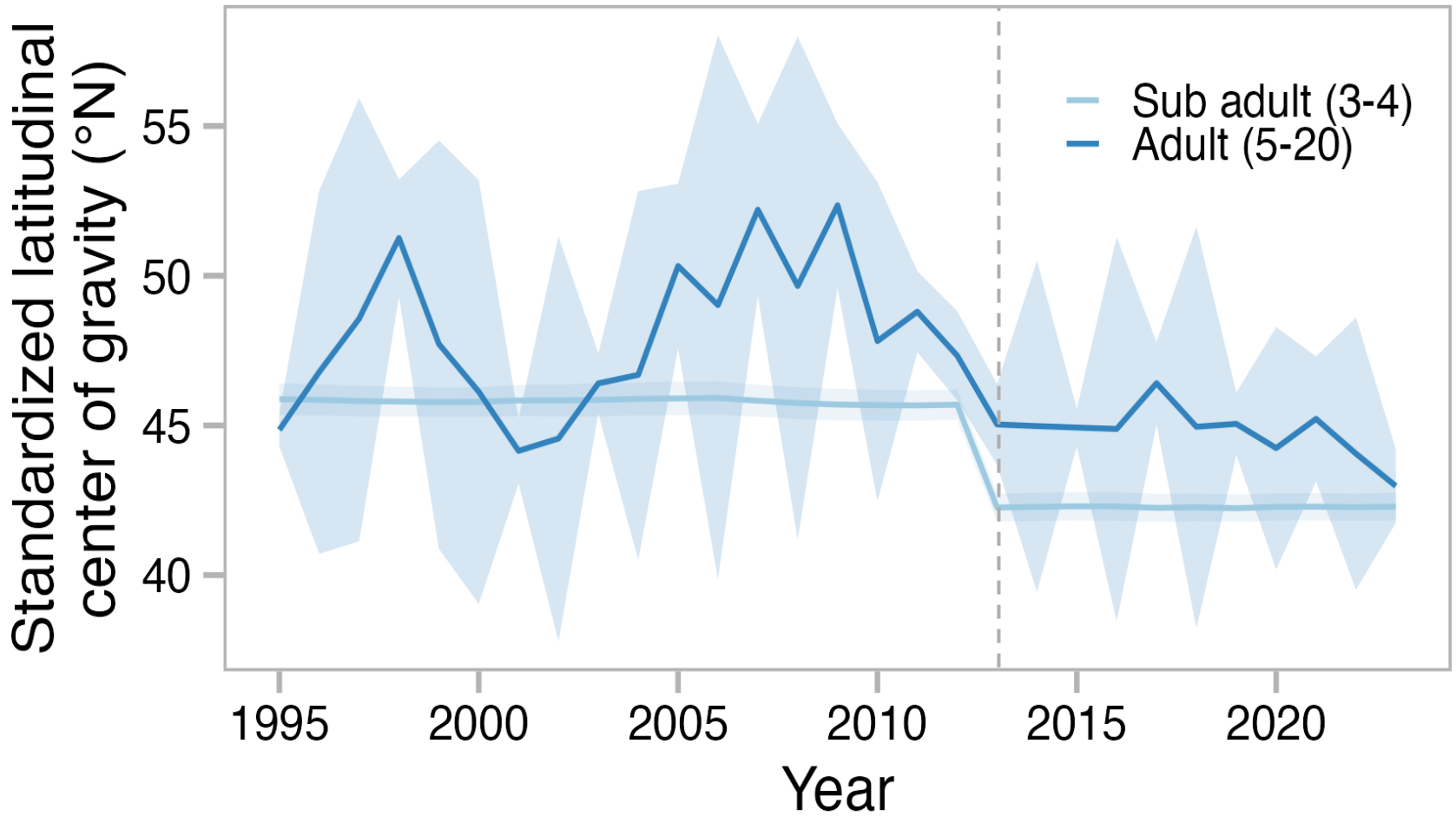
Basin scale drivers

- North Pacific Current bifurcation index
- Categorical regime term


CU maximum strength
Large zooplankton nitrogen
55°N
50°N
45°N
40°N
Latitude
Marginal effect
0.5
0.0
-0.5
-1.0
-1.5
Marginal effect
0.5
0.0
-0.5
130°W
128°W
126°W
124°W
122°W
Longitude
130°W
128°W
126°W
124°W
122°W
Longitude

Age 2

Age 5+


Standardized latitudinal center of gravity (°N)
55
50
45
40
1995
2000
2005
2010
2015
2020
Year
Sub adult (3-4)
Adult (5-20)