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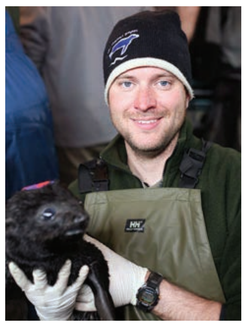

Delineating a physical and biological breakpoint in the Gulf of Alaska

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INTRODUCTION

The early life survival of marine fish is thought to be influenced by climate driven variability, and differences in survival of fish among years and areas results in fluctuations in available prey, which directly affects the dietary preference and foraging strategy of top level predators.

It has been hypothesized that environmental and biological variability are less pronounced in the eastern Gulf of Alaska (eGOA) than the central GOA (cGOA)and the greater stability and higher species diversity in the eGOA make the region more ecologically resilient to climate change and human forcing.

However, the boundary between these two regions is not clearly defined.

OBJECTIVES

1) Quantify the spatial variability of key physical and biological drivers in the coastal GOA through a retrospective analysis of historical datasets.

2) Delineate a physical or faunal break between the shelf waters of the eastern and central GOA for use in hypothesis testing, modeling and management efforts.

By comparing the responses of upper trophic level variability to climate forcing between these two contrasting systems, we can gain a better understanding of how these systems may respond to future climate variability and how inherent differences in the structure of these systems affect their resilience to such variability.

METHODS

Examined EOF loadings for
- Sea surface temperature (SST),
- Photosynthetically-available radiation (PAR),
- Chlorophyll-a (chl-a),
- Sea surface salinity (SSS)

Demersal fish CPUE and diversity indices
- modeled as smooth functions of longitude
- break points estimated using the R package 'bfast'

Upwelling
- Hierarchical cluster analysis of daily time series at 25 stations along the shelf break

RESULTS

- All variables exhibited a similar longitudinal break point (Table 1) with a median location off the Kenai Peninsula at 149.0 °W ± 1.2°
- Division lines for SST, PAR, SSS, and Chl-a oriented southeast from the Kenai Peninsula coast. Upper portion of Chl-a division line possibly affected by outflow from Prince William Sound.
- SST, PAR, and SSS EOF Mode 2 spatial loadings exhibited a clear spatial dichotomy between shelf and offshelf waters of the eastern and central GOA (Figures 1-3).
- Chl-a EOF Mode 3 spatial loadings exhibited a clear spatial dichotomy between shelf waters of the eastern and central GOA (Figure 4). Offshore breakpoint evident in EOF Mode 2 (not shown).
- Demersal species total CPUE was higher in the central GOA but species diversity was higher in the eastern GOA (Figure 5). Trends of both indices exhibited similar break points.
- 62 of 78 demersal species examined (79%) had significantly dichotomous distributions with at least $p < 0.001$ (logistic regression). Figure 6 illustrates the CPUE distribution by longitude for 12 select species.
- Cluster analysis of upwelling patterns suggest two unique upwelling regimes (Figure 7).

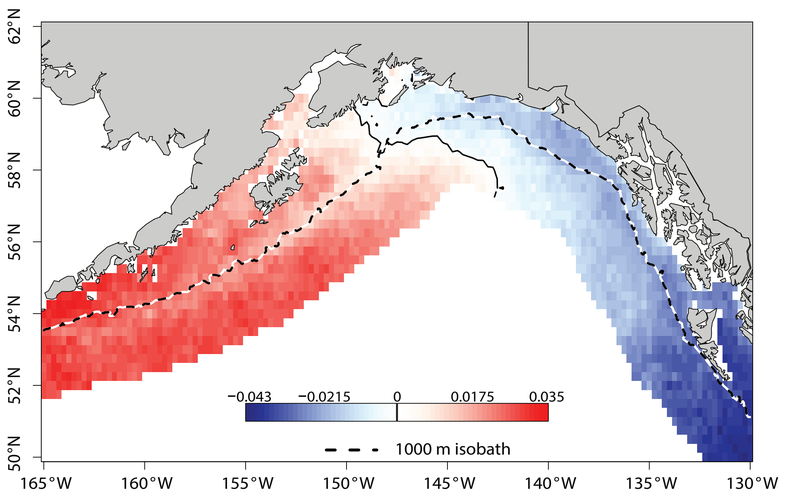

Figure 1. EOF Mode 2 spatial loadings for 8-day AVHRR Pathfinder sea surface temperature (SST) anomalies, 1998-2010.

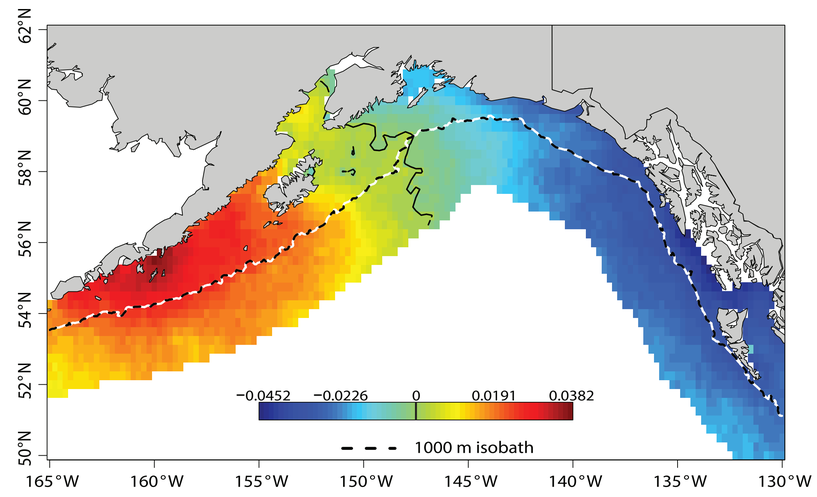

Figure 2. EOF Mode 2 spatial loadings for 8-day SeaWiFS / MODIS-Aqua photosynthetically-available radiation (PAR) anomalies, 1998-2011.

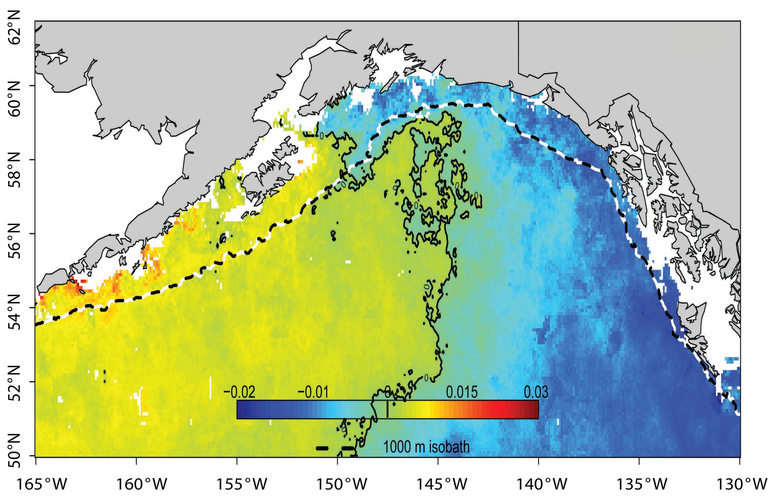

Figure 3. EOF Mode 2 spatial loadings for 8-day Aquarius sea surface salinity anomalies (SSS), September 2011 - October 2013

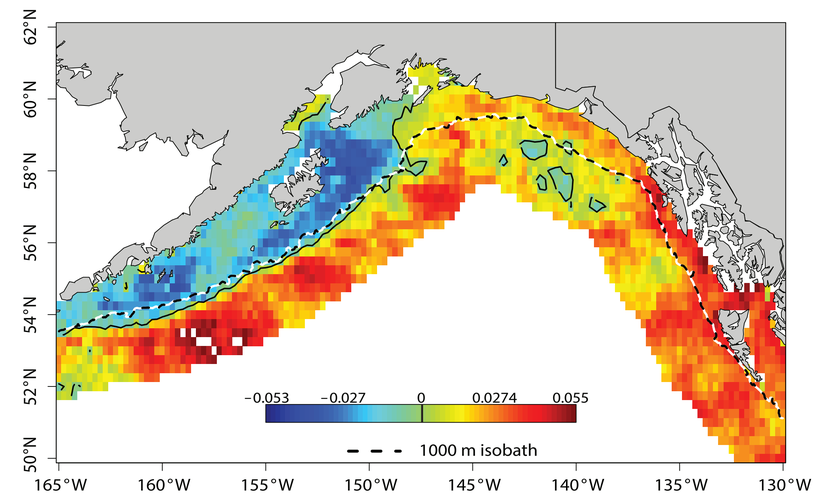

Figure 4. EOF Mode 3 spatial loadings for 8-day SeaWiFS / MODIS-Aqua chlorophyll-a (chl-a) anomalies, 1998-2011.

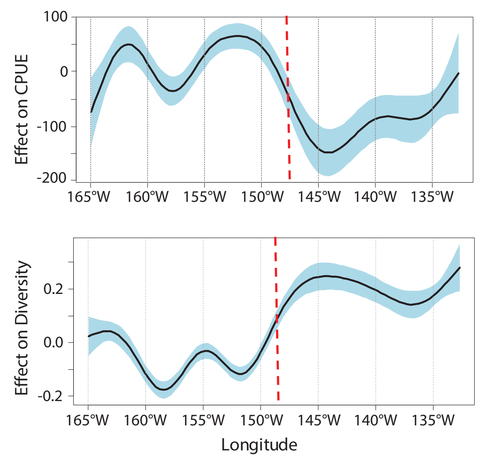

Figure 5. Relationship between longitude and total demersal CPUE and species diversity, 1990-2011. Red line indicates estimated breakpoint.

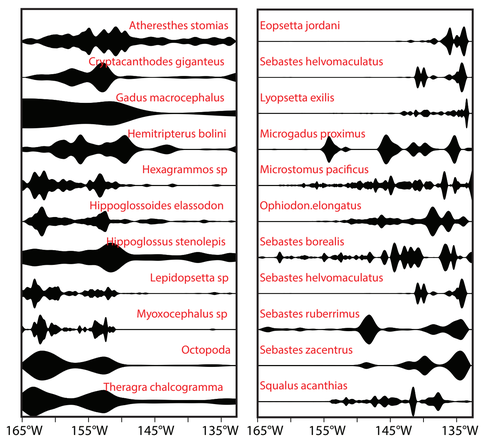

Figure 6. Distribution of CPUE by longitude for selected demersal species exhibiting a strong east-west gradient, 1990-2011.

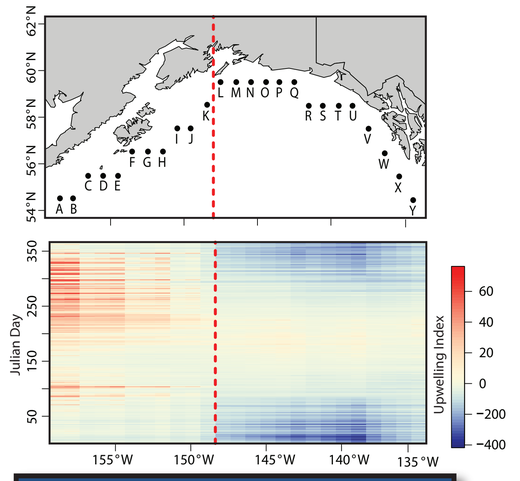

Figure 7. Hovmöller plot of upwelling index for 25 stations along the shelf break, 1967-2011. Warm colors represent upwelling and cool colors represent downwelling.

Table 1. Approximate median breakpoints between eastern and central Gulf of Alaska shelf waters for 8 biological and physical variables.

Variable	Median Breakpoint
Sea Surface Temperature	148.8 °W
Photosynthetically-Available Radiation	150.8 °W
Chlorophyll-a	147.9 °W
Sea Surface Salinity	150.4 °W
Total Demersal CPUE	147.3 °W
Demersal Species Diversity	149.8 °W
Demersal Species Composition	149.0 °W
Upwelling	148.0 °W

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DISCUSSION

- Multiple physical and biological variables point to a similar longitudinal breakpoint between eastern and central GOA shelf waters.
- The location of this common breakpoint may be influenced by:
  1. Transition of the Alaska current from an eastern to a western boundary current
  2. Broadening of the continental shelf
  3. Outflow from Prince William Sound
  4. Anti-cyclonic eddies downstream of Kayak Island
  5. Large-scale atmospheric processes, such as the Aleutian Low
  6. Tidal mixing associated with Cook Inlet
  7. Storm patterns
- Additional evidence for a breakpoint emerged from modeling efforts suggesting offshelf flow on average in the eastern GOA and onshelf and onshelf flow on average in the western GOA