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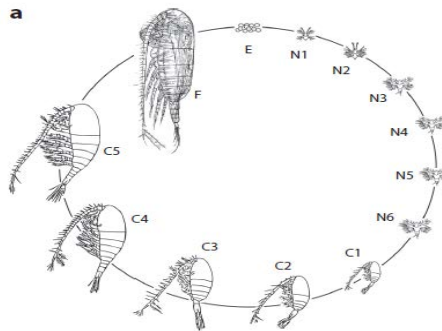


# Zooplankton in the northwest Atlantic

Ryan Morse

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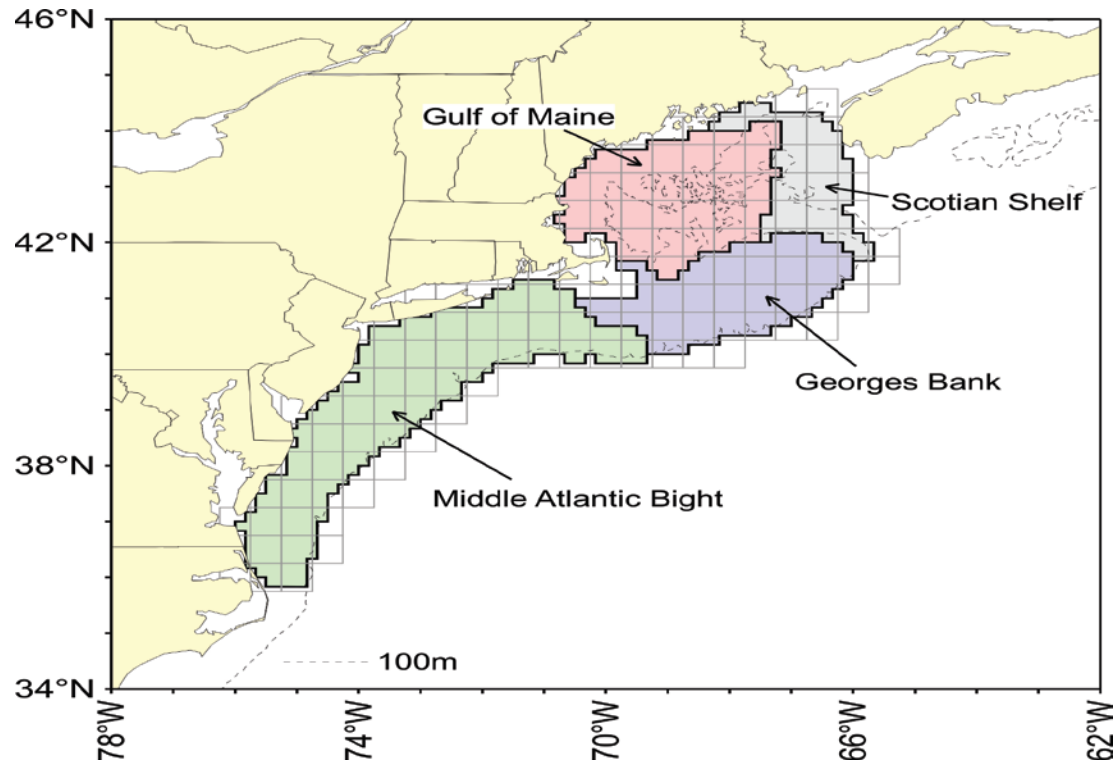
State of the Science Workshop on Wildlife and Offshore Wind Energy Development  
November 14, 2018

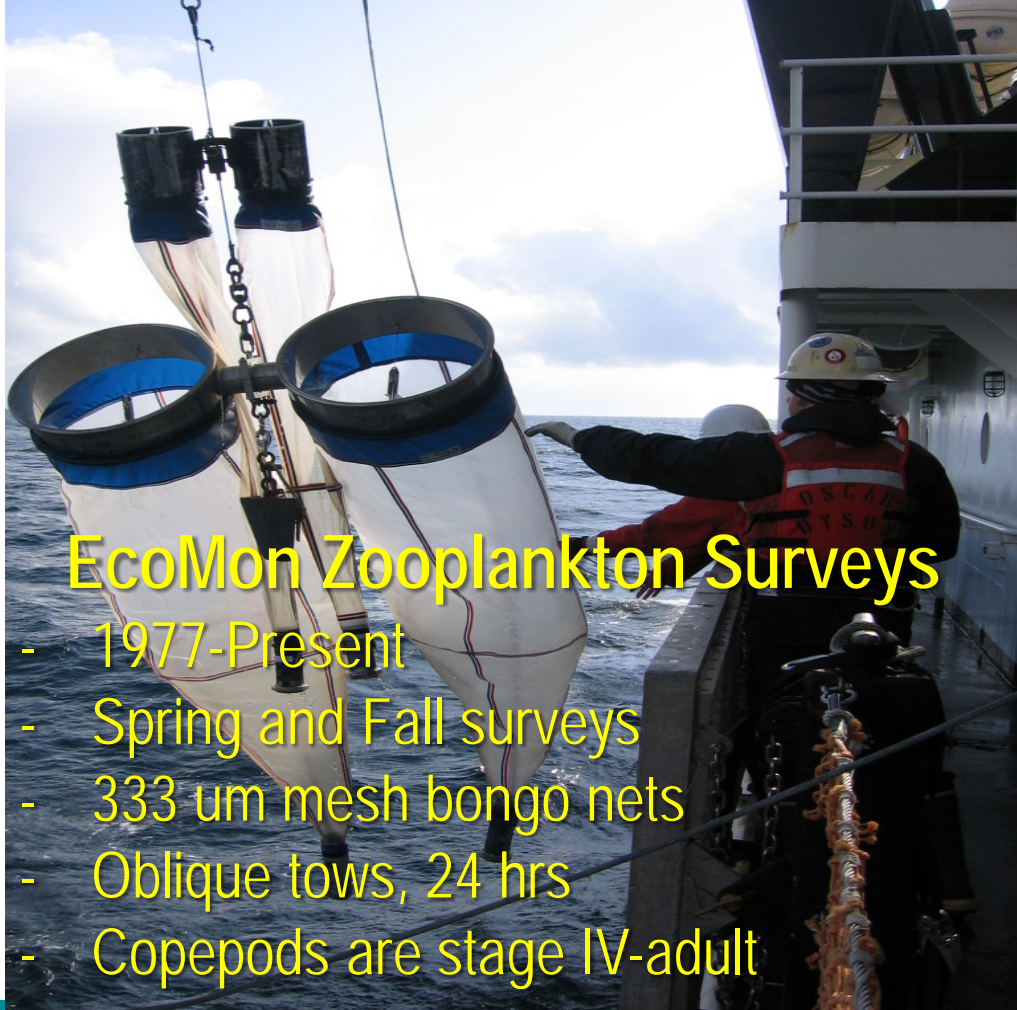


# Change in plankton communities

- 1) Underlying physical dynamics
- 2) Changes in abundance and community composition – regime shifts
- 3) Changes in spatial distribution – seasonal, long-term

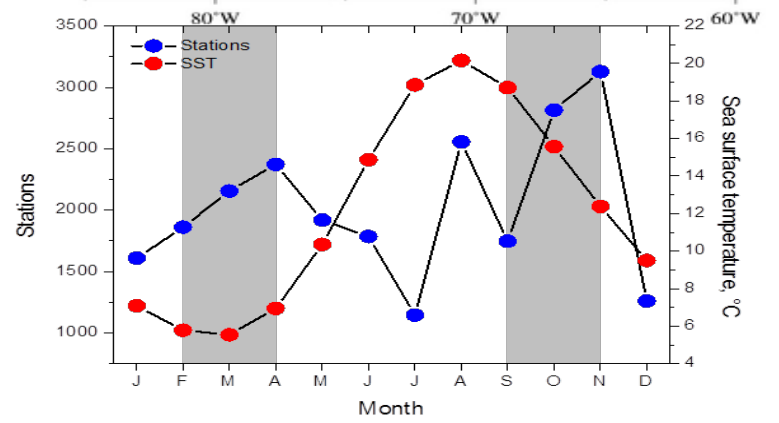
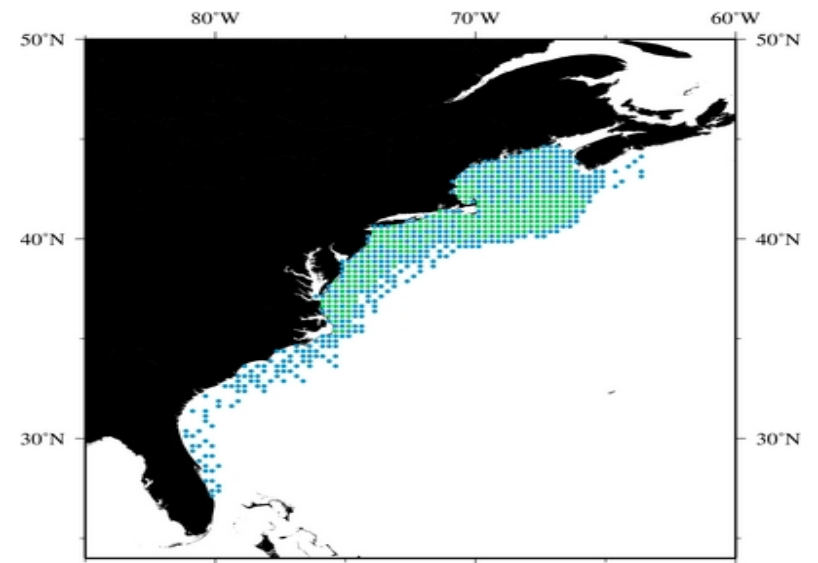
# Northeast Continental Shelf LME Ecological Production Units





# EcoMon Zooplankton Surveys

- 1977-Present
- Spring and Fall surveys
- 333 um mesh bongo nets
- Oblique tows, 24 hrs
- Copepods are stage IV-adult



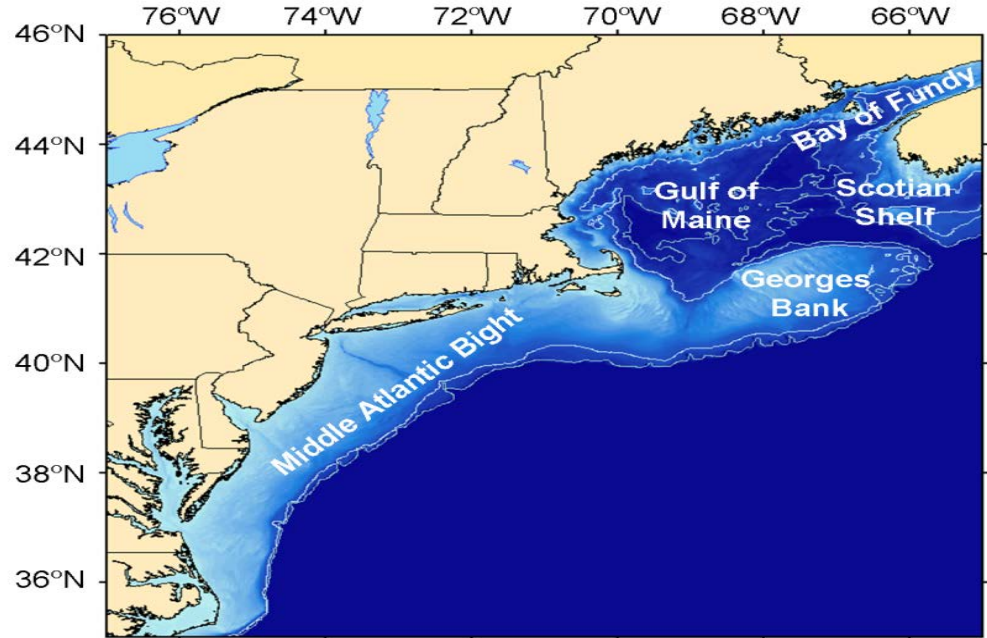
# Data Preparation

Focus on dominant taxa

Spring: Feb-Apr

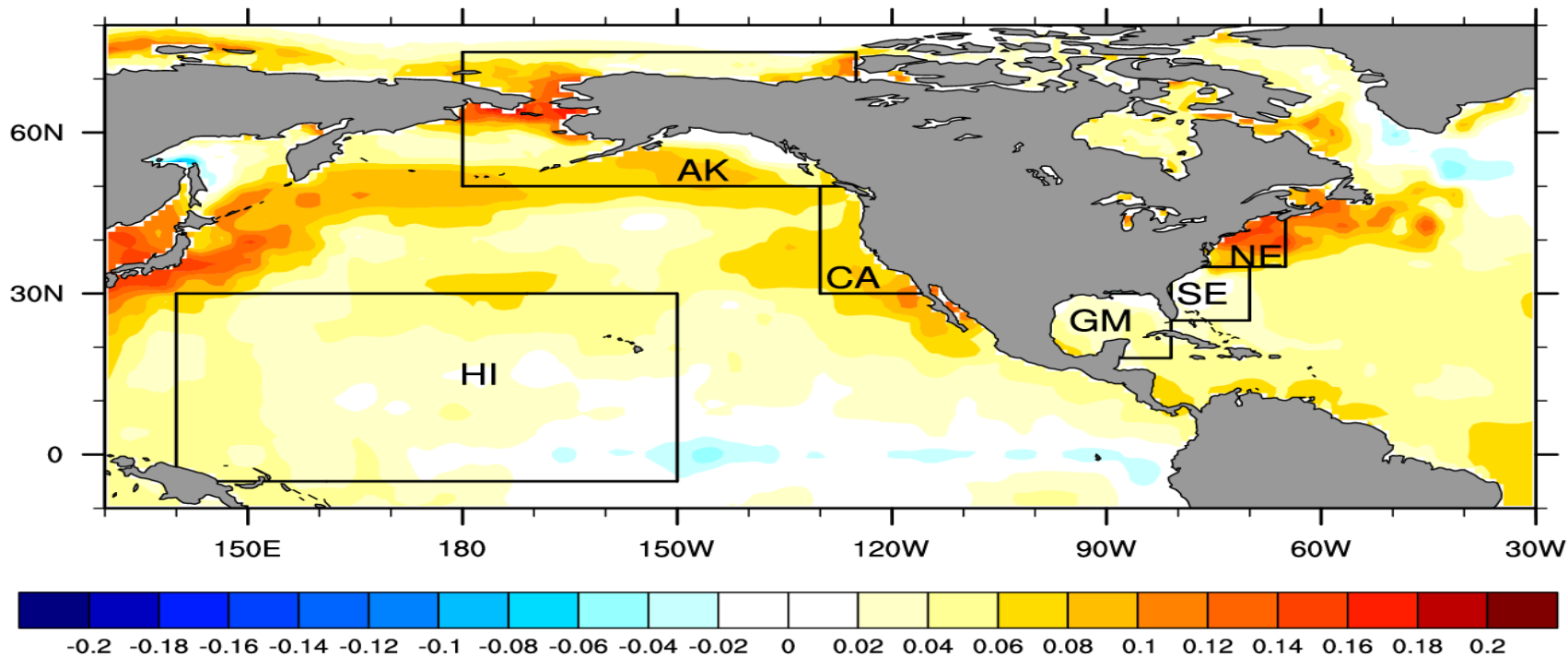
Data were post-stratified by 1°  
lat/lon bins

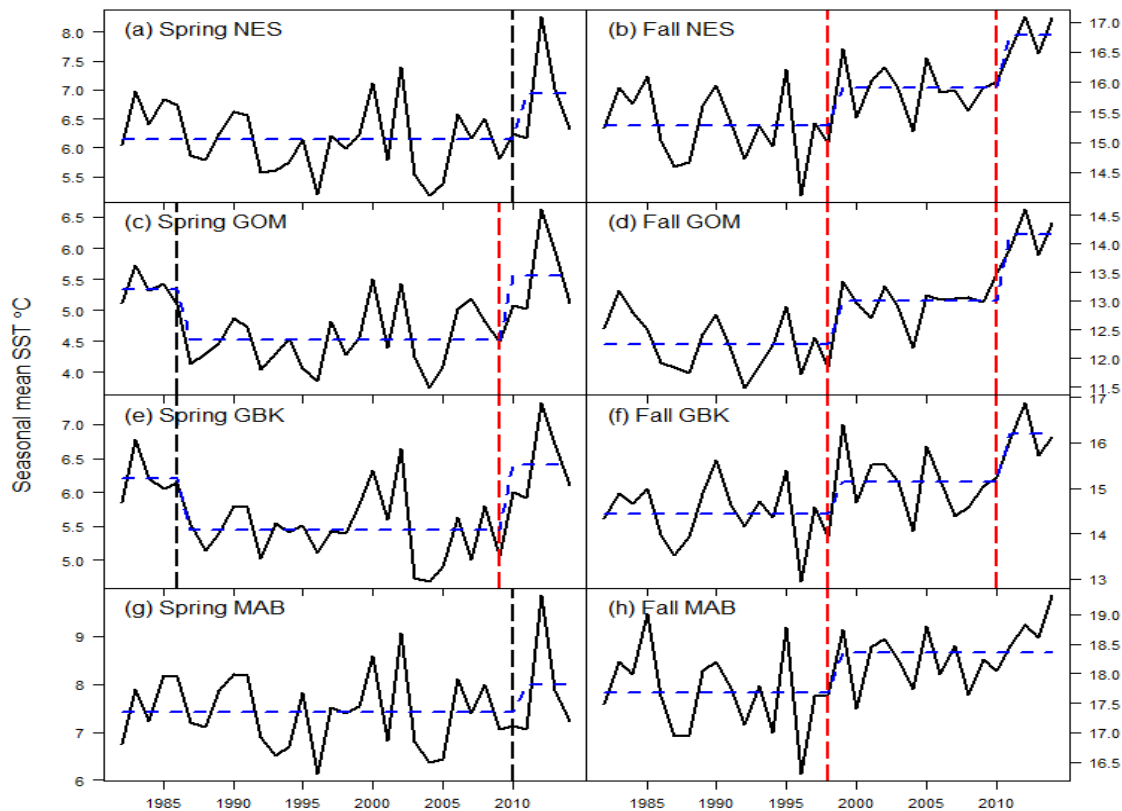
Bins sampled < 30 years and years  
with < 35 % EPU coverage were  
excluded from analysis; tows with  
zero catch included in analysis



# Warming of Northeast Shelf and US LMEs

Hadley SST Trend 1900-2011 ( $^{\circ}\text{C}/\text{decade}$ )

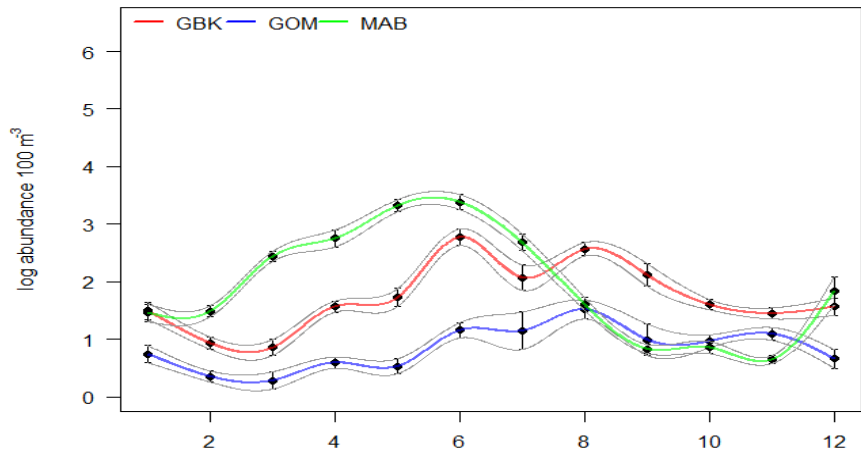




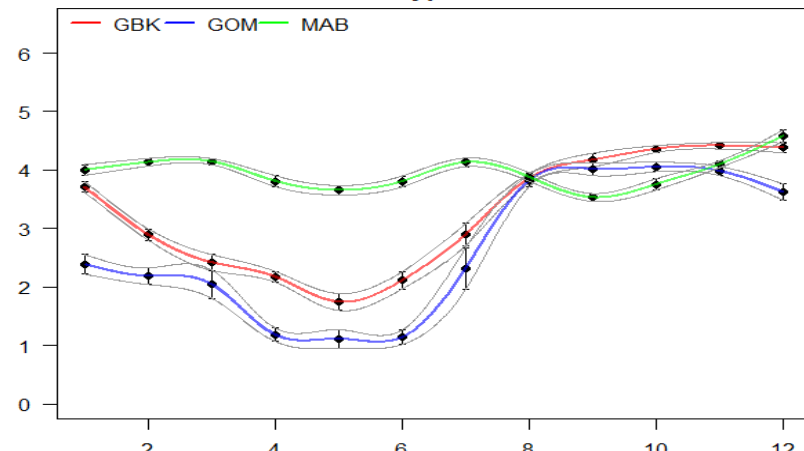
Changes in the spring (a, c, e, and g) and fall (b, d, f, and h) mean sea surface temperatures for the NES and its ecoregions.

Morse et al. 2017

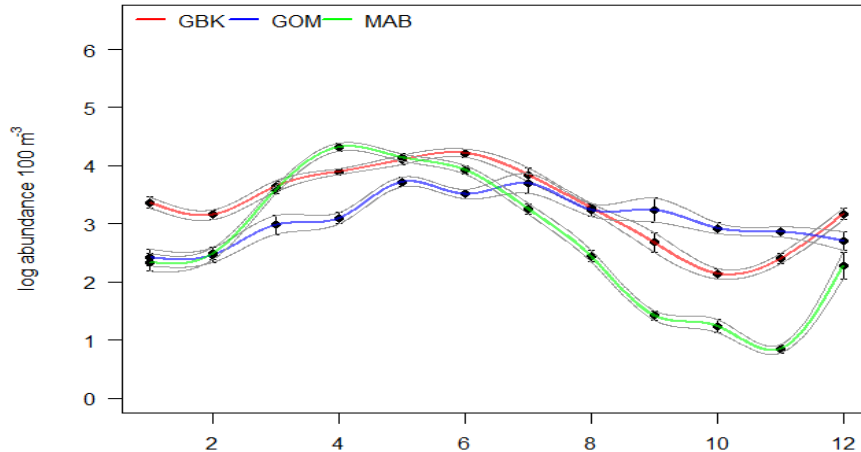
**Temora longicornis**



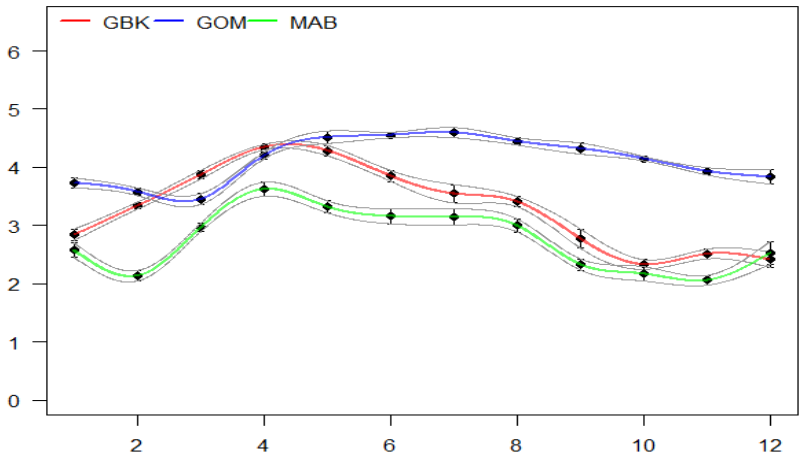
**C. typicus**



**Pseudocalanus spp.**



**Calanus finmarchicus**





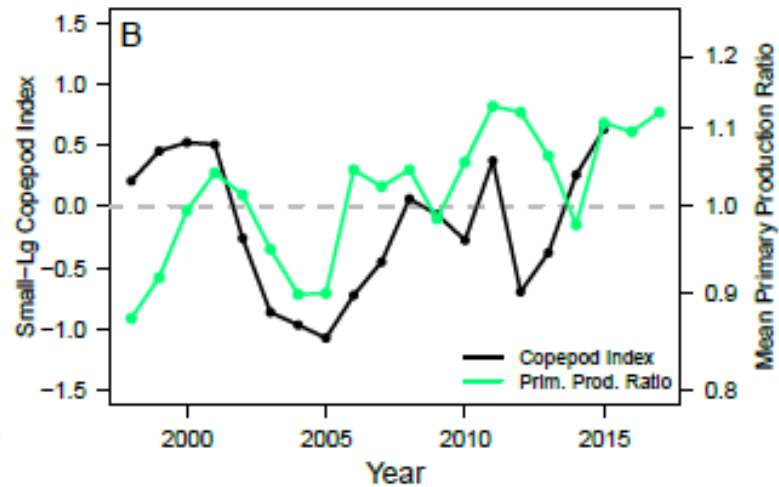
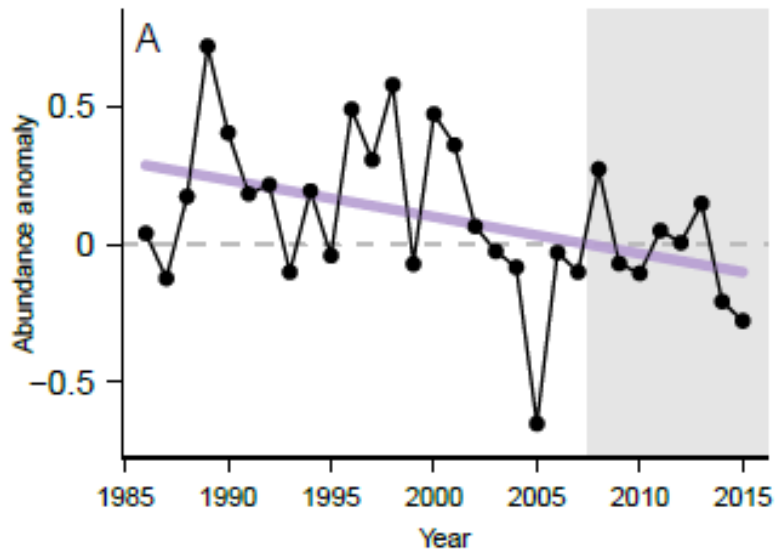


Figure 29: *C. typicus* abundance anomaly (A), and small-large copepod index with primary productivity anomaly (B) in the Mid-Atlantic.

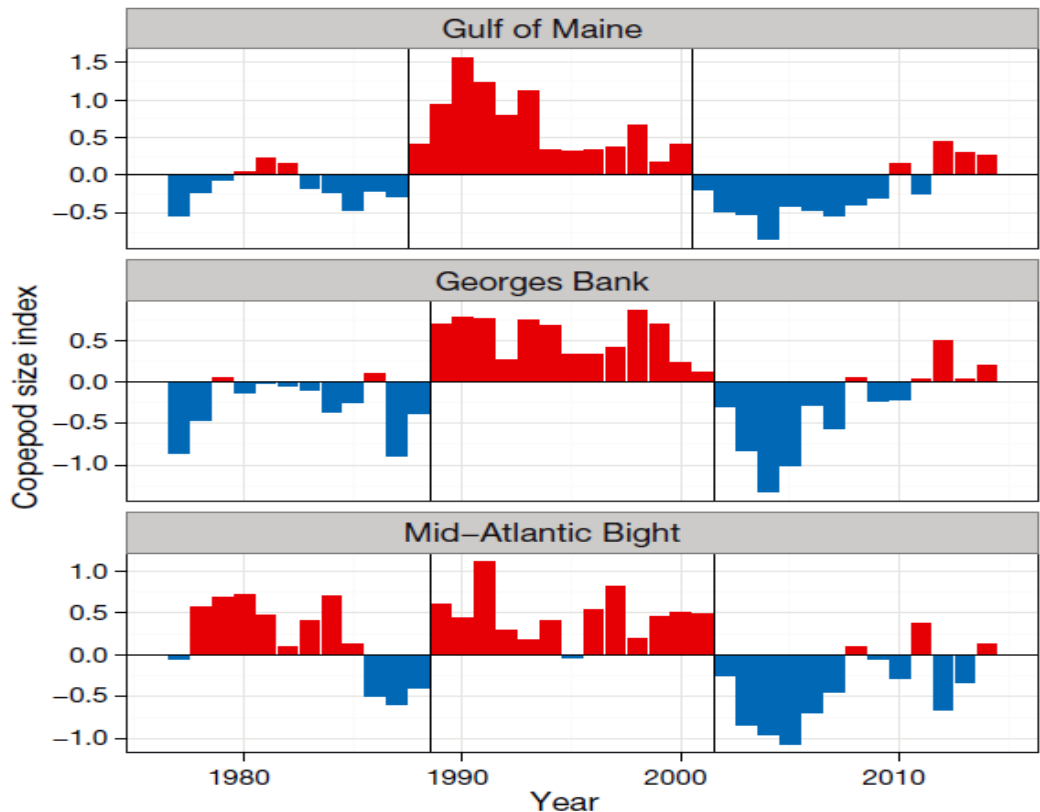
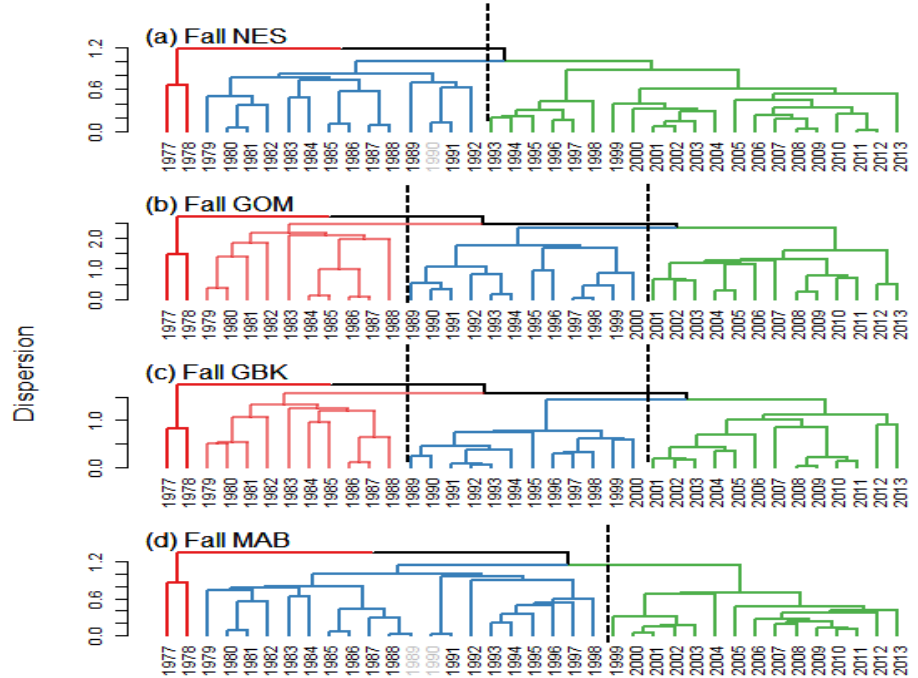
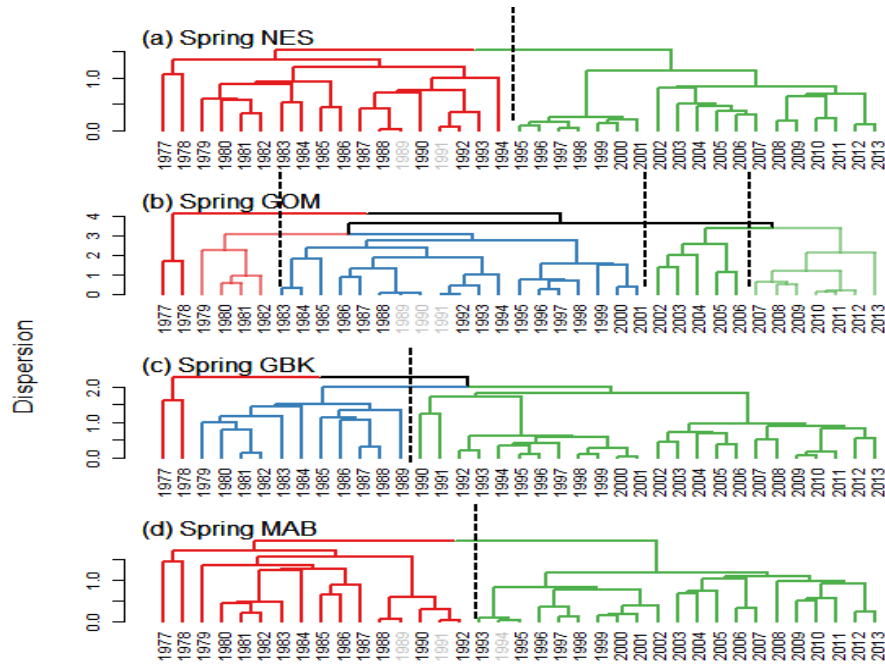


Fig. 4. Copepod size index (small copepod anomaly – large copepod anomaly) time series. Each bar represents the average annual anomaly, and vertical lines denote regime change points

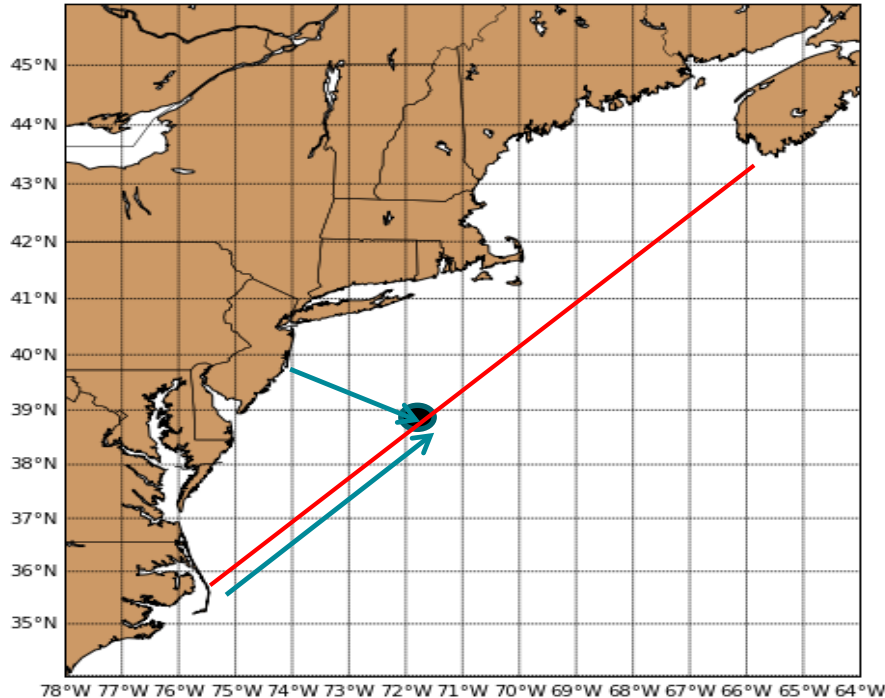
# Selection due to changes in physical environment



Morse et al. 2017

Movement – seasonal, long term population shifts

## Temporal trends in the distribution of animals: 3 methods



### 1. Center of Biomass

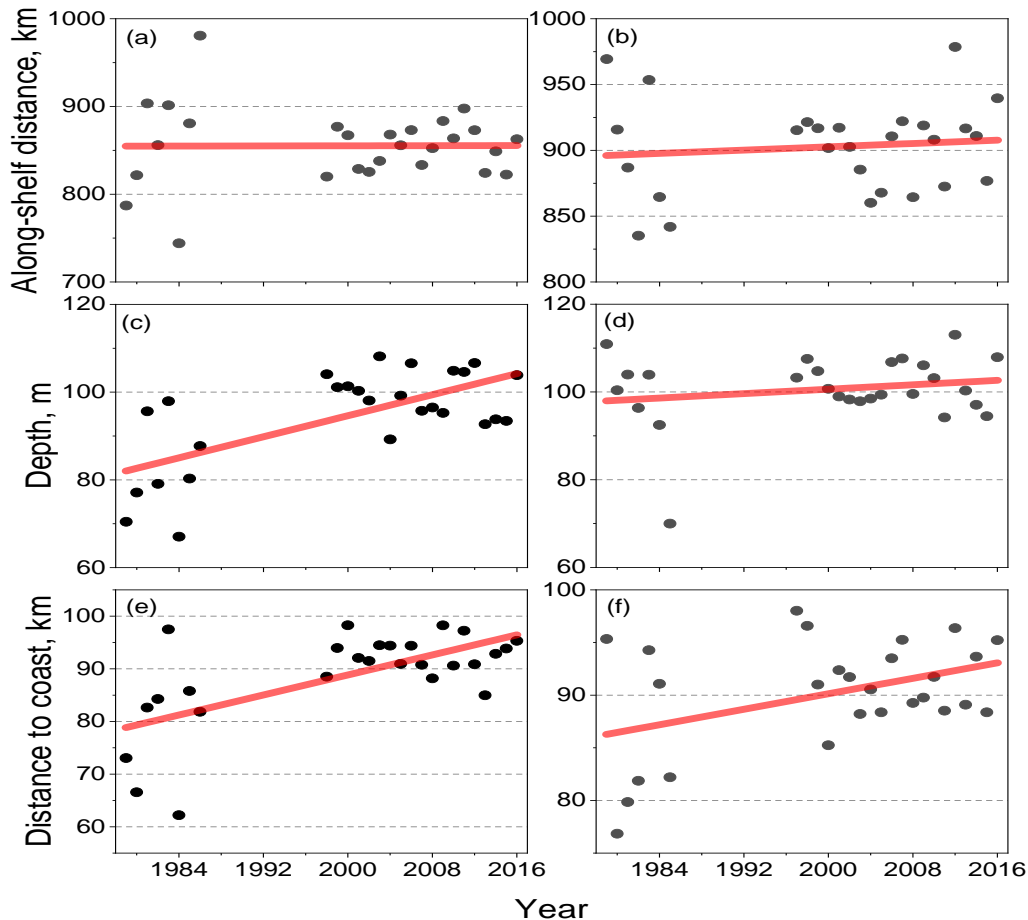
- Distance Along Coast
- Distance From Coast
- Depth at COB

### 2. Kernel Density Estimate (KDE)

- Gridded Probability Density Function

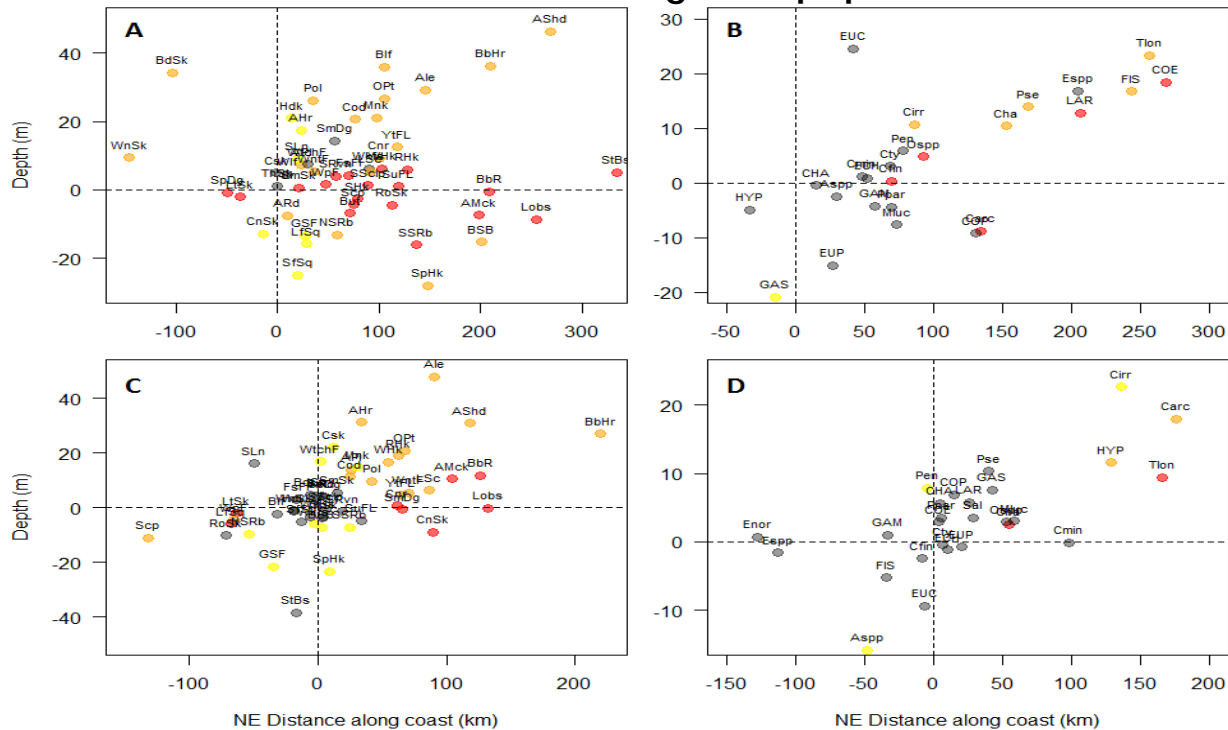
### 3. Pixel-wise Trend Analysis

- Compute per-pixel trend based on KDE



**Figure 2.** Time series of chlorophyll concentration center of gravity based on remote sensing date.

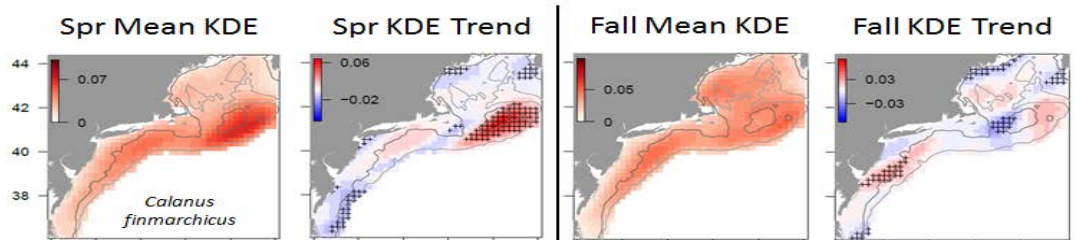
# Movement – seasonal, long term population shifts



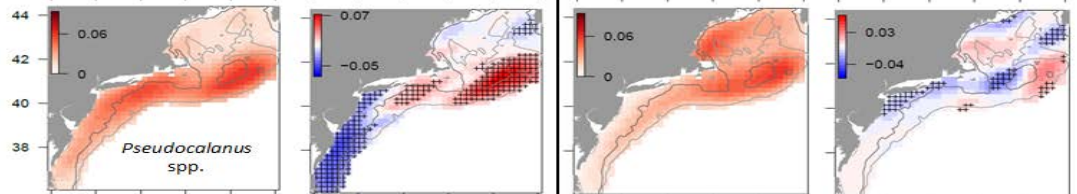
Change in the seasonal center of biomass with respect to depth and distance along coast for 51 fish taxa (A, C), and 27 zooplankton taxa (B, D) between 1977 and 2015. Spring communities (A, B), and fall communities (C, D). Time series with significant trends (t-Test,  $p < 0.05$ ) are shown in *red* for taxa that show significant changes in position along the coast, *yellow* for taxa that show significant changes in depth, and *orange* for taxa that show significant changes in both distance and depth.

Morse et al. In Prep

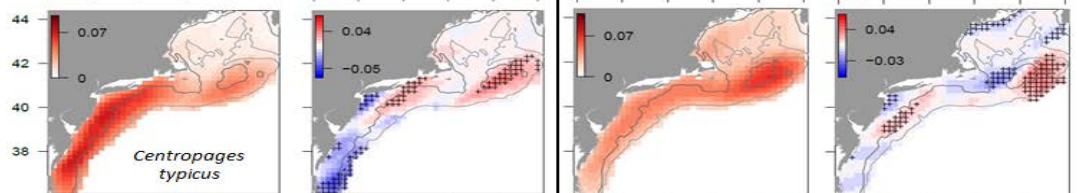
*Calanus finmarchicus*



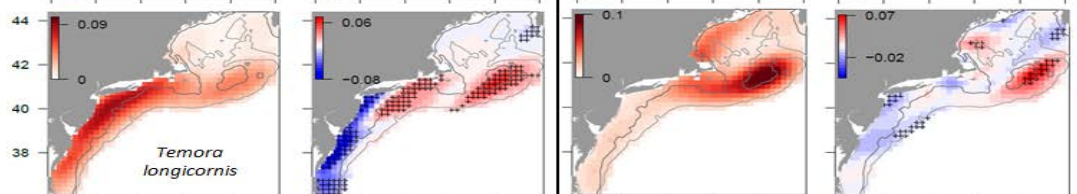
*Pseudocalanus*  
spp.



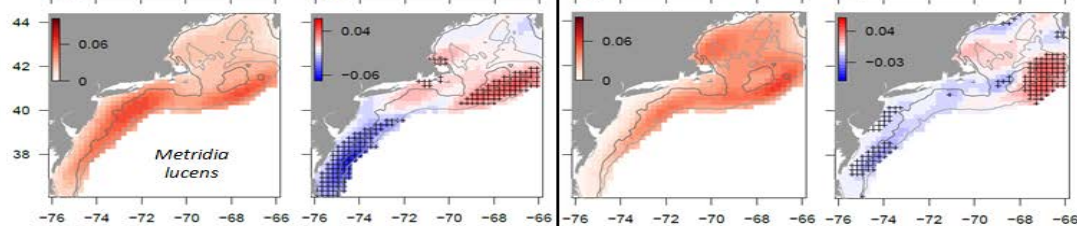
*Centropages typicus*

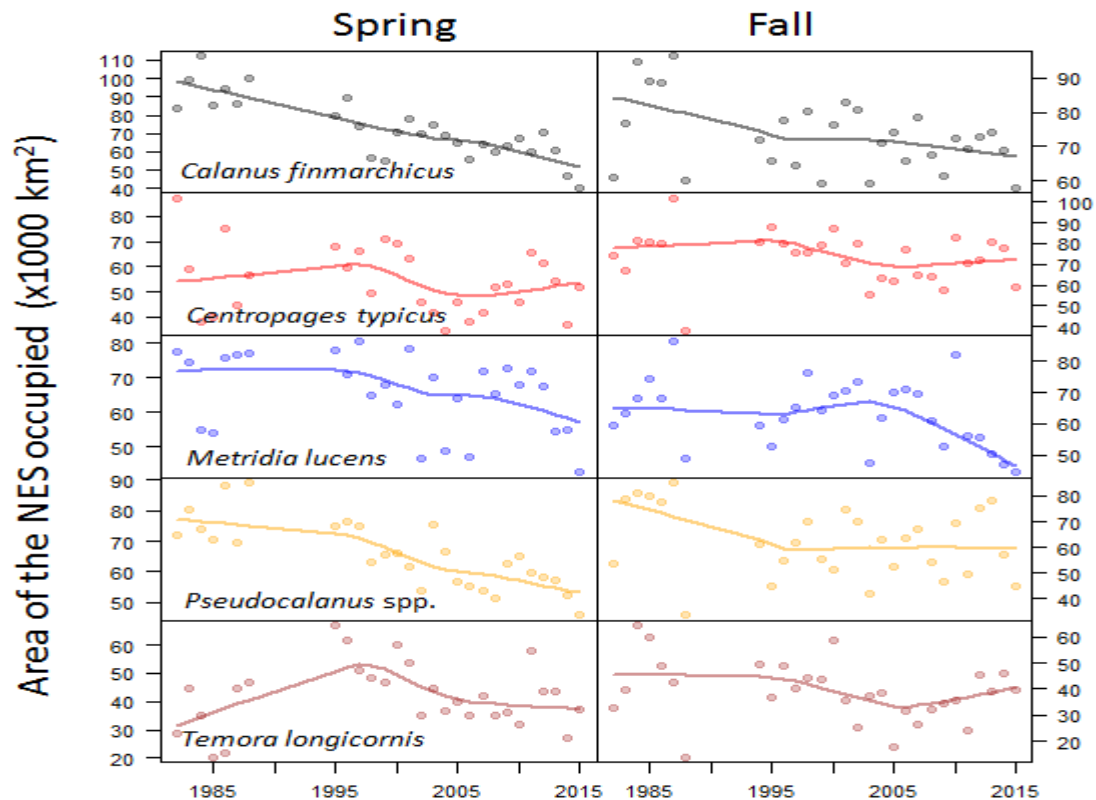


*Temora longicornis*



*Metridia lucens*



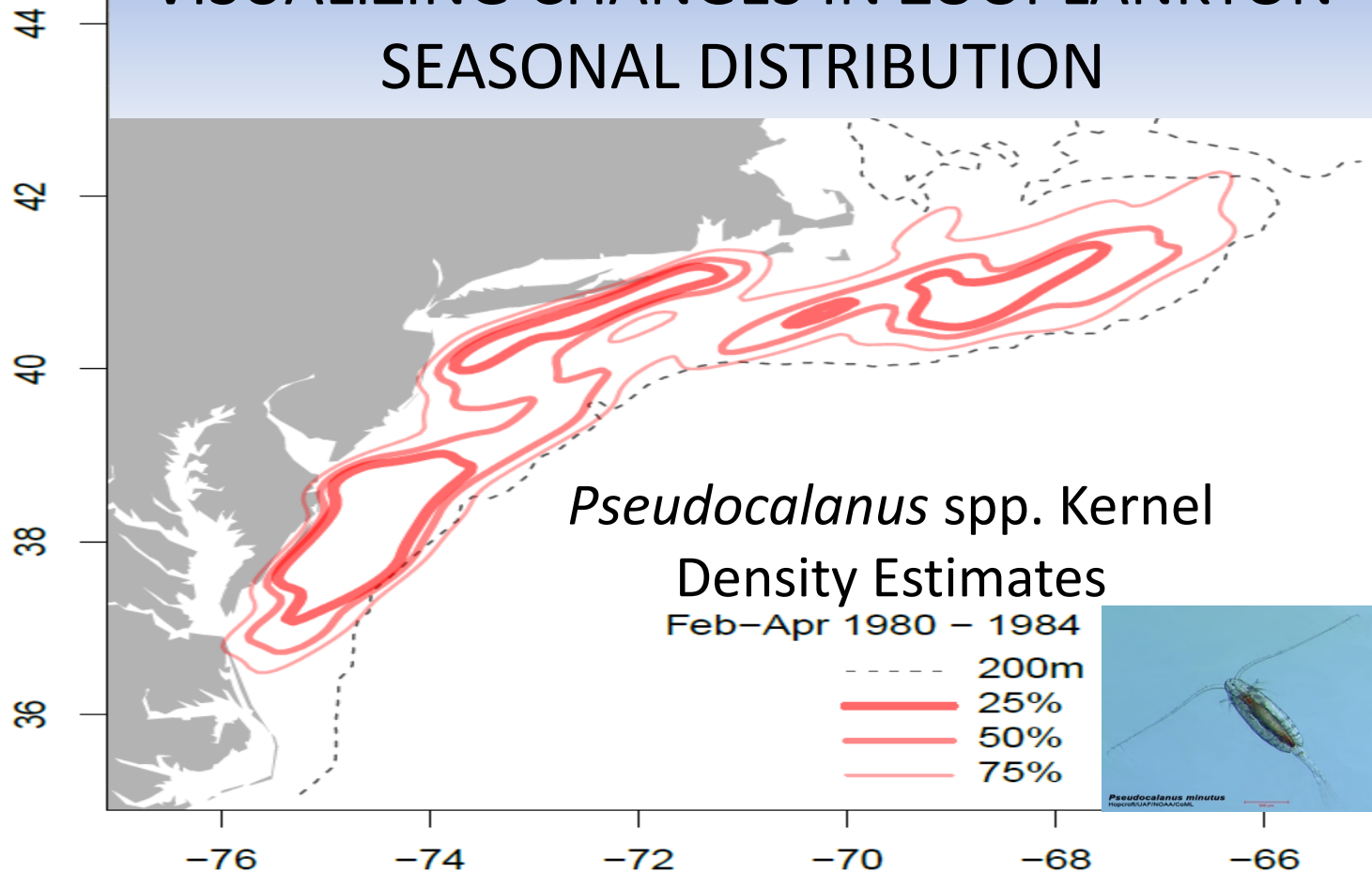


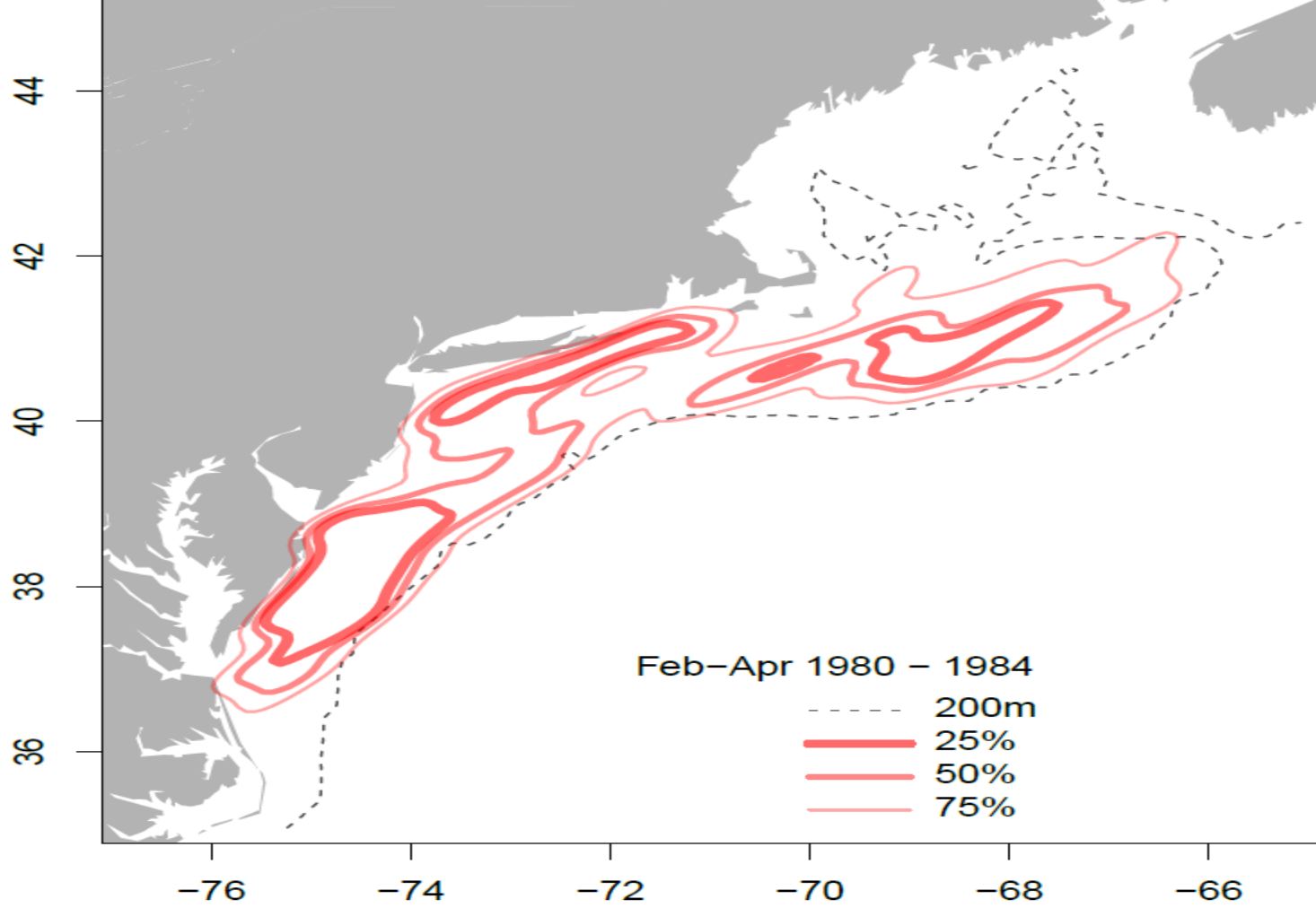
Area of the NES occupied by the 50% probability contour bands of five copepods:

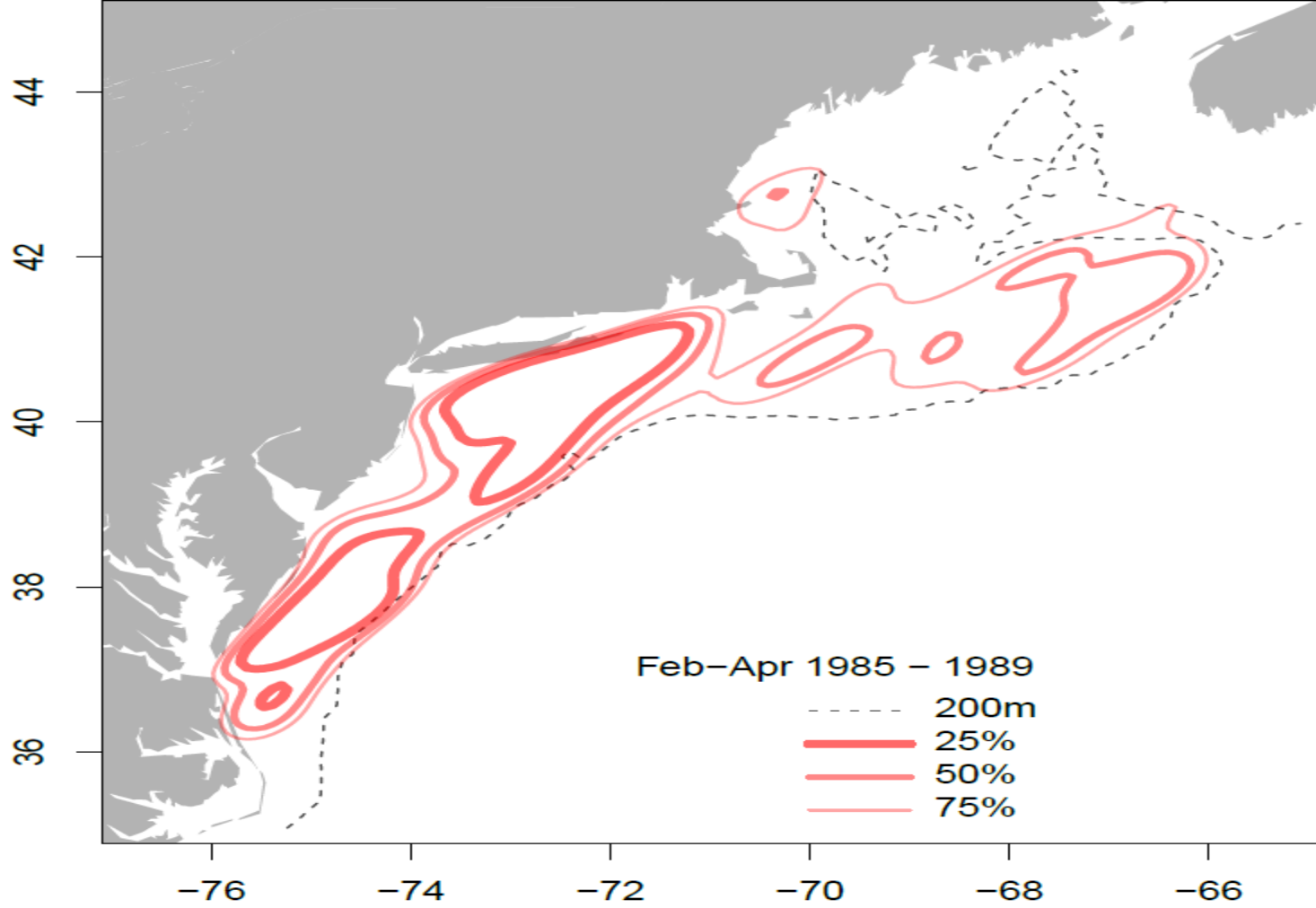
Morse et al. In Prep

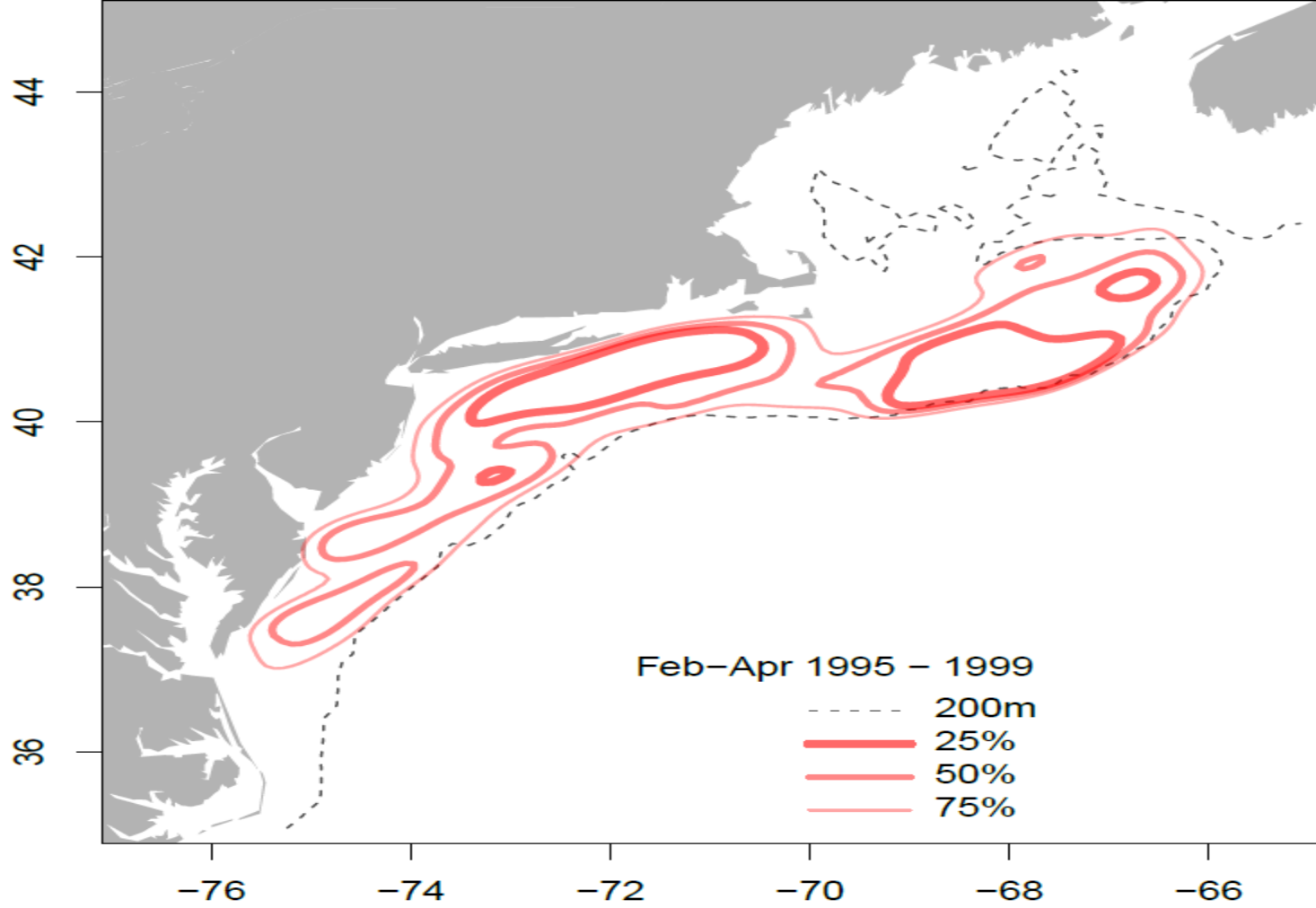


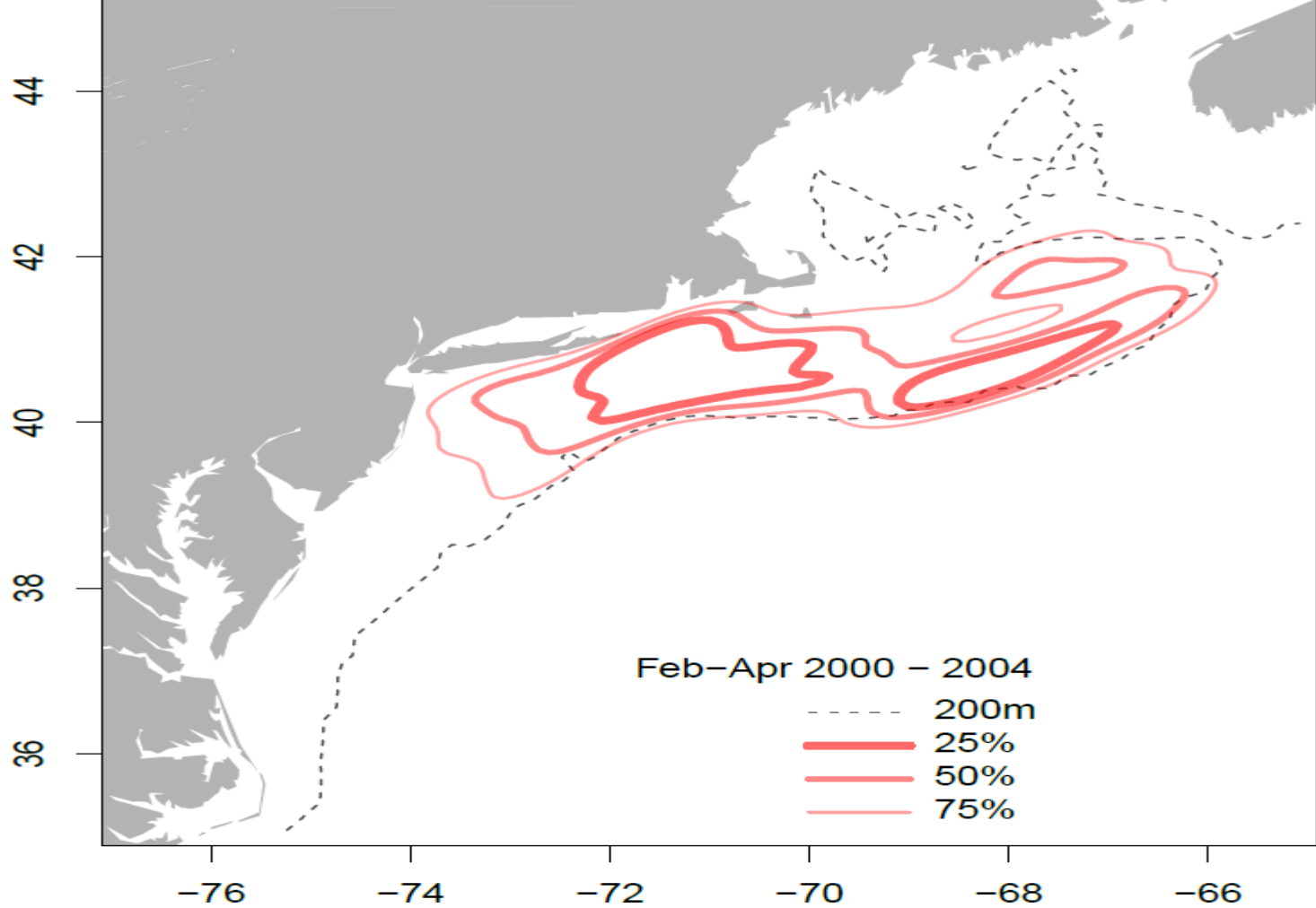
# VISUALIZING CHANGES IN ZOOPLANKTON SEASONAL DISTRIBUTION

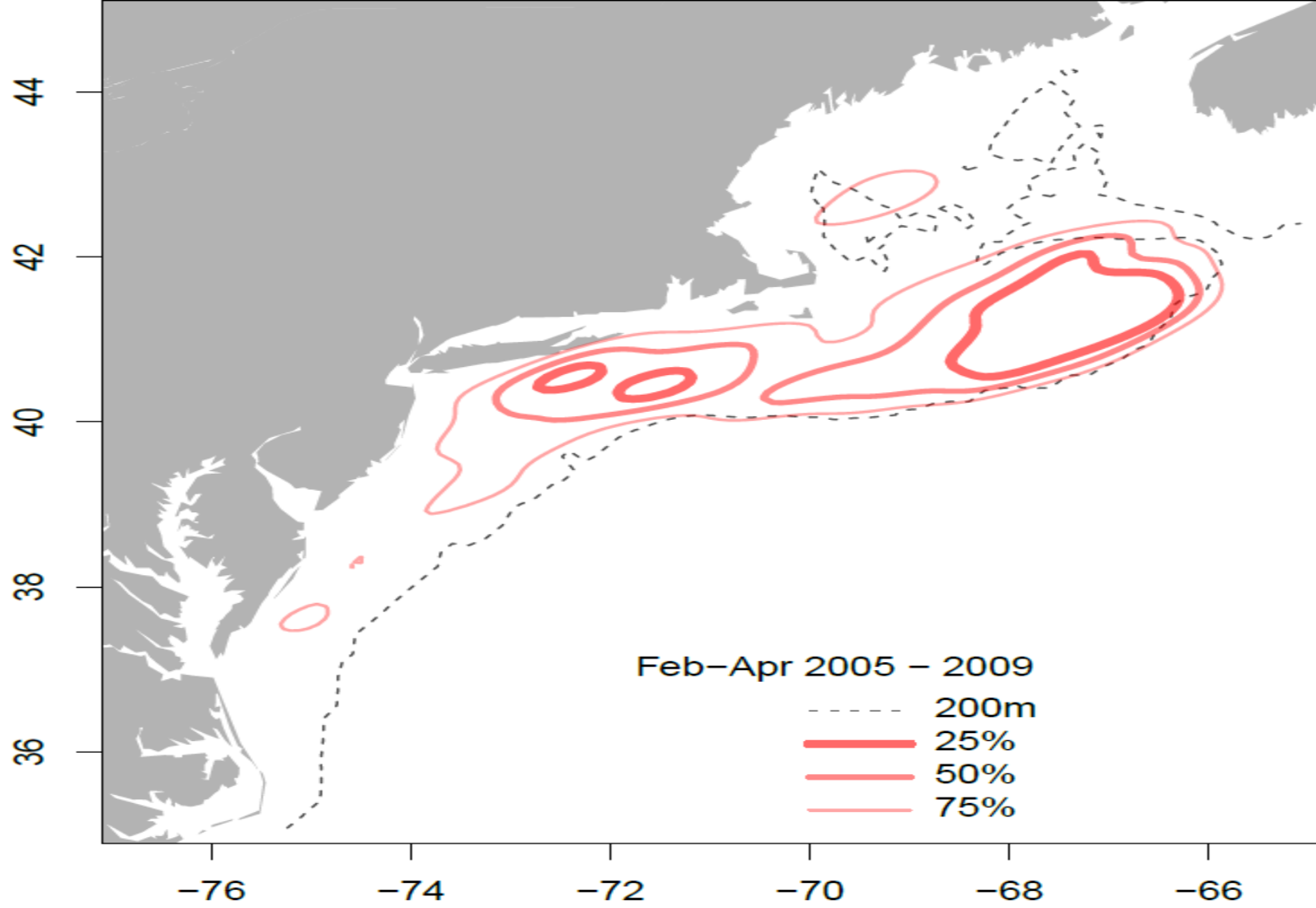


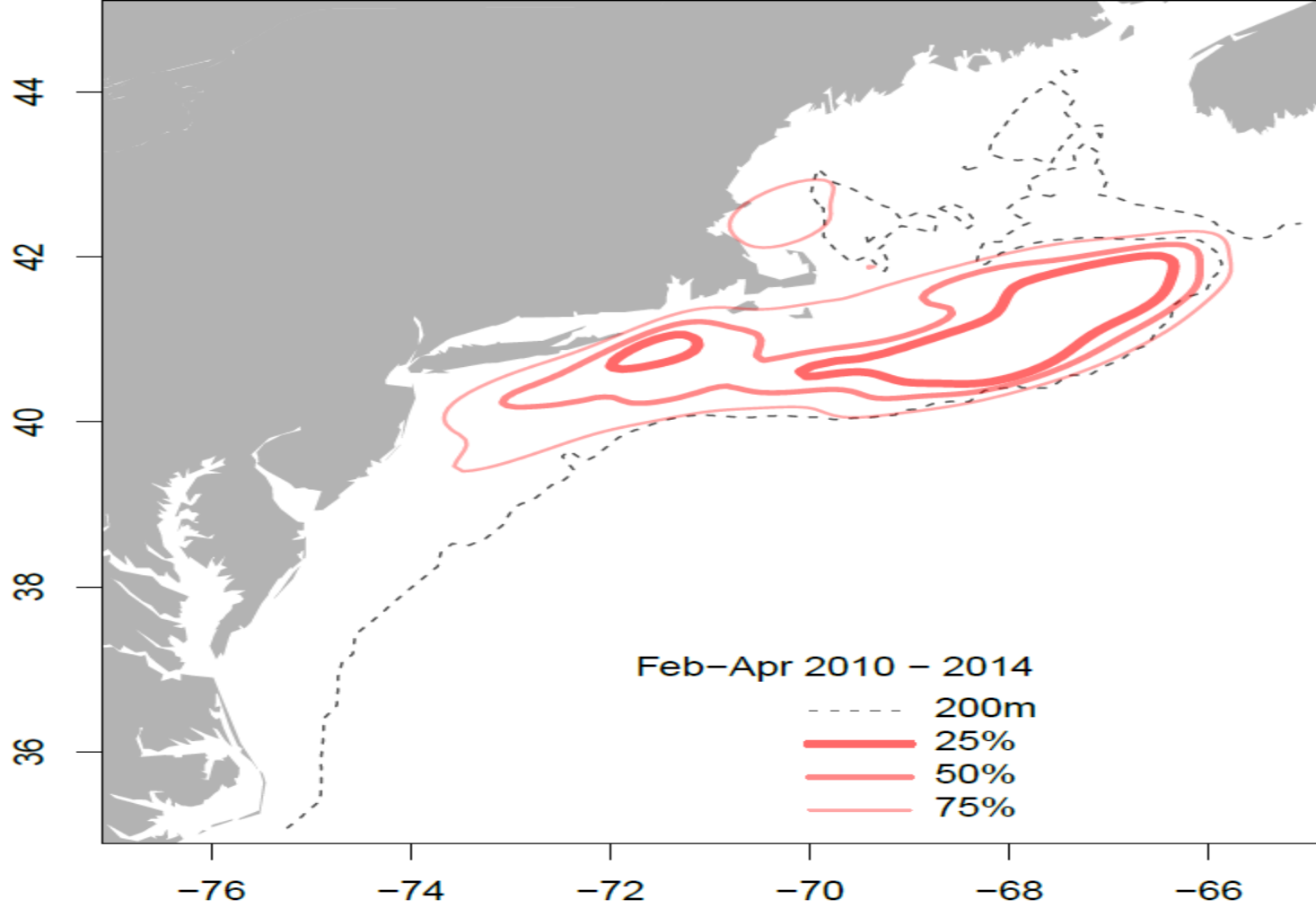


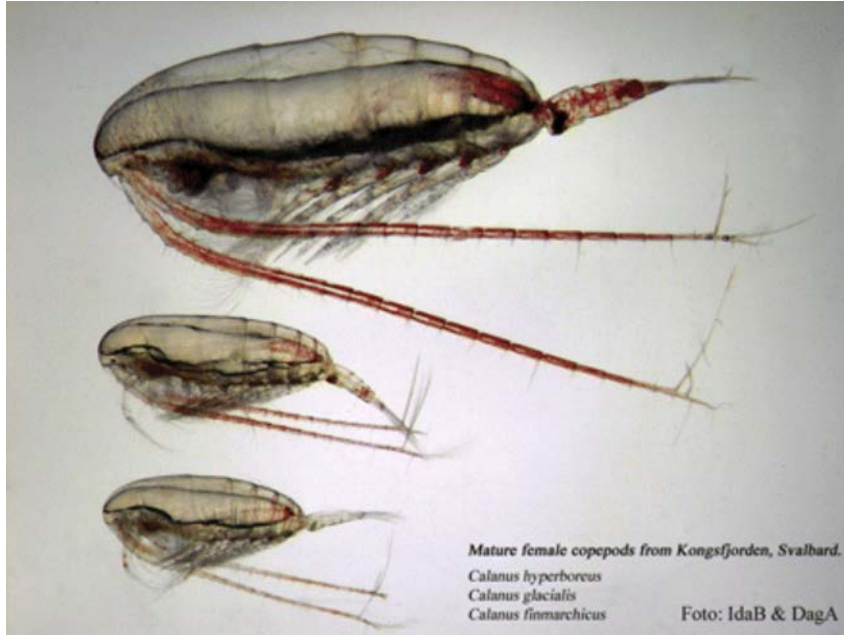












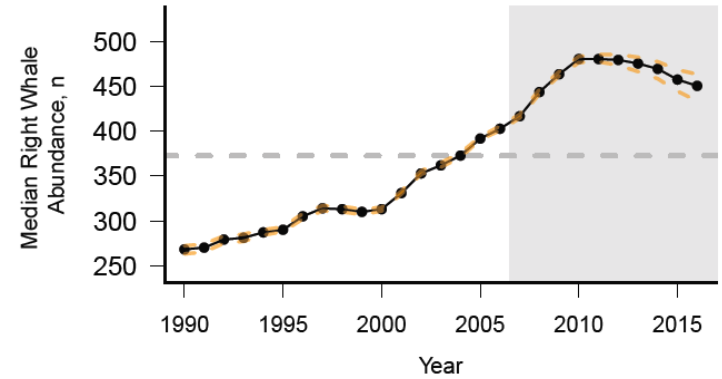
From: Evolution of the Arctic Calanus complex: an Arctic marine avocado?

J Plankton Res. 2012;34(3):191-195. doi:10.1093/plankt/fbr103

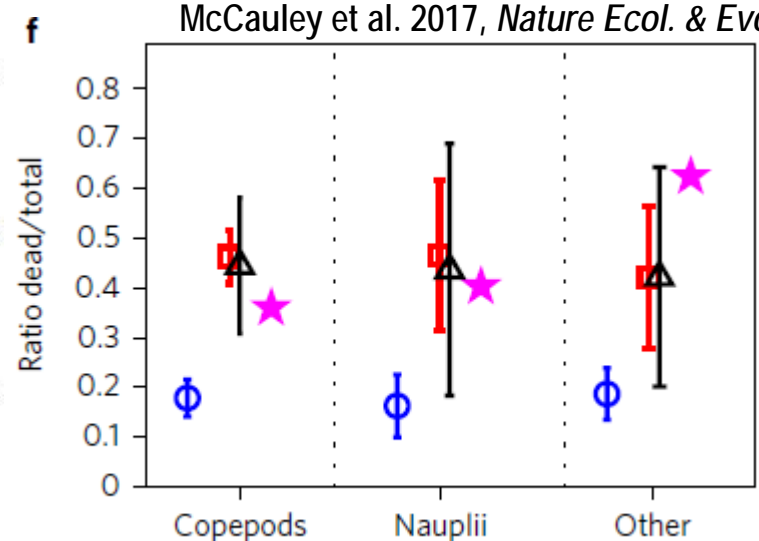
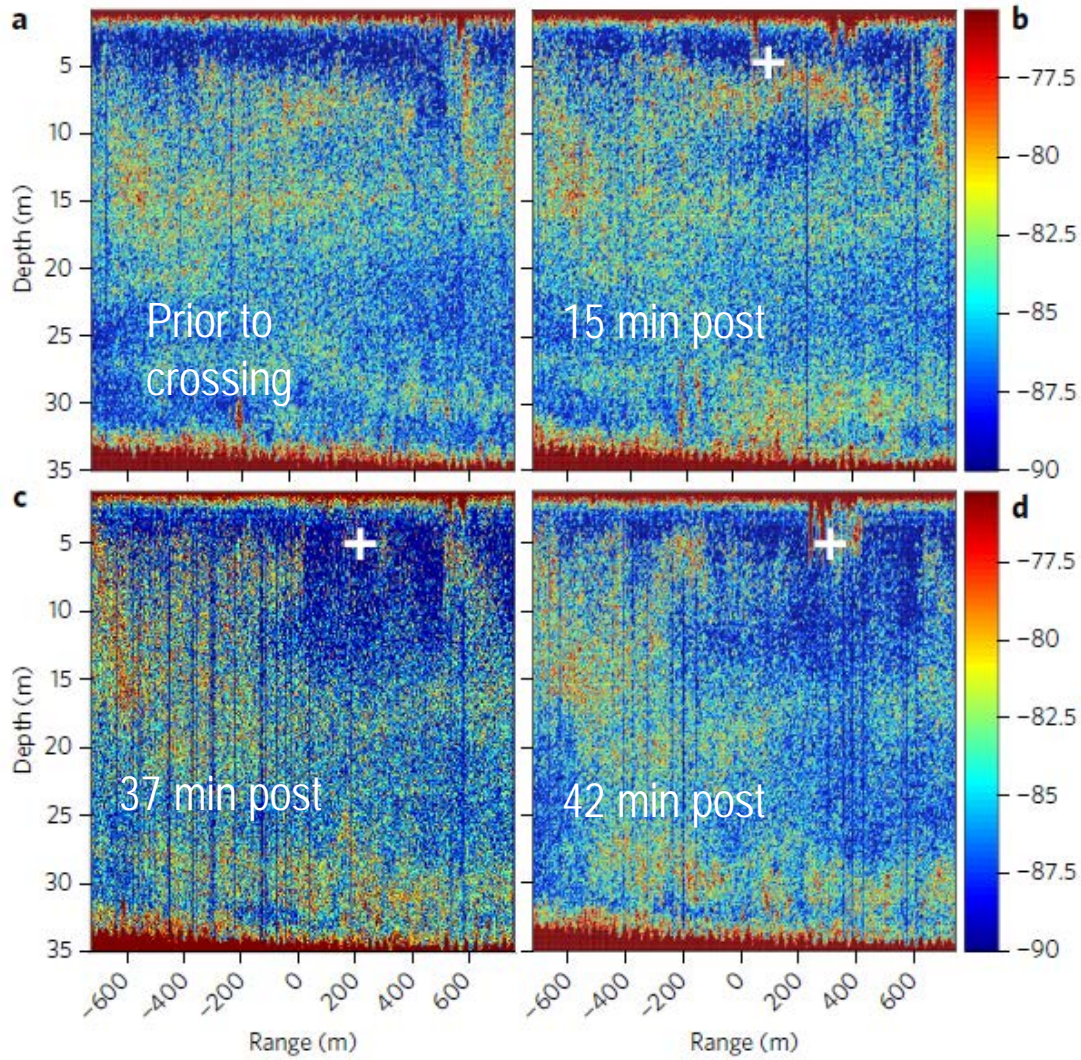
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## NOAA NEFSC 2018 State of the Ecosystem Report







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the years



Sardet, Christian. *Plankton: wonders of the drifting world*. University of Chicago Press, 2015.

*Questions and comments:*  
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