Identifying species assemblages on the Northeast Shelf from bottom trawl surveys

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Summary
"Integrated Ecosystem Assessments" (IEAs) provide guidance on a suite of species and account for factors such as climate change, which are often not addressed in traditional stock assessments. The U.S. Northeast shelf is a highly productive, temperate system strongly influenced by local oceanography. Many studies have illustrated shifts in species distributions, both in response to changing temperatures and fishing pressure. However, the Northeast shelf is a diverse region, with shallower warmer waters south of Georges Bank and deeper, more variable bottom topography in the Gulf of Maine. To better address this diversity and following an ecosystem approach, we examine changes in the distribution of assemblages, defined by species-specific thermal and bathymetric preferences, regionally within the Northeast shelf. We identify four assemblages regionally based on survey data from the Northeast bottom trawl that are well defined by bottom temperature and depth. We use these assemblages to examine latitudinal and depth-related movements of the species and compare this to predicted species-specific climate velocities. In general, we find depth to be a stronger descriptor of species and assemblage shifts in the northern region of our study area while both depth and latitudinal shifts are important in species distributions in south of Georges Bank.

Introduction
"Integrated Ecosystem Assessments" (IEAs) are described as ecosystem analogs to species assessments. They differ from conventional management approaches because they provide system-wide guidelines rather than advice on specific components ecosystem. The U.S. Northeast shelf is a highly productive, temperate region with complex biotic, environmental, and anthropogenic forces at play. Therefore, it is critical to gain a better understanding of the effects of fishing pressure, and to understand the role of climate change in shifting species distributions. Developing this knowledge is key for the incorporation of ecosystem-based fishery management principles into the decision making process. Examining temporal and spatial persistence of species assemblages can help identify unique ecological qualities that describe communities and responses to climate change. Several recent studies have focused on either defining species assemblages (e.g., Cope and Haltuch 2012) or defining changes in species distributions specifically in relation to climate change (e.g., Nye et al. 2009; Pinsky et al. 2013). However, few studies have looked at changes in assemblages with respect to climate change (notable exception: Lucey and Nye 2010). Additionally, distribution studies have tended to look at the Northeast shelf as a whole, despite the fact that the bathymetry and oceanography of the Gulf of Maine is significantly different than the shelf south of Georges Bank. To better address this diversity and following an ecosystem approach, we examine regional changes in assemblage distribution, defined by species-specific bathy-thermal preferences.

Materials and Methods
Data from the Northeast Fishery Science Center (NEFSC) bottom trawl survey are used to provide information on abundance, biomass, and environmental variables for 74 fish taxa. Hierarchical clustering analysis (HCA) and k-means are used to distinguish assemblages based on surface and bottom temperature and depth in each region (north and south) and season (spring and fall). In order to assess

potential shifts in assemblage distribution over time, we divide the time series into four periods from 1968 through 2012, and perform the assemblage analysis in each period. We find that four clusters are optimal for both seasons in both the northern and southern regions of our study area. For each of the four assemblages, we define 'principal' species to be those that clustered together according to both methods and in at least three of the four periods. To examine the relationship between changes in distribution and climate conditions, we calculate the center of biomass of each principal species in five-year time blocks following the approach detailed in Nye et al. (2009). This approach re-grids latitude and longitude of the survey points using the along-shelf and cross-shelf positions in order to avoid centers of biomass that are off the shelf and outside the survey area. These 'rotated' latitudes and longitudes are used to calculate (1) the bearing and direction of species shift, (2) velocity of species shift, and (3) a species-specific climate velocity. For details on (2) and (3) see Pinsky et al. (2013).

Results and Discussion

Of the four assemblages identified in each season and region, there is a strong separation between the assemblages based on bottom temperature and depth with assemblages corresponding to shallower and warmer waters (assemblage 1) to progressively cooler and deeper waters (assemblage 4). In general, species in the southern region display an average direction of movement in the northeast direction (Figure 1, left), versus to the southwest in the northern region (Figure 1, right). This result is consistent between seasons. The shift to the southwest in the north may reflect the fact that bottom temperatures are cooler in the southwest Gulf of Maine than towards the Scotian Shelf. In terms of the velocity of species shifts, depth is found to be a stronger descriptor of species and assemblage shifts in the northern region while both depth and latitude reflect changes in species distributions in the southern region.

References

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Figures

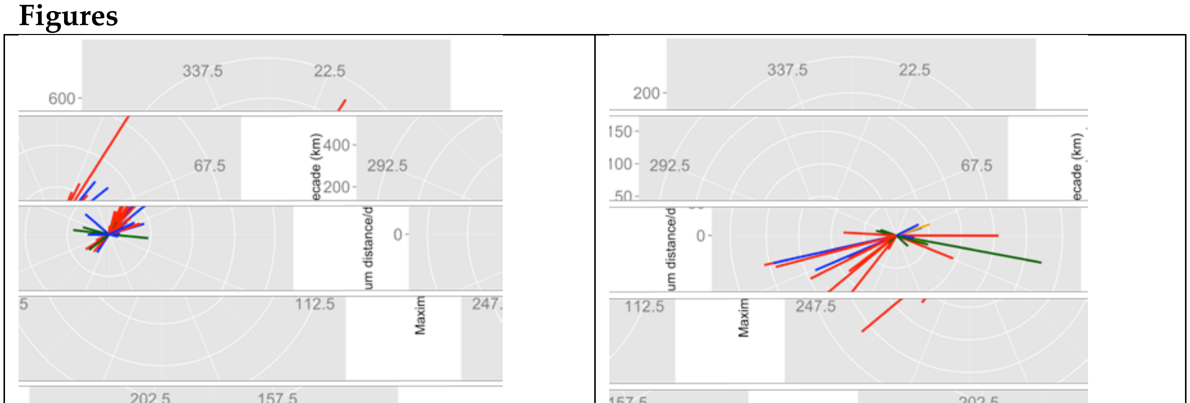

Figure 1. Bearing and direction of shifts in center of biomass, defined by assemblage (red=1, blue=2, green=3, yellow=4) in the fall for the southern (left panel) and northern (right panel) regions. The average bearing was 29 degrees (NE) in the south and 211 degrees (SW) in the north.