Spatial Considerations for Ecosystem-Based Fishery Management on the Northeast U.S. Continental Shelf

Michael J. Fogarty[1], Robert Gamble[1], Sean Lucey[1],
Kimberly Hyde[2], and Charles Keith[1],

[1] Northeast Fisheries Science Center
Woods Hole, MA 02543
USA
[2] Northeast Fisheries Science Center
Narragansett, R.I. 02882
USA

Extended Abstract

The recent signing of an Executive Order establishing a new National Ocean Policy for the nation lends special urgency to adopting the basic tenets of Ecosystem-Based Management: (1) a commitment to establishing spatial management units based on ecological rather than political boundaries, (2) consideration of the inter-relationships among the parts of the ecosystem and with the physical environment and (3) the recognition that humans are an integral part of the ecosystem. To address this first need, we assembled a set of physiographic, oceanographic and biotic (lower trophic level) variables to identify ecological production units on the Northeast U.S. Continental Shelf. The physiographic variables considered in this analysis include bathymetry and surficial sediments. The physical oceanographic and hydrographic measurements include satellite-derived estimates of sea surface temperature, annual temperature span and temperature gradients. We also employed ship-board estimates of surface and bottom temperature and salinity in spring and autumn based on Northeast Fisheries Science Center research vessel surveys. The biotic measurements considered include satellite-derived estimates of chlorophyll *a* and primary production, and chlorophyll gradients. Temperature and chlorophyll gradients are included to identify frontal zone positions.

We employed a principal components analysis (PCA; e.g. Pielou 1984; Legendre and Legendre 1998) to examine the multivariate structure of the data and as a prelude to classification of ecological production units. We then used a K-means cluster analysis on the principal component scores to define our spatial units. We identified seven major cluster units. The clusters represent major ecological production units on the shelf including (1) Eastern Gulf of Maine- Scotian Shelf, (2) Western-Central Gulf of Maine (3) Inshore Gulf of Maine, (4) Georges Bank-Nantucket Shoals (5) Intermediate Mid-Atlantic Bight (6) Inshore Mid-Atlantic Bight and (7) Continental Slope (Cape Hatteras to Georges Bank). These spatial units are considered to be open and interconnected, reflecting oceanographic exchange and species movement and migratory pathways.

We can further consolidate some ecological subareas to reflect movement patterns of exploited species from both the shelf-break region and the immediate nearshore

regions to the adjacent shelf areas. These regions would then be considered special zones associated with the adjacent shelf regions. We can further retain the option for special management considerations to be implemented in both nearshore and shelfbreak areas in a nested array to reflect the distribution of ecologically sensitive species, areas of high biomass and species richness, and the confluence of multiple human use patterns in nearshore regions. Following this approach, we specify four major ecological zones including (1) the Western-Central Gulf of Maine, (2) the Eastern Gulf of Maine-Scotian Shelf, (3) Georges Bank-Nantucket Shoals, and (4) the Mid-Atlantic Bight (Figure 1). For the purposes of this representation, we have included estuaries and embayments with the nearshore regions but note that it may be desirable to identify these areas separately as yet another nested layer in the overall spatial structure.

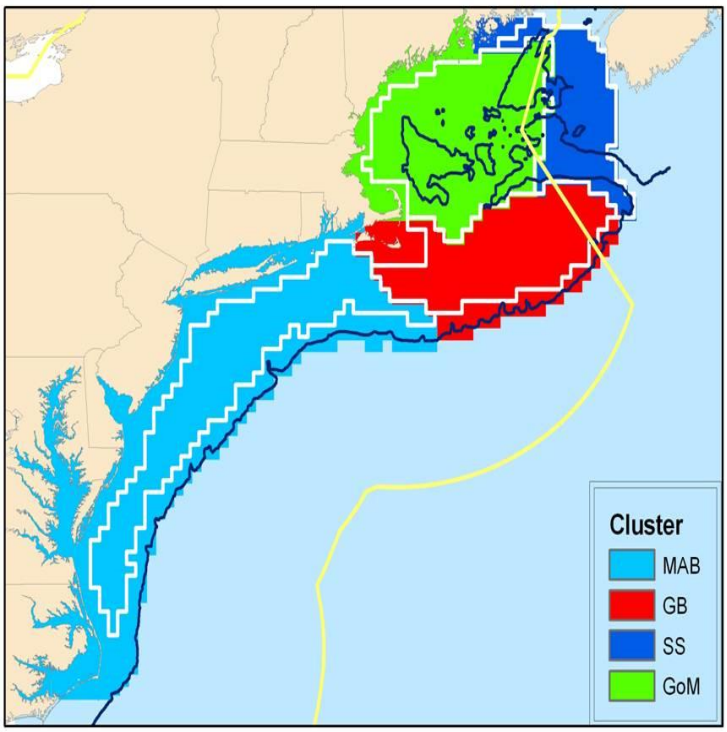

Figure 1. Proposed ecological subunits of the Northeast Continental Shelf including (1) Western-Central Gulf of Maine (GoM) (2) Eastern Gulf of Maine-Scotian Shelf (SS), (3) Georges Bank-Nantucket Shoals (GB) and (4) Middle-Atlantic Bight (MAB). White lines indicate boundaries between areas, including the designation of special areas at the edge of the continental shelf and in the immediate nearshore areas of the Middle-Atlantic Bight and the Gulf of Maine.

Consideration of the place of humans in fishery ecosystems and its implications for shaping spatial management units is no less important in devising effective strategies for EBFM and for gaining acceptance of this concept within fishing communities. The connection between humans and the geography of the sea has been well documented in

the northeastern United States, providing important perspectives on how we might integrate the human dimension into spatial management within the general context of EBFM. To assess general concordance between our proposed ecological subregions and human use patterns (with a focus on fishing activity), we mapped the distribution of fishing effort by vessel size, gear type, and port of origin. The observed distribution patterns reflect important social considerations on how, when, and where fishers operate as well as constraints imposed by logistical factors and management requirements. Not surprisingly, small vessels with more limited fishing ranges are often characterized by distribution patterns predominately in one of the proposed ecological units. Increasing vessel size and mobility is reflected in more spatially diverse fishing patterns and occupation of multiple ecological subunits. We find that fishing patterns also often follow major boundaries of our ecological subunits, reflecting topographical and productivity features that are often not represented by more conventional stock areas used under present management regimes.

An analysis of operational fishery units defined by species catch composition, seasonal and spatial fishing patterns, and gear type also finds strong correspondence between the proposed ecological subunits and the spatial extent of these fishing assemblages. The confluence between ecological structures related to productivity patterns and spatial fishing strategies does suggest the potential utility of the ecoregions defined in this study as management units for EBFM.

These considerations hold important implications not only for defining potential management units for EBFM but for identifying both ecologically important areas and regions of critical importance for fishing communities. Decisions in Marine Spatial Planning will hinge on demonstrating the importance of spatially defined regions of joint human and ecological concern.

We conclude that:

- Ecological subunits of the Northeast Continental shelf can be effectively defined based on physiographic, oceanographic, and lower trophic variables
- The number and size of the major spatial management units ultimately chosen will involve tradeoffs involving interchange among areas (smaller units involve more interchange).
- Hierarchical spatial management structures can be defined to reflect distribution of vulnerable species, biomass and biodiversity, human use patterns, and management requirements
- These mapping exercises highlight areas of importance to fisheries and can be used to represent fisheries interests in marine spatial planning

We recommend that the MAFMC evaluate options for the designation of spatial management units as the basis for development of integrated management plans for

defined ecoregions. The proposed ecological units cleanly delineates the main area of responsibility of the council in the Mid-Atlantic Bight although for some migratory species under council authority, coordination with other management authorities (notably the Atlantic States Marine Fisheries Commission and the New England Fishery Management Council) will be necessary. A transition strategy can be defined that first adopts place-based management as the ultimate goal for the council and then begins to assess how existing management plans can be adjusted to accommodate broader ecosystem objectives. These extended plans would then ultimately be absorbed into a fully integrated Ecosystem-Based Management Plan for the Mid-Atlantic Bight.