

Stellwagen Bank National Marine Sanctuary

Proposed Sanctuary Ecological Research Area

Preamble

This proposal would establish a proposed Sanctuary Ecological Research Area (proposed SERA) within Stellwagen Bank National Marine Sanctuary. As the first step, the proposal is submitted to the New England Fishery Management Council (NEFMC) for inclusion in its Essential Fish Habitat (EFH) Amendment process, under provisions of the Northeast Multispecies Fishery Management Plan, pursuant to authorization under the Magnuson Fishery Conservation and Management Act (MFCMA). In addition, the proposal similarly may need to be reviewed by other fishery management authorities to ensure comprehensive management.

Because this proposal is comprehensive in scope, it will be submitted for consideration to the Mid-Atlantic Fishery Management Council (for provisions in the proposal regarding dogfish, bluefish, surf clam and ocean quahog management) and to the Atlantic States Marine Fisheries Commission (for provisions regarding lobster and pink shrimp management), the latter pursuant to authorization under the Atlantic Coastal Fishery Cooperative and Management Act, as well as to the NMFS Highly Migratory Species Management Division (for provisions regarding bluefin tuna, billfish and shark management), pursuant to authorization under the MFCMA and the Atlantic Tunas Conservation Act.

Therefore, whereas this proposal is presented to the NEFMC for primary action, it will be presented separately in series to other fishery management authorities for review and possible adoption of appropriate subcomponents of the proposal. This approach is consonant with the National Marine Sanctuaries Act (NMSA) process for issuing fishing regulations for national marine sanctuaries.

I. Introduction

The NOAA Office of National Marine Sanctuaries (ONMS) proposes designating a Sanctuary Ecological Research Area (SERA) within Stellwagen Bank National Marine Sanctuary (SBNMS or sanctuary). A proposed SERA designation would establish a dedicated research area to conduct studies that aid sanctuary managers and the public in meeting objectives focused on the conservation of marine biological diversity as well as afford an improved understanding of ecological processes linked to human uses in SBNMS. Here biological diversity includes not only species diversity but genetic and community-landscape diversity as well. Biological diversity encompasses the suite of marine organisms found in SBNMS and includes microbes, invertebrates, fishes, seabirds and marine mammals.

One of the purposes and policies of the National Marine Sanctuaries Act (NMSA) is “to support, promote, and coordinate scientific research on, and long-term monitoring of, the resources of [national marine sanctuaries] (16 U.S.C. 1431(b)(5)). Not only will this proposal directly support this purpose, but it is entirely consistent with a priority goal of the SBNMS Final Management Plan (NOAA, 2010)—the conservation of marine biological diversity—and the primary objective of the National Marine Sanctuaries Act—the protection of sanctuary resources.

Results of studies from the proposed SERA also will be of direct interest to managers in other parts of NOAA (e.g., NMFS) and the New England Fishery Management Council (NEFMC) in regard to conservation of essential fish habitat and the ecology of protected species (e.g., taxa on the species of concern list). Knowledge about how the ecosystem responds to the proposed SERA will benefit managers of other national marine sanctuaries and related protected areas. Linkages to the information

needs of other Federal, State and local agencies, stakeholder groups (e.g., fisheries and environmental non-governmental organizations) and individuals may emerge as the SERA proposal is considered.

II. Role of the Sanctuary Ecological Research Area

The primary purpose of the proposed SERA is to establish reference and treatment subareas based on different types of human use to facilitate the research and monitoring needed to better understand the dynamics and processes (biological and physical) that mediate patterns of biological diversity within the sanctuary. Patterns of biological diversity within SBNMS vary based on characteristics of habitat and are mediated by processes that include both natural disturbance and anthropogenic impacts (Nenadovic, 2009; Tamsett *et al.*, 2010).

Commercial and recreational fishing has been determined to be the major local anthropogenic activity affecting biological communities, seafloor habitats and species richness and abundance within the sanctuary (NOAA, 2010). Because of the long history of fishing in the Gulf of Maine generally and the sanctuary area specifically, there is little knowledge of earlier community states or how ecological processes functioned in different environmental settings.

Implementation of an appropriate research design that partitions different types of fishing activities across representative habitats would enable sanctuary managers to better understand the response of marine communities and their component species to variations in natural and human-caused disturbances, discern how human uses influence major ecological processes (e.g., predation, competition), and develop a capacity to predict the dynamics of community recovery and resilience within the sanctuary. The assessment of ecological impact due to different classes of fishing would inform not only sanctuary management but also fisheries management, particularly as the latter implements conservation of essential fish habitat and ecosystem-based fishery management approaches.

While establishment of the proposed SERA would provide the foundation to conduct research, the results of research would not be acquired instantaneously or on a set schedule. Time is needed for collaborations to be built among researchers (government, academic, non-governmental, industry participants) to develop proposals for projects and to secure necessary support.

III. Rationale

There is no formally designated undisturbed reference area within SBNMS or anywhere else offshore within the Gulf of Maine under U.S. jurisdiction. The National Marine Fisheries Service (NMFS), at the recommendation of NEFMC, established the Western Gulf of Maine Closure Area (WGoMCA) in 1998 (Nies 2007; Figure 1). This action was established under Framework Adjustment 25 to the Northeast Multispecies Fishery Management Plan (Plan) for the purpose of reducing fishing mortality on Atlantic cod populations. A portion of the WGoMCA overlaps the SBNMS. The use of commercial groundfish gear including bottom trawls, gillnets and scallop dredges is prohibited but recreational fishing is allowed; midwater herring trawls were allowed beginning in 2001.

In 2004, Amendment 13 to the Plan established habitat closure areas for the conservation of essential fish habitat. Other fishery management plans were amended accordingly. While the eastern borders of the WGoMCA were changed by the Amendment, the closure boundaries within the SBNMS remained the same. Allowable gear in the WGoMCA include lobster pots, hagfish pots, pelagic longline, pelagic hook and line, recreational hook and line, pelagic gillnets, tuna purse seining and midwater trawls. All other bottom contact gears have been prohibited. The WGoMCA overlaps approximately 22% of the eastern region of the sanctuary; the area of overlap has been referred to as the “sliver” (Figure 1).

See Table 1 for the size of the Gulf of Maine and regulatory or statistical areas associated with the proposed SERA.

Table 1. Size of Gulf of Maine and Regulatory or Statistical Areas Associated with proposed SERA	
	Area Sq. Nm.
Gulf of Maine (GoM)	27,184
Western Gulf of Maine Closure Area (WGoMCA)	883
Western Gulf of Maine Level 3 Habitat Closed Area	662
Stellwagen Bank National Marine Sanctuary (SBNMS)	640
Proposed SERA	251
Proposed SERA Subarea A	89
Proposed SERA Subarea B North	28
Proposed SERA Subarea B South	78
Proposed SERA Subarea C	56
Remainder SBNMS	389
Statistical Area 514	2,582
Offshore Area 19	1,629
NOAA Fishing Area 4	7,305

Because of the sanctuary’s need for a reference site, the sliver has become a *de facto* reference area that sanctuary and other researchers are using to investigate the effects of human versus natural disturbance on seafloor habitats and their associated biological communities. However, the sliver is far from an adequate reference area owing to two critical shortcomings: (1) there is no gradient of fishing effects to facilitate studies to better discern the ecological effects of one type of fishing method from another; and, (2) deep mud habitat is seriously underrepresented within the sliver relative to the sanctuary overall (sliver: 74.0% gravel, 23.4% sand, 1.0% mud, 1.6% boulder; SBNMS overall: 36.9% gravel, 34.1% sand, 28.2% mud, 0.8% boulder) making it difficult to understand variation in the dynamics of deep mud communities and the effects of fishing in this habitat type.

To address this lack of a reference area, the 2010 SBNMS Final Management Plan includes two strategies that call for establishing research areas or reference areas. Strategy 2.1 of the Ecosystem Alteration Action Plan calls for developing a process to establish reference areas that serve as benchmarks for assessing human and natural impacts on habitat. Strategy 4.1 of

the Ecosystem-Based Sanctuary Management Action Plan recommends continuing to convene the Zoning Working Group established by the Sanctuary Advisory Council (SAC) in 2004 to: (1) evaluate the adequacy of existing zoning schemes in SBNMS; (2) address the scientific requirements to meet the goals of ecosystem-based management; and if needed (3) develop a modified zoning scheme including consideration of fully protected reserves.

While no consensus was reached by the Zoning Working Group on specific zoning options, the recommendations of the scientific subgroup of the Zoning Working Group were clear. The scientific subgroup recommended protection of representative examples of the full range of biological communities associated with seafloor habitats (e.g. deep mud, boulder reefs), protection and enhancement of size class composition for all species, and protection of key ecological patterns indicative of community and ecosystem processes. With that guidance and by means of this proposal, SBNMS is implementing Strategy 2.1 to initiate a process that establishes scientific research reference areas in representative communities (using seafloor habitats as proxies) in the sanctuary.

Increased and better coordination of research within the sanctuary facilitated by the proposed SERA would create greater opportunities for leveraged partnering, collaboration, and synergy. Dedicated research permitting and coordination would ensure compatibility among projects and reduce conflicts and interference that could bias results of monitoring programs and experiments. Establishment of the proposed SERA and associated permitting and enforcement would provide the much needed security of tenure that is critical to attracting support for—and ensuring the success of—long-term research and monitoring programs.

IV. Process for Establishment of the Proposed SERA

The NEFMC is undertaking an Essential Fish Habitat (EFH) Omnibus Amendment process that involves two phases. Phase I (completed) involved the identification and mapping of EFH

in the Gulf of Maine. Phase II (underway) involves the quantification of fishing gear impacts on EFH and the mitigation of these impacts through management measures, such as habitat closed areas, seasonal closed areas, gear modifications, and fishing effort reductions.

The Phase II process currently is nearing completion, in part using the results of the Swept Area Seabed Impacts (SASI) model. The SASI model was developed by the NEFMC to identify vulnerable habitats based on sensitivity to disturbance, period of recovery, and fishing intensity (NEFMC, 2011). While designation of Dedicated Habitat Research Areas (DHRAs) will be a part of the Phase II process, the NEFMC is first reevaluating all of the existing Habitat Closed Areas, current and proposed Habitat Areas of Particular Concern, and existing groundfish closed areas. It is not entirely clear how DHRAs will factor into this process or the criteria used for identifying such areas. DHRAs must be defined spatially, have clearly defined objectives, and have restrictions specified.

ONMS would like the proposed SERA proposal considered within the mix of habitat closures the NEFMC is considering for the Gulf of Maine so that the range of various alternatives can be discussed. The proposed SERA, as well as SBNMS in its entirety, serves as EFH for all life stages of 21 of the 25 managed species identified in Phase I of the EFH Omnibus Amendment process. Inclusion of this proposal in the EFH Amendment process is consistent with NOAA's process for determining how it will administer the regulation of fishing in national marine sanctuaries. This process outlines the integration and coordination among ONMS, NMFS, and regional fishery management councils and serves to identify the best legal mechanism by which to fulfill intended goals and objectives – Magnuson-Stevens Act (MFCMA), National Marine Sanctuaries Act (NMSA), or both. The decision of which regulatory mechanism to use would

focus on how to address the following principal goals:

- Long-term Time Frame - The proposed SERA needs a time frame sufficiently long to serve as a valid reference area that affords the capacity to evaluate long-term changes in biodiversity and associated baseline conditions across all major habitats due to fishing and climate-driven factors. Biological community processes and climate change driven ecological shifts operate on the scale of decades or more. A lengthy time frame also is required to provide the security of tenure for long-term monitoring and research and to help attract and sustain long-term funding commitments.
- Holism - ONMS is mandated by the NMSA to protect the full suite of species, habitats and associated biological communities occurring within explicitly designated areas, i.e., the sanctuary and hence the proposed SERA. The proposed SERA is a representative subset of the sanctuary. NMFS primarily regulates managed species and associated essential fish habitat on a regional basis. Managed species are known to be just a fraction of the biodiversity extant in the sanctuary and the proposed SERA.
- Permitting - Past related actions in national marine sanctuaries (e.g., Channel Islands for marine reserves; Monterey Bay for Davidson Seamount) have shown that regulatory research can be handled by NOAA through the NMSA. It is therefore relevant to consider having ONMS co-lead any permitting role.

V. Configuration of the Proposed SERA and Associated Restrictions

The proposed SERA would include 39% of the sanctuary area and represent 0.9% of the Gulf of Maine region overall. The proposed SERA comprises three contiguous subareas (Figures 1, 2 and 3): Subarea A would be a no-fishing

Table 2. Proposed Restrictions on Fishing Gear Types by Subarea.

Shading denotes gear types affected by subarea restrictions

Subarea	Bottom trawling	Scallop dredging	Bottom gillnetting	Pelagic gillnetting	Long-lining	Lobster, crab, fish trapping	Hook and line	Herring trawling	Purse Seining	Shrimp trawling	Tuna and shark fishing
A	N	N	N	N	N	N	N	N	N	N	N
B North	N	N	N	N	N	N	Y	N	N	N	Y*
B South	N	N	N	N	N	N	Y	N	N	N	Y*
C	N	N	Y	Y	Y	Y	Y	Y	Y	N	Y
Remainder SBNMS	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y = Yes allowed

N = Not allowed

* Hook-and-line only

reference area and constitute 13.8% of SBNMS. Subarea B would be limited to hook-and-line fishing (party, charter, private, commercial handline) and account for 16.5% of SBNMS. Subarea C would allow all forms of fishing except bottom-tending mobile fishing gear and comprise 8.7% of SBNMS. Mobile gears (trawls, dredges) are the major source of fishing impacts in the northeast region (99.5% in 2009) based on the NEFMC’s Swept Area Seafloor Impacts (SASI) analysis. Fishing with all of the above gear types would occur in the rest of the sanctuary (61%) outside the proposed SERA unless restricted by NMFS under other regulations.

The proposed restrictions by subarea within the proposed SERA are summarized in Table 2. While not allowing for a perfectly designed research area in all regards due to consideration of existing uses of SBNMS by fishing gear type, the proposed research design enables studies to discern effects between natural disturbance and different types of fishing gear used in the sanctuary across the range of representative habitat types and depths and their associated ecological communities.

The configuration of the proposed SERA within SBNMS has several attributes that would make it particularly appropriate for the types of research that would be conducted. These attributes include scientific, practical, and jurisdictional elements.

- The proposed SERA would include the five major seafloor habitat types found in the sanctuary and across the Gulf of Maine—rocky outcrop, boulder, gravel, mud, and sand. This enhances the application of results to management of the sanctuary and the exportability of research results to managers of other temperate protected areas as well as to those concerned with habitat for fisheries. The proposed SERA (as well as the entire sanctuary) has been mapped by USGS to 10m resolution using multi-beam sonar. This is among the highest resolution seafloor mapping within the Gulf of Maine and greatly leverages the ability to conduct research on benthic habitats and associated biological communities.
- The proximity of the proposed SERA to the ports of Gloucester, Boston, Scituate, Plymouth, and Provincetown would make it accessible to researchers for day trips using small and relatively inexpensive vessels. In fact, it is this geographic proximity that has allowed researchers from multiple universities to conduct studies in the WGoMCA across the time period of the existing closure. Currently, the study area for the Massachusetts Ocean Partnership-funded Ecosystem Services Tradeoff Modeling effort overlaps the majority of SBNMS and the proposed SERA (Figure 4). This effort involves numerous area

Table 3. Number of Fishing Trips by Gear Type based on VTR Data (May 1, 1998 – 2009) Shading denotes number of trips affected by subarea restrictions						
	Total	Mobile	Fixed	Party	Charter	Com Hnd
Total SBNMS	118,174	39,849	58,608	4,874	10,068	4,775
A	8,228	2,240	3,986	1,077	718	207
B North	1,975	163	925	487	338	62
B South	4,689	256	796	840	2,647	150
C	10,339	2,816	6,035	498	735	255
Remainder SBNMS	92,943	34,374	46,866	1,972	5,630	4,101
Number of Affected Trips	13,184	5,475	5,707	1,077	718	207
% Affected within Subareas		13.7%	9.7%	22.1%	7.1%	4.3%
% Affected of Total SBNMS	11.2%	4.6%	4.8%	0.9%	0.6%	0.2%

Com Hnd = Commercial handline

institutions and will provide critical science-based support for multi-use decision making within what becomes the regional planning body in the Northeast as called for in the National Ocean Policy.

- A portion of the proposed SERA area (the "sliver") has already been closed to fishing for over 13 years as part of the WGoMCA. From a scientific perspective, the existing time series data at paired inside-outside monitoring sites in mud, sand, gravel, and boulder habitats (1998-2010), conducted during the Seafloor Habitat Recovery and Monitoring Project (SHRMP), enhances our ability to study ecological processes related to the patterns of disturbance and recovery of seafloor communities. The proposed SERA design would preserve most of these existing study sites except outside mud (Figure 4).
- The proposed SERA design also would take advantage of HabCam survey work done as a component of the Northeastern Benthopelagic Observatory (NEBO) project in SBNMS (2007-2010), especially where sampling effort was concentrated in relation to each of the proposed SERA subareas (Figure 5). The ongoing NEBO studies are focused on linking community structure and seafloor features, evaluating differences in community structure inside and outside of

the WGoMCA, detecting variations in distribution and abundance of rare species related to seafloor habitats, and assessing the distribution of invasive species. To date, HabCam surveys have collected over 15 million optical images in SBNMS.

- ONMS has the capacity and authority to monitor and enforce the area (see Endnote).

The proposed SERA configuration is based in part on minimizing impacts to fishing activities in SBNMS, and emerged from an analysis of the spatial distribution of total fishing effort (137,618 trips) historically expended in the sanctuary (Figure 6). This analysis is based on Vessel Trip Report (VTR) data from 1996-2009, which is the same time frame used in the EFH Omnibus Amendment for assessing spatial variations in fishing effort. The proposed SERA configuration would have minimal impact on private recreational fishing as well (Figure 7).

VI. Results of Spatial and Socio-Economic Analyses

Results of detailed analyses illustrating the spatial variation in use of the proposed SERA subareas based on gear type are presented in Table 3 and Figure 8. These analyses include 99.2% of all fishing trips (118,174) in SBNMS based on VTR data from May 1, 1998-2009, i.e., since the WGoMCA was established. The proposed SERA configuration affects 11.2% of

the total number of reported fishing trips in SBNMS over that time period. Of that percentage, affected mobile gear trips account for 4.6% of the overall total, fixed gear trips 4.8%, party boat trips 0.9%, charter boat trips 0.6%, and commercial handline trips 0.2% (Table 3).

VTR data include some but not all fishing trips for lobster (i.e., for about 70% of permit holders) and tuna. Additional data for lobster and tuna fishing permitted respectively by the Atlantic States Marine Fisheries Commission and NOAA’s NMFS Highly Migratory Species Division also will be analyzed. These data will be analyzed prior to meeting with the ASMFC and the Highly Migratory Species Advisory Panel. These data are supplemental to the VTR data used in the EFH Omnibus Amendment assessment by the NEFMC and are reported at a much greater spatial scale than SBNMS, i.e. Offshore Area 19 for lobster and NOAA Fishing Area 4 for tuna (Table 1).

Details of the socioeconomic impact studies conducted based on the VTR data in conjunction with the proposed SERA analyses are presented in Appendices I-III. The analysis is limited at this time as it does not reflect potential socioeconomic impacts of the SERA proposal in the greater context of the final New England Fishery Management Council (NEFMC) EFH Omnibus Amendment process in the Gulf of Maine, where a range of other alternatives will be discussed including the reopening of existing closed areas.

These preliminary analyses address the maximum potential economic impact of the proposed SERA – including all subareas, on commercial, party/charter recreational fishing, as well as the seafood industry. The completion of these three analyses conclude “Step 1” and assumes that all fishing-related activities impacted by the proposed SERA configuration will be displaced (i.e., no mitigation or offsets through behavioral response, e.g. relocation of fishing effort), which ultimately is unlikely to occur. The models used to conduct the socioeconomic analyses were developed by the NMFS NEFSC and are consistently used to

gauge the impact of fisheries closures on fishers in the Northeast.

At this early point in the overall process, the socioeconomic impacts of the proposed SERA have been identified as minimal (<1% sales, income, employment). The calculated maximum potential impact suggests that the proposed SERA would result in an annual loss totaling no more than 0.15% of annual revenues and 0.11% job equivalents in the commercial fishing and seafood industry; and, 0.79% of annual revenues and 0.68% job equivalents in the party/charter fishing industry. Published results from other national marine sanctuaries that have implemented closed areas reveal that the socioeconomic impacts actually realized were near zero or zero (Jeffrey et. al., 2010).

“Step 2” analyses qualitatively assess the benefits and costs associated with the proposed SERA to evaluate how the maximum potential loss estimates from “Step 1” could be offset (Appendix IV). Based on “Step 2” analysis, the overall assessment is that net benefits are likely to derive from the proposed SERA subareas with little to no impacts on income and employment.

VII. VTR Data and Spatial Design

To validate the spatial patterns of fishing effort produced with VTR data (1996-2009), a map-based visual comparison with NMFS Observer data (1989-2010) parsed by gear type was conducted at the scale of 1 nm sq and resulted in highly similar spatial distributions. A quantitative comparison of VTR and Observer data for a similar time period (May 1, 1998-2009) based on the percent of trips fished within the proposed SERA subareas, identified differences of only 0.8%-6.2% for all gear types across all subareas and of 0.2%-2.7% for mobile and fixed gear affected by subarea restrictions (Appendix V). In both sets of analyses, the spatial patterns produced within the sanctuary using the two data sources were comparable and mutually reinforcing.

Additionally, the distribution of effort based on a fishery-independent systematic visual survey of vessels within SBNMS and VTR data for the

same period (2001-2002) also exhibited consistent spatial patterns when comparable categories of fishing activity were mapped and analyzed using identical methodologies (NOAA, 2010). A related but independent analysis of commercial fishing in the sanctuary area also concluded that the VTR data, once aggregated and processed via GIS, were a good predictor of broad categories of fishing activities and the locales at sea where the activities occurred (Martin and Hall-Arbor, 2006).

As further validation of the proposed SERA spatial design, the proposed configuration maximizes inclusion of areas identified as optimal to represent all habitats within the smallest area based on a MARXAN analysis of the distribution of major sediment types in the sanctuary (Cook and Auster, 2006).

VIII. Research Plan

Research activities inside and adjacent to the proposed SERA would take advantage of the reference site and variation in fishing gear uses partitioned into subareas. This plan allows four treatments that include the no-fishing reference site, an area with hook-and-line only, and another area with the additive effects of hook-and-line plus all fixed gears (i.e., no bottom-tending mobile). The fourth treatment is outside the proposed SERA within SBNMS and is subject to the additive effects of all fishing categories as allowed.

While more designated areas with exclusive use by particular fishing gears would provide a superior research design, the configuration as proposed accommodates, to the extent practicable, existing fishing practices in SBNMS while enabling research activities of sufficient scientific rigor that results can inform management.

Composition of epibenthic seafloor communities in the Gulf of Maine region varies by broad changes in sediment type and depth (i.e., as a proxy for oceanographic regime). That is, across region-wide scales, species composition shifts as grain size shifts from mud, to sand, to gravel, and to boulder - as well as from shallow

to deep based on communities residing in Maine Surface (0-60m), Intermediate (61-150m) and Deep Water (>150m) regimes (Cook and Auster, 2006).

The configuration of the proposed SERA maximizes representation of seafloor habitat types, and hence community types, within the SBNMS region, allowing comparisons of community and population metrics across treatments (Figure 9). Subarea A affords remarkable similarity to and representation of SBNMS overall based on the proportionality of sediment types (Figure 9). The comparisons are aided by the proposed SERA subareas predominantly occurring within the Maine Intermediate water regime (Figure 10), thereby controlling for depth effects. Studies on the continental shelf of the northeastern United States, including portions of SBNMS, indicate that substrate and water mass characteristics are highly correlated with the composition of benthic communities (Auster et al., 2001; Watling and Skinder, 2007) and therefore may serve as proxies for the distribution of biodiversity.

Priority research questions that would be addressed based on variation in disturbances across proposed SERA subareas include:

- How does variation in the direct impacts of fishing (e.g., using nets and dredges vs. hook and line vs. fixed fishing gear) affect elements of biodiversity (species richness, size, abundance, functional groups, community state, recovery dynamics, etc.) across taxonomic levels of diversity (including microbes, invertebrates, fish, seabirds and marine mammals)?
- What are the spatial patterns of diversity and do they vary in phase with increasing levels of disturbance (i.e., both natural and human-caused)?
- How do the drivers of change in marine communities (e.g. physical forcing, competition, predation) vary across habitats and disturbance regimes?

- How do variations in drivers of change influence diversity, recovery, and ecological resilience?
- Do communities across disturbance regimes exhibit predictable shifts in state, or are changes stochastic, especially as species distributions shift under climate change?
- What is the relationship between biodiversity (e.g., species diversity, trophic diversity) and ecological resilience?
- What are the relationships between disturbance regime and persistence of rare species?
- Do changes in community state alter the provision of ecosystem goods and services from specific habitat types?
- What are patterns of connectivity between habitats and how are these influenced by variation in disturbance regimes?
- What are the differences in primary (benthic microalgae) and secondary production across habitats and disturbance regimes (e.g., reference compared to fished areas)?
- What strategies can mitigate for particular types of human impacts (e.g., live-release of species of concern such as cusk and wolffish in order to reduce fishing mortality, use of fixed versus mobile fishing gear to reduce mortality of vulnerable invertebrate species)?

In an ideal field experiment, each habitat type would support the same community of organisms across all treatments. Here we start with a situation in which the WGoMCA has been closed for over 10 years with clear evidence of differences in communities of the same habitat type across the boundary (Nenatovic, 2009; Tamsett *et al.*, 2010). However, these differences are not an impediment to producing the information needed to inform management concerning ecological processes in the sanctuary. In fact, addition of a time component based on new areas falling under long term gear control regimes (e.g., the extension of a no-fishing area to the west of the present WGoMCA boundary) can enhance our understanding of recovery dynamics and ecological resilience. Given that communities vary across the SBNMS landscape, changes in

each treatment can be quantified over time using a variety of approaches such as differences in functional groups, dominance curves, taxonomic diversity, and ratios in the abundance of key species across treatments (e.g., Clarke and Warwick, 1998; Clarke, 1990; McGilliard *et al.*, 2011).

For example, a time series study to assess the dynamics of species diversity and patterns of recovery under different direct disturbance regimes could be based on photo-quadrat and seafloor samples for infauna across the range of habitats as well as over a gradient of fishing effort within each fished subarea. The sampling design would also take into account the existing and newly closed portions of subarea A, essentially producing two no-fishing treatments (i.e., the area in the existing “sliver” closed since 1998 and the newly closed area to the west). Comparisons across a time series would depend on a set of samples collected at the time of implementation of the proposed SERA. Analyses based on changes in community composition, population trajectories of key species, species diversity, and functional group composition under the different disturbance regimes (i.e., natural and based on gear type) would separate the effects of gear treatment and effort.

The proposed SERA is also designed to accommodate tests of hypotheses related to assessing the indirect effects of removal of predators on seafloor communities. For example, contrasts in community structure and functional groups between the no-fishing reference subarea, the hook-and-line only subarea, the no-bottom impact mobile gear subarea, and the open fishing area can partition effects of gear from the effects of removal of predators on seafloor species, especially habitat forming species and key prey taxa. Studies of local food webs in each of the subareas can identify effects of fishing on patterns of productivity, as well as assess variations in energy transfer pathways.

The issue of the geographic size of each treatment area (i.e., subarea) is of clear importance to the utility and success of the

proposed SERA. However, an empirical understanding about the effect of treatment size would require an actual experiment to assess area effects on recovery dynamics and associated responses to disturbance. We used existing information to infer the spatial scale at which important patterns and processes operate in relation to the adequacy of the proposed SERA design.

Previous research has demonstrated that dynamics of seafloor communities respond to local disturbance at the scale of meters (Witman 1985, 1987; Thrush *et al.*, 1994; Blyth *et al.*, 2004; Tamsett *et al.*, 2010) while recovery dynamics are related to how the disturbed areas are nested within undisturbed communities (e.g., Pickett and White, 1985; Auster and Langton, 1999). These patterns suggest that the subareas are of adequate size to assess local scale effects of each fishing treatment, the primary questions for which the proposed SERA is proposed to answer.

Additionally, the overall size of the proposed SERA based on aggregating each of the subareas, and when linked to the existing or a reconfigured arrangement of the WGoMCA that is of similar size, should continue to provide spillover of managed species across the boundary (Murawski *et al.*, 2005). This spillover effect suggests that productivity is enhanced inside areas protected from fishing activities (Hermsen *et al.*, 2003).

IX. Relevance to Management of EFH and SASI Model Validation

Research in the proposed SERA could significantly aid refinement of the SASI modeling approach. A final peer review of the SASI model was completed in April 2011 by the NEFMC (Sullivan *et al.*, 2011) and indicated that the model is a good first step in providing an objective mechanism for synthesizing many of the complex interactions that take place between fishing activity and seafloor habitat. However, reviewers pointed out that a number of important assumptions need to be validated.

Studies in the proposed SERA could test SASI predictions as well as improve the values used in the model to represent gear-specific impacts and rates of habitat recovery. These relationships are currently based on a broad and general application of the global literature on fishing gear effects; however, only some of these studies were conducted in the New England region. While the current model adequately represents general relationships between gear effects and habitat, a more refined and region-specific understanding could improve predictions and the evaluation of trade-offs.

The MSA stipulates that management should "...minimize to the extent practicable adverse effects on such habitat [EFH] caused by fishing..." but there is a need to define measurable thresholds for achieving this requirement. The SASI review panel stated that current research is insufficient to quantify the relationship between an adverse effect on habitat and population responses of fish or prey species at particular life-history stages. Further, there is insufficient information about effects from particular fishing gear configurations and susceptibility and recovery of habitat. The spatial distributions of structure forming organisms (e.g., sponges, bryozoans) are not well represented in the SASI model, nor is seasonal and long-term (e.g., decadal) variability in these populations. There is also a need to better understand the effects of the spatial resolution of the model with respect to fine-scale habitat features and the fishing effort distribution by gear type. Finally, there is the need to address the underlying linkages between the productivity of managed fish species and their habitats.

The proposed SERA design could greatly facilitate efforts to improve our ecological understanding along these critical lines of inquiry. There is a clear and significant synergy between the NEFMC and SBNMS in regards to the need for such knowledge. That is, the ability to evaluate trade-offs between alternative management approaches based on variation in fishing gears and spatial patterns of effort across habitat types is not only of benefit for managing

EFH but is critical for understanding the effects of human activities in SBNMS.

X. Alternatives

The proposal focuses on the preferred plan for the proposed SERA. Within this context, there are alternatives by subarea that can be implemented although restricting the scope of what can be accomplished.

Alternatives for Subarea A

Alternative 1 (Preferred). Subarea A is the no-fishing reference area and excludes all forms of fishing. This alternative will allow research to address questions related to the coupling of pelagic and seafloor communities. For example, research elsewhere has demonstrated that pelagic predators pursue prey towards the seafloor and enhance feeding opportunities for demersal and other pelagic species (e.g., Auster *et al.*, 2009). The no-fishing reference site would allow research that assesses the full suite of seafloor habitat impacts, as well as linkages between pelagic and demersal-benthic communities, especially those mediated by the behavior of highly mobile species.

In addition, the restrictions on fishing in Alternative 1 would protect four shipwrecks at three sites currently listed on the National Register of Historic Places from adverse impacts due to fishing.

Alternative 2. The no-fishing reference area allows hook and line and harpoon fishing for tuna (excluding nets, longlines). This alternative would confound research focused on linking pelagic predators due to the uncertainties produced by the removal of predators within the subarea and the potentially cascading effects on their prey.

Alternatives for Subarea B

Alternative 1 (Preferred). Subarea B allows hook-and-line fishing in general (i.e., both recreational and commercial). Commercial handline fishing, currently excluded in the sliver under provisions of the WGoMCA, would be allowed along with recreational hook-and-line fishing (as stipulated in Alternative 2). This

alternative would increase total hook-and-line fishing effort in Subarea B, thereby maximizing the treatment. This alternative would allow examination of the combined effects of commercial and recreational hook-and-line fishing.

Alternative 2. Subarea B is limited to recreational hook-and-line fishing including party, charter and private boats. These are the principal types of fishing gears currently allowed to catch groundfish in the sliver under provisions of the WGoMCA. Subarea B incorporates much of the sliver area. This alternative would address the specific effects of recreational fishing activities. Recreational fishing has accounted for as much as 30% of the total cod removals from the Gulf of Maine, and as much as half of that may be caught in the WGoMCA (Nies, 2007). Recreational catch of Gulf of Maine haddock has accounted for about 50% of the landings since the mid-1990s (NOAA, 2008).

Status Quo Alternative

No Action. Without the ability to implement a research plan that produces the four treatments as described, the current sliver of the WGoMCA allows continued study based on fishing and limited fishing treatments, but leaves uncertainties about how best to scale fishing gear use given the goal of conservation of biodiversity within SBNMS. Without the specific knowledge gained from applying the full proposed SERA treatments, the status quo alternative would not enable the sanctuary's management to identify and ultimately reconcile issues of compatibility of specific human use in SBNMS, as required by the NMSA. Without research conducted under the provisions of the proposed SERA, there would be no discerning or true understanding of the impacts of natural disturbance and climate change on biological community functions and ecosystem processes within SBNMS.

XI. Endnote

As further rationale for this proposal and to indicate ONMS's commitment to its implementation, SBNMS is building critical

structural capacity that will enhance directed research activities in the proposed SERA by adding dedicated infrastructure that attracts research interest and offers collaborative support to sanctuary research partners. These commitments build upon the \$3+ million already invested by SBNMS in the seafloor habitat research (SHRMP) conducted in the “sliver” during 1998-2010.

In 2006 ONMS built and put the R/V *Auk* into service in the sanctuary. The R/V *Auk* is a 50 ft. aluminum hydrofoil-assisted research catamaran; it is a multi-purpose research vessel designed to support the sanctuary’s science and education missions. The SRVx, an 85 ft mono-hull research vessel operated by the ONMS and home-ported in Norfolk, VA, is also available to support research in SBNMS when a larger vessel offering greater capacity is required.

In 2010, ONMS began renovation of the sanctuary’s boathouse and 300-ft. pier converting them into a fully functioning marine operations center to better utilize existing capacity and to better support vessel operations, including multi-day research missions to SBNMS. In 2011, land adjacent to the facility was purchased for expanded parking and the pier bulkhead is being reconstructed and strengthened. Completion of the marine operations center is planned for 2012/13.

Also in 2010, ONMS developed a joint enforcement plan with NOAA Office of Law Enforcement (OLE) that in out years would ensure dedicated enforcement of the proposed SERA if adopted. SBNMS has had a cooperative enforcement agreement in effect with OLE since 2001, which will be strengthened by this national commitment. The US Coast Guard directs air and on-the-water enforcement patrols to the sanctuary on an on-going basis, which could extend more specifically to the proposed SERA (USCG Commandant Instruction 16004.3A, Oct 15, 2003).

These recent and planned infrastructure and programmatic improvements, in addition to the sanctuary’s existing staff capacity and research track record within the sanctuary, provide

assurance that the proposed SERA would be a functioning research area that meets the stated goals. By virtue of the proposed SERA’s proposed long-term nature and the security of tenure it would afford researchers, the proposed SERA is viewed as an off-shore extension of the sanctuary’s land-based research infrastructure.

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Figure 9. Map indicating the distribution of habitat types within SBNMS based on sediment classification.

Figure 10. Map showing the distribution of the three principal oceanographic regimes within SBNMS.

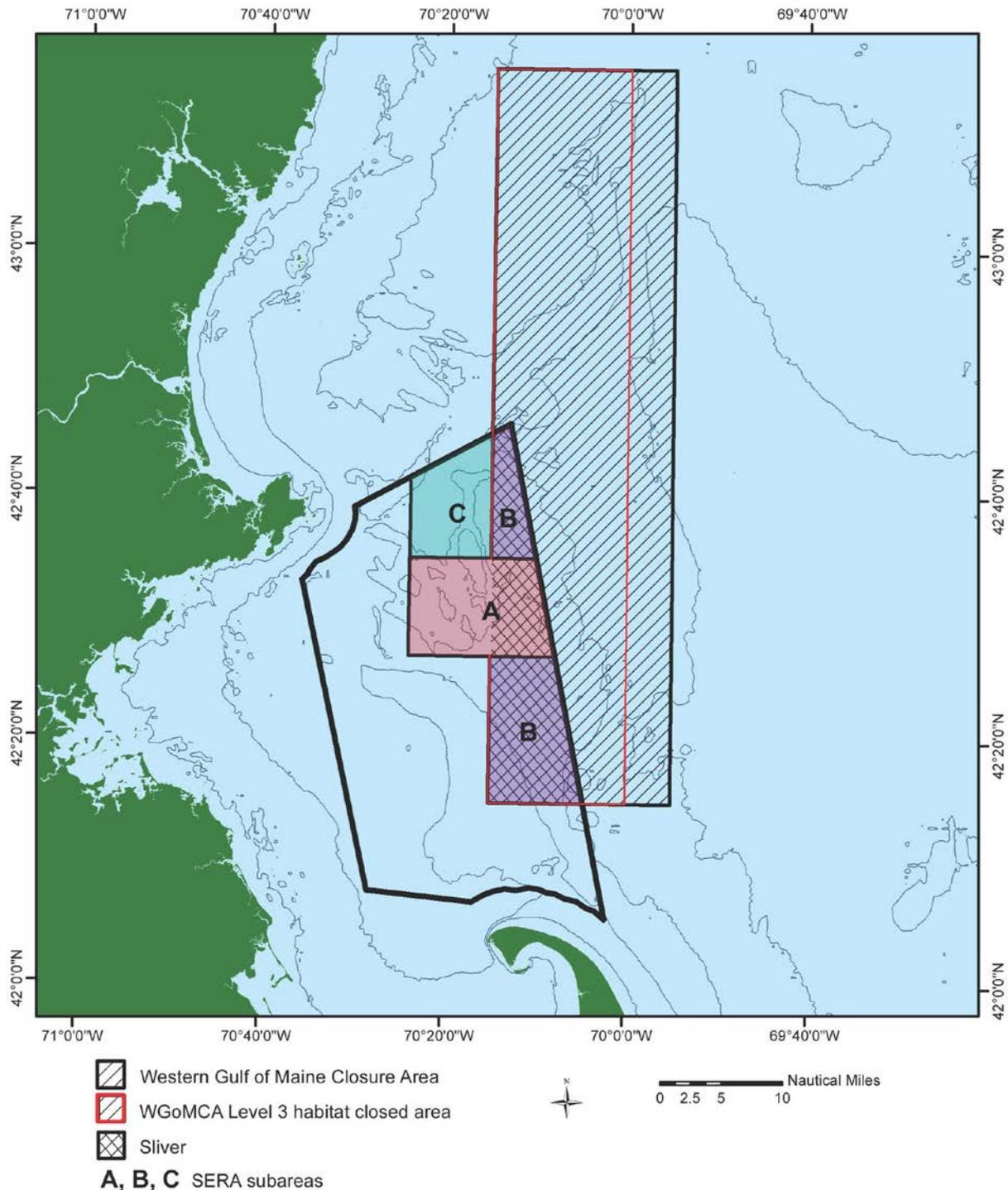


Figure 1. Map indicating the WGoMCA (cross-hatched) and its overlap with SBNMS. Area of overlap with SBNMS is referred to as the “sliver” and encompasses 22% of SBNMS. The majority of the WGoMCA is a Level 3 habitat closed area (red outline) for the purpose of protecting EFH. Configuration of the proposed Sanctuary Ecological Research Area (proposed SERA) is overlaid with subareas indicated. The proposed SERA would include 39% of the sanctuary area, equal 38% of the Level 3 habitat closed area and represent 0.9% of the Gulf of Maine region overall (Appendix I).

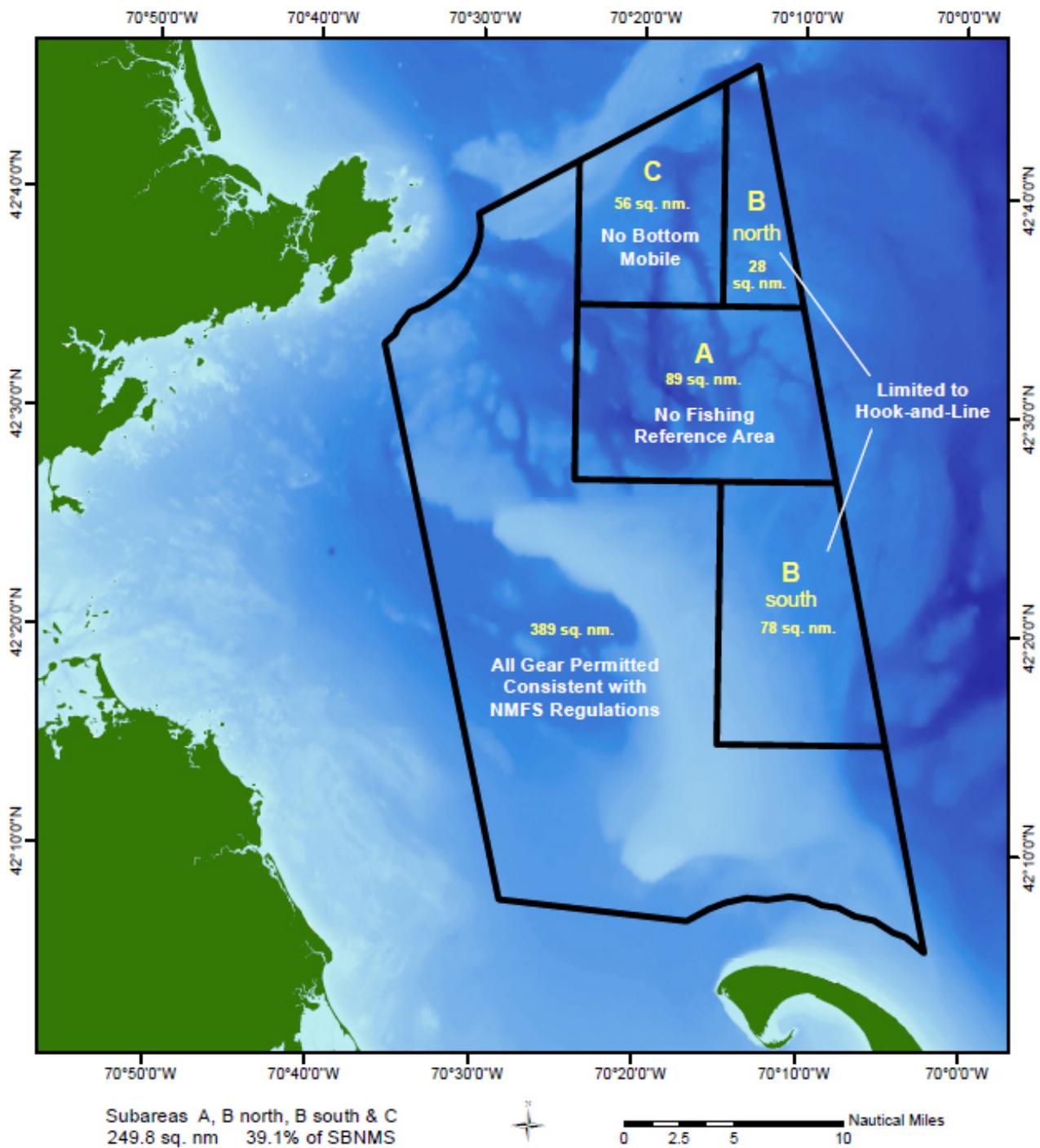


Figure 2. Map indicating the proposed SERA and its subareas overlaid on bathymetry. Subarea A would be a no-fishing reference area and constitute 13.8% of SBNMS; Subarea B (both north and south) would be limited to hook and line fishing (party, charter, private, commercial handline) and constitute 16.5% of SBNMS; Subarea C would allow all forms of fishing except bottom-tending mobile fishing gear and comprise 8.7% of SBNMS. Fishing with all of the above gear types would occur in the rest of the sanctuary (61%) outside the proposed SERA unless restricted by NMFS under other regulations.

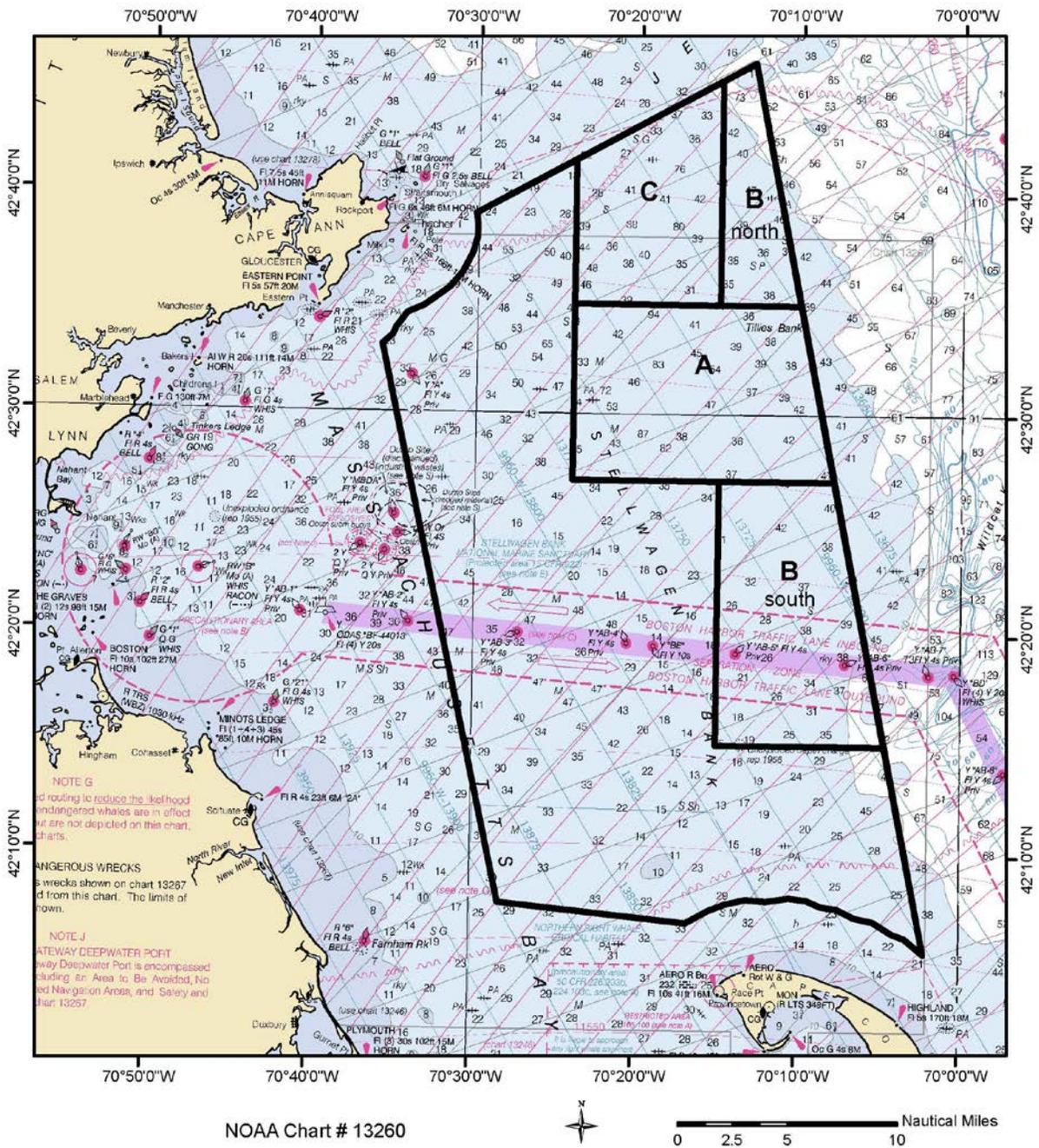


Figure 3. Map indicating the proposed SERA and its subareas on the respective nautical chart.

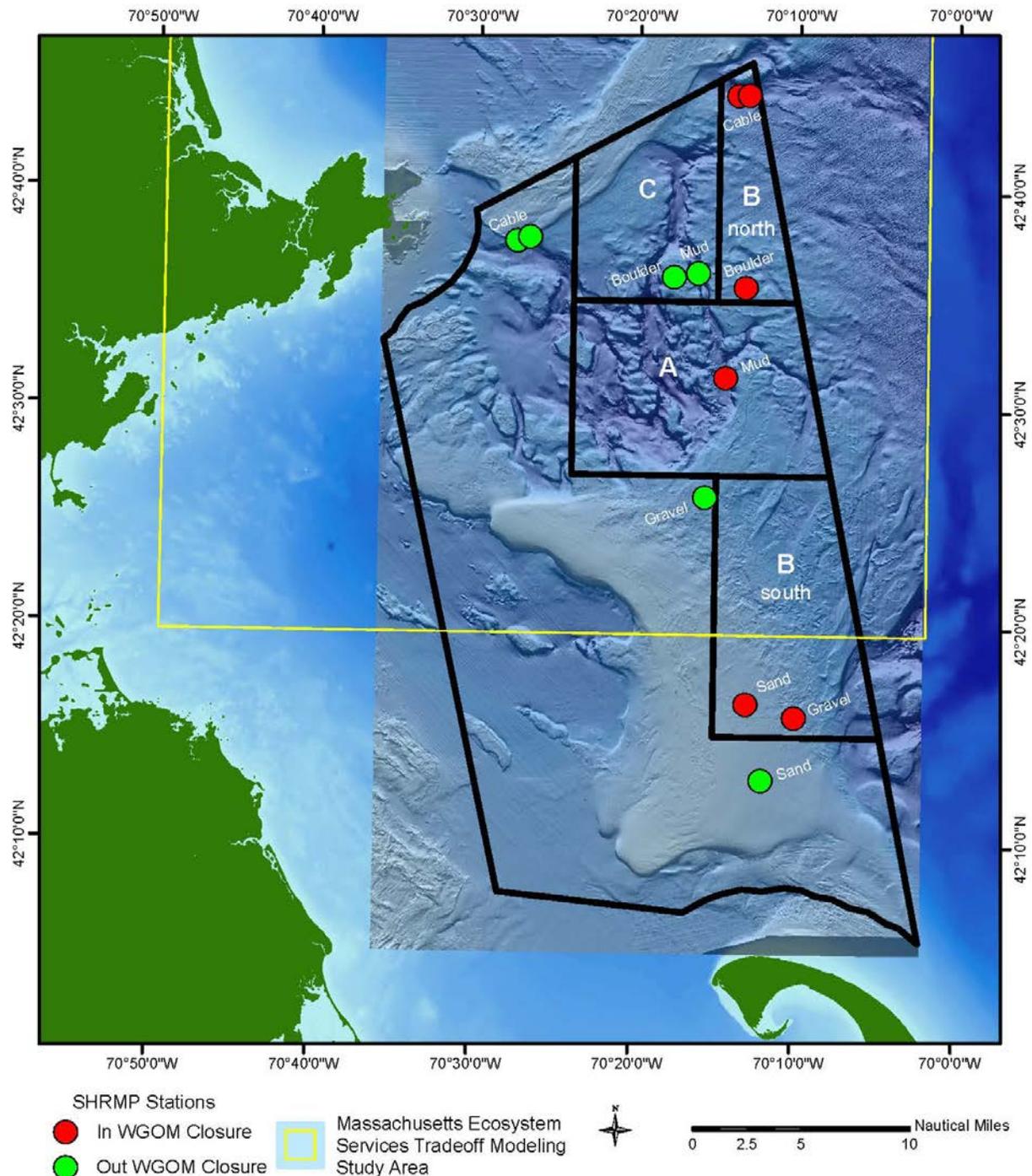


Figure 4. Map indicating the proposed SERA and its subareas relative to paired inside-outside monitoring sites in mud, sand, gravel and boulder habitats conducted during the 1998-2010 Seafloor Habitat Recovery and Monitoring Project (SHRMP). This project assessed change over time in representative seafloor habitats inside and outside the WGoMCA and at stations on-off an underwater cable laid within SBNMS. This is the only offshore habitat study conducted in the Gulf of Maine to examine habitat and community change over a decadal timeframe. Major aspects of this project could be continued under the proposed SERA design taking advantage of earlier considerable investment. Map of the sanctuary is draped over 10m resolution USGS multi-beam backscatter bathymetry with hill shaded relief (among the highest resolution seafloor mapping within the Gulf of Maine). Outline of the Massachusetts Ecosystem Services Tradeoff Modeling Study Area where it overlaps SBNMS and the proposed SERA is indicated.

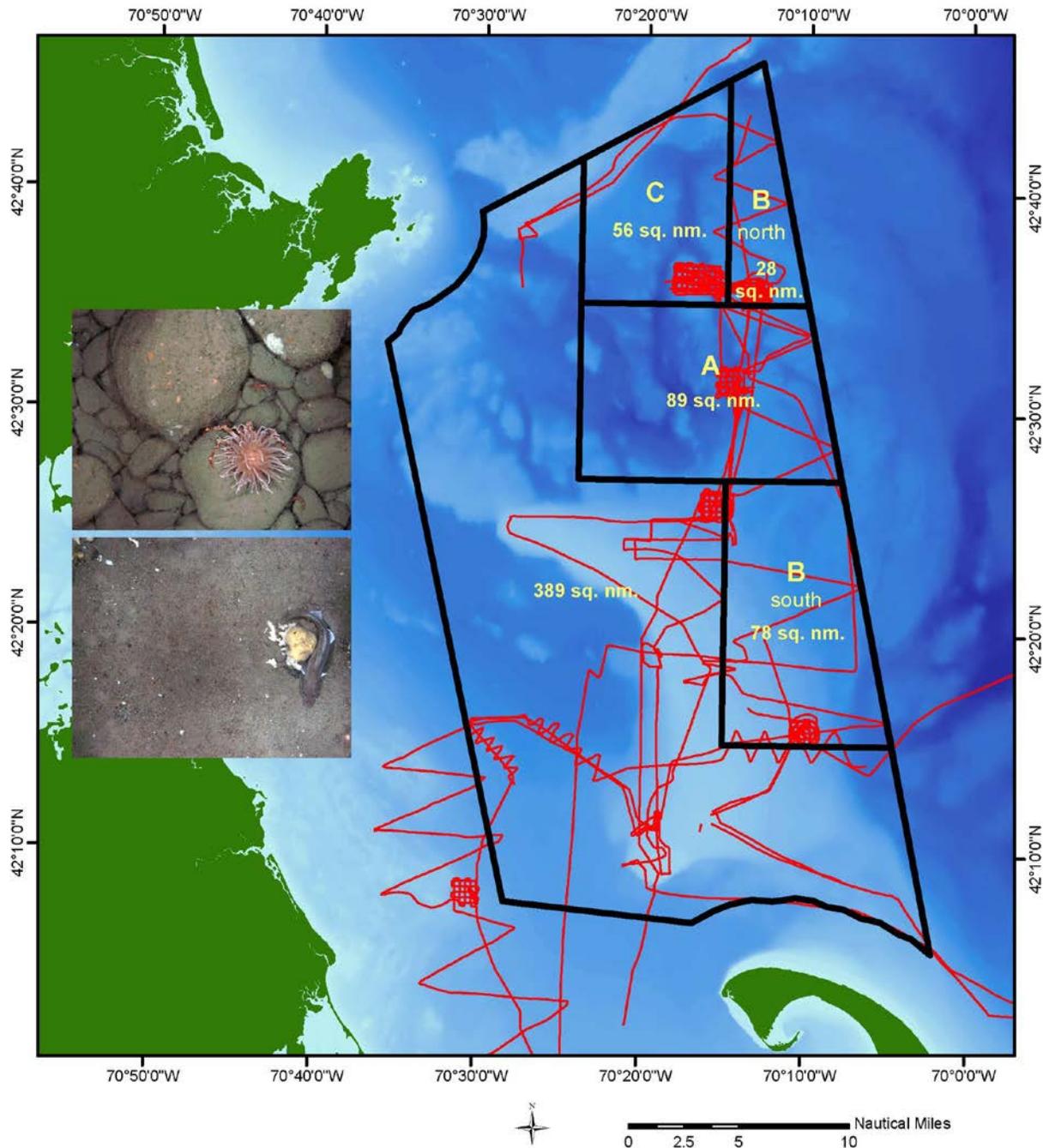


Figure 5. Map indicating the proposed SERA and its subareas relative to HabCam surveys conducted in SBNMS during 2007-2010. Survey track lines (in red) indicate where the HabCam vehicle flew over the seafloor taking six images a second creating a continuous image ribbon 1m in width. Sampling effort was concentrated in relation to the SHRMP sites in each of the proposed SERA subareas. HabCam is an optical habitat mapping system for characterizing benthic community structure, sediment characteristics and water column properties. The map is overlaid on bathymetry. The HabCam images inserted depict boulder (upper) and gravel (lower) habitats. The images demonstrate the close affinity exhibited by crustaceans (spider crab) and fish (cod) to even small elements of biogenic structure (anemone and sponge, respectively). To date, HabCam has collected over 15 million images in SBNMS.

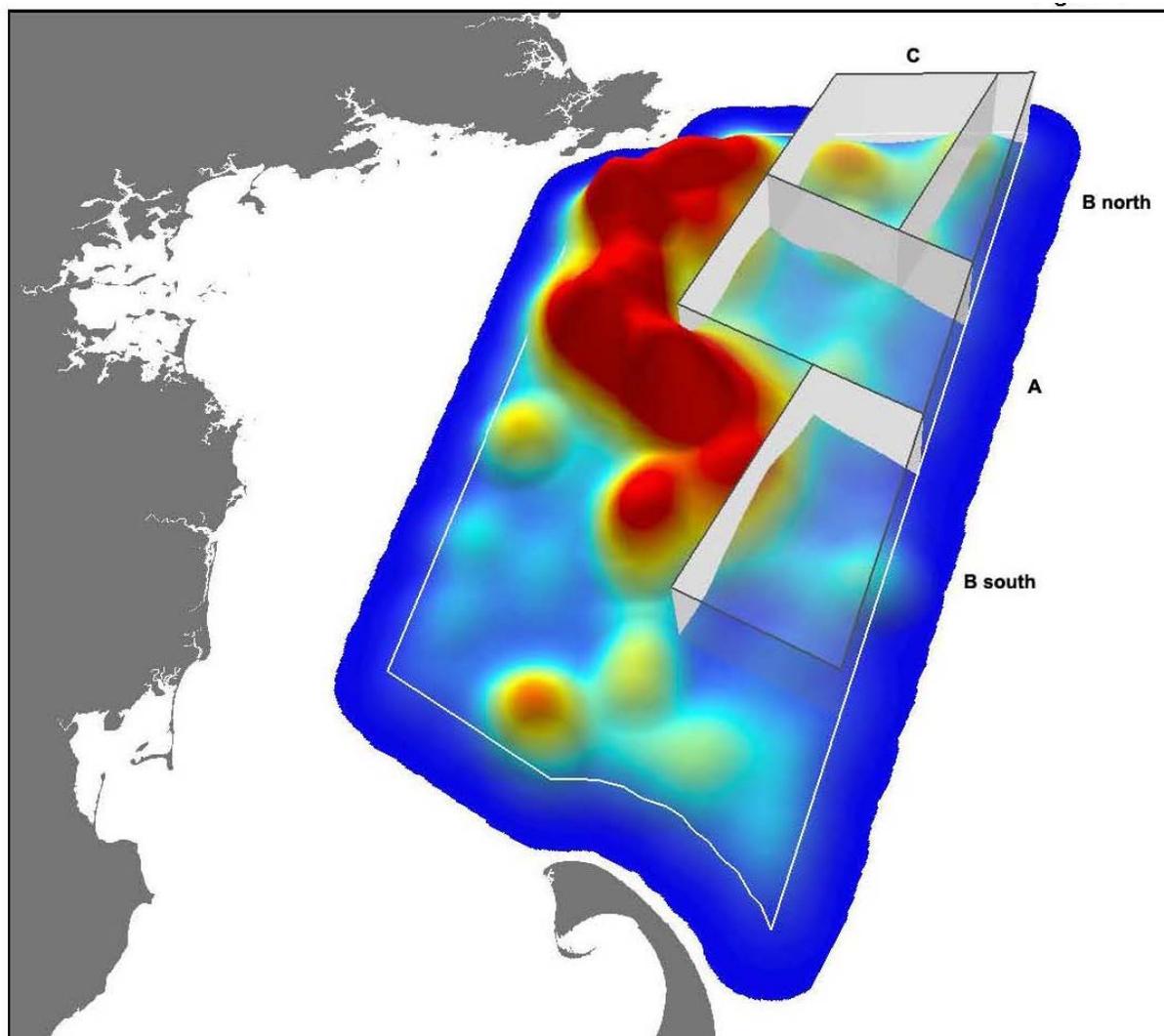


Figure 6. Three-dimensional map indicating the spatial distribution of total fishing effort (137,618 trips) expended within the sanctuary based on Vessel Trip Report (VTR) data (1996-2009). The proposed SERA is located where historical fishing effort is lowest within SBNMS.

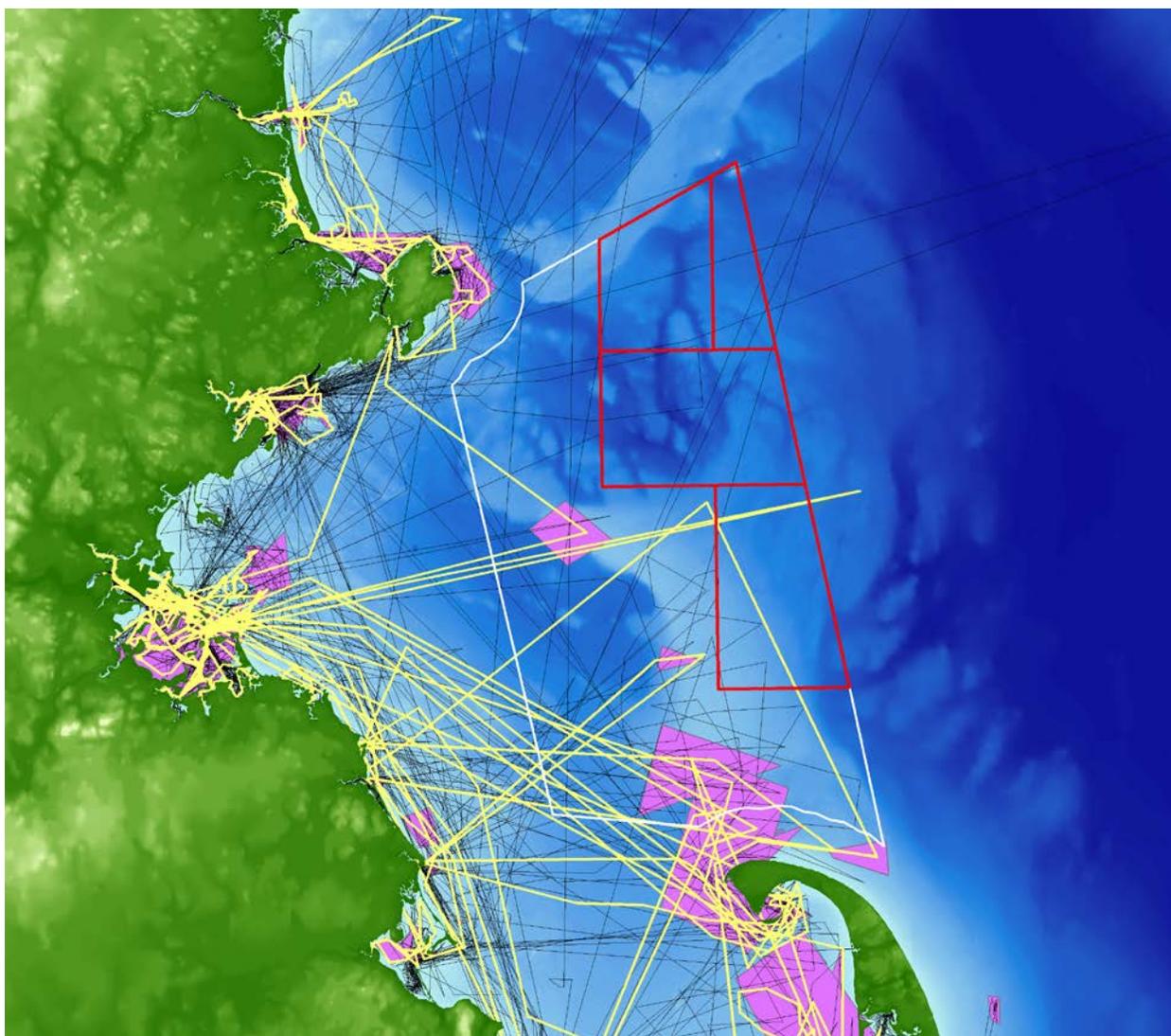


Figure 7. Map indicating the proposed SERA and its subareas relative to routes and areas fished by recreational boaters. Yellow lines = routes fished; purple polygons = areas fishing; black lines = all boater routes. The lines represent the “last trip of the month” routes plotted by recreational boaters between May and October 2010 as an addendum to the economic data collected. There are 430 areas of activity in the spatial dataset, of which 191 (44.4%) involved fishing. Six areas fishing (3.1%) were in SBNMS; no areas fishing were in the proposed SERA. Source: 2010 Massachusetts Recreational Boater Survey, Technical Report #03.UHI.11, Massachusetts Ocean Partnership, June 2011.

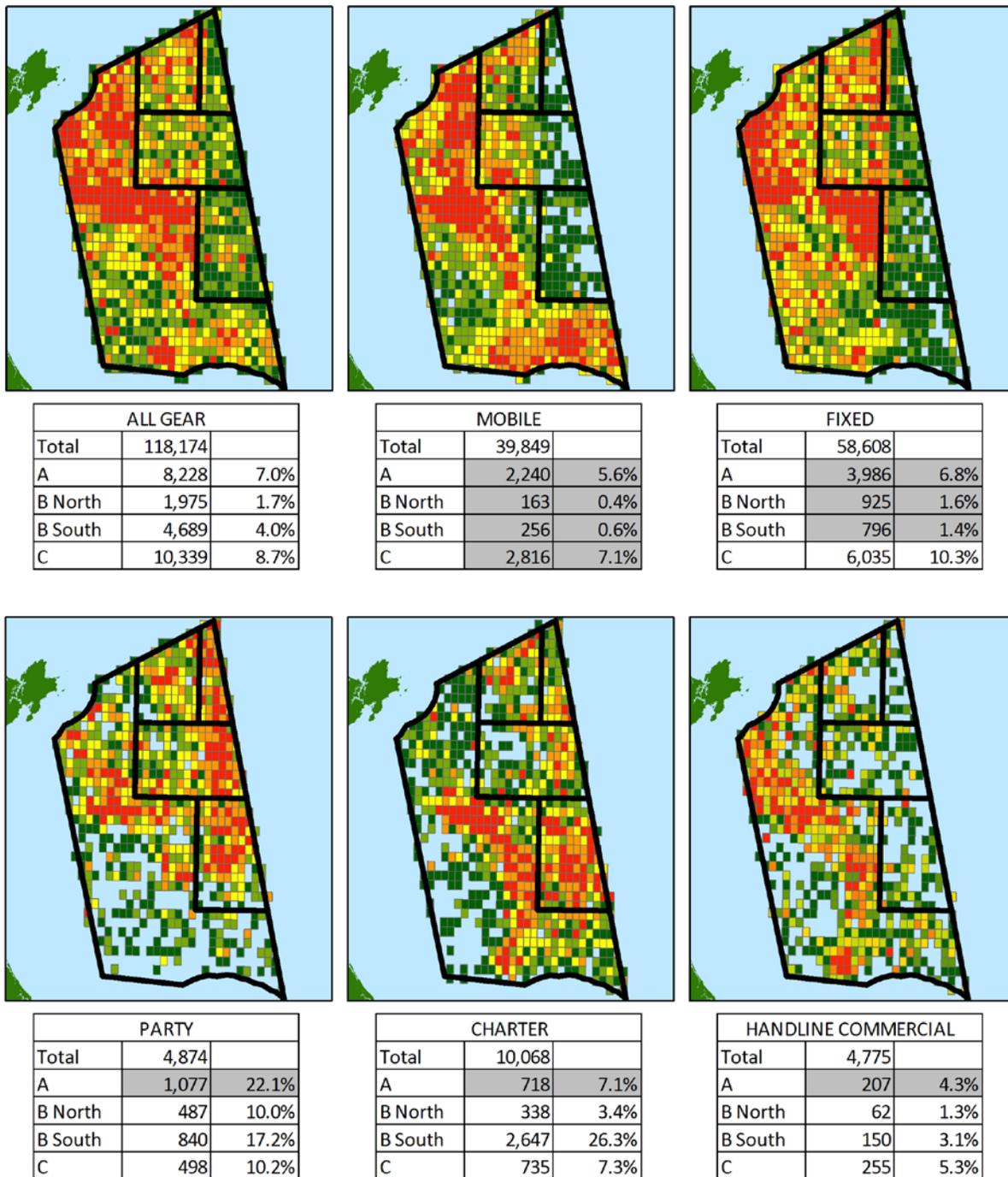


Figure 8. Maps presenting grid cell (1 nm sq) analysis of fishing trip data (VTR) for all gear types combined and for individual gear types (mobile, fixed, party, charter, and commercial handline) in SBNMS. The analysis covers the period May 1, 1998-2009, i.e., since the Western Gulf of Maine Closure Area was established, and includes 99.2% of all fishing trips and gear types during this period. The proposed SERA subareas are indicated on the maps. Results of data analysis by subarea for all gear and for each gear type are tabulated below each respective figure. Shading in tables denotes number and percent of trips affected by subarea restrictions for each gear type. Grid cell color is based on quintile breaks - red highest, green lowest.

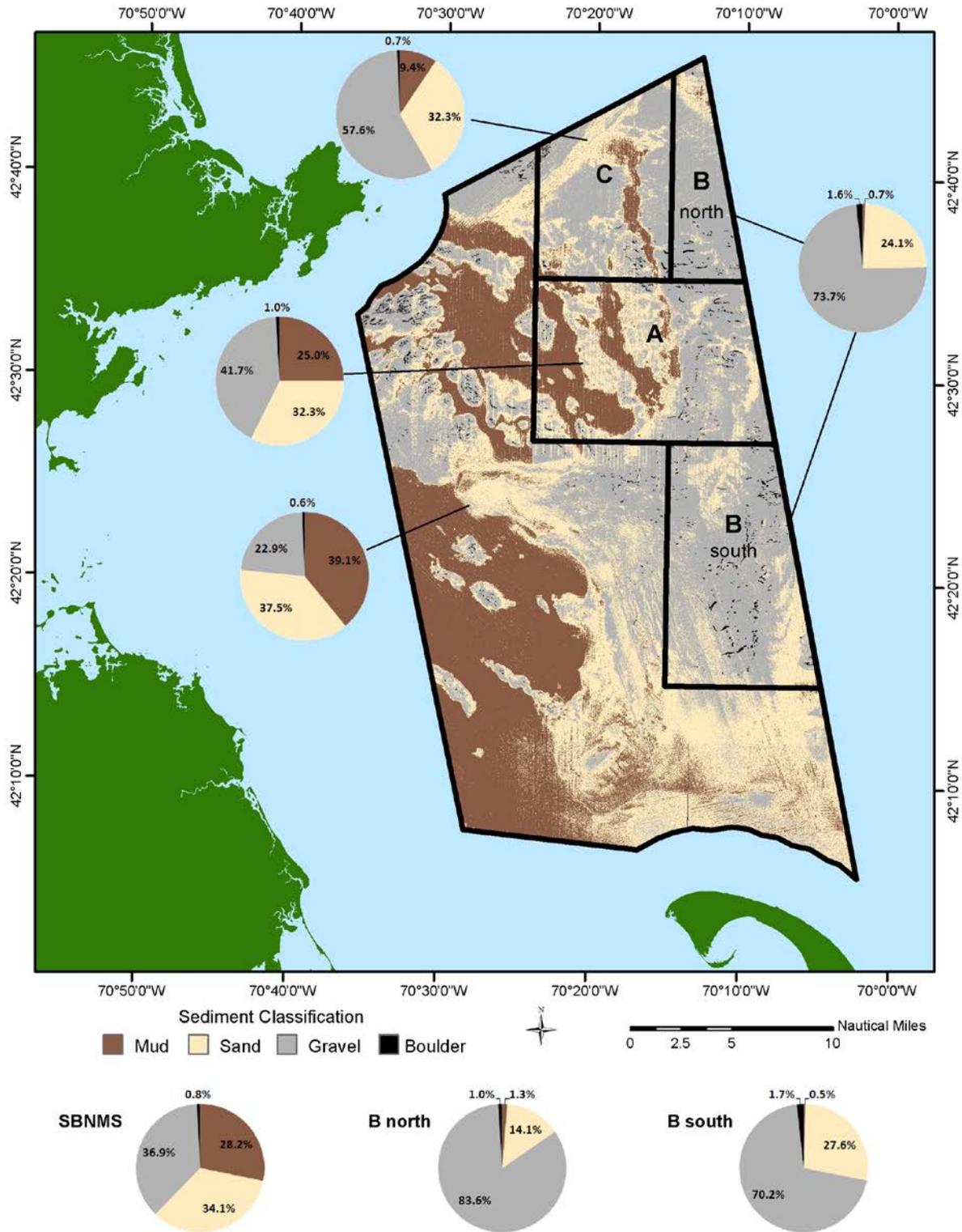


Figure 9. Map indicating distribution of habitat types within SBNMS based on sediment classification. Pie charts indicate proportionality of sediment composition by proposed SERA subarea as well as for the remainder of the sanctuary not within the proposed SERA. The sediment composition for SBNMS overall is indicated by the pie chart below the map, where separate pie charts are also provided for subarea B north and subarea B south.

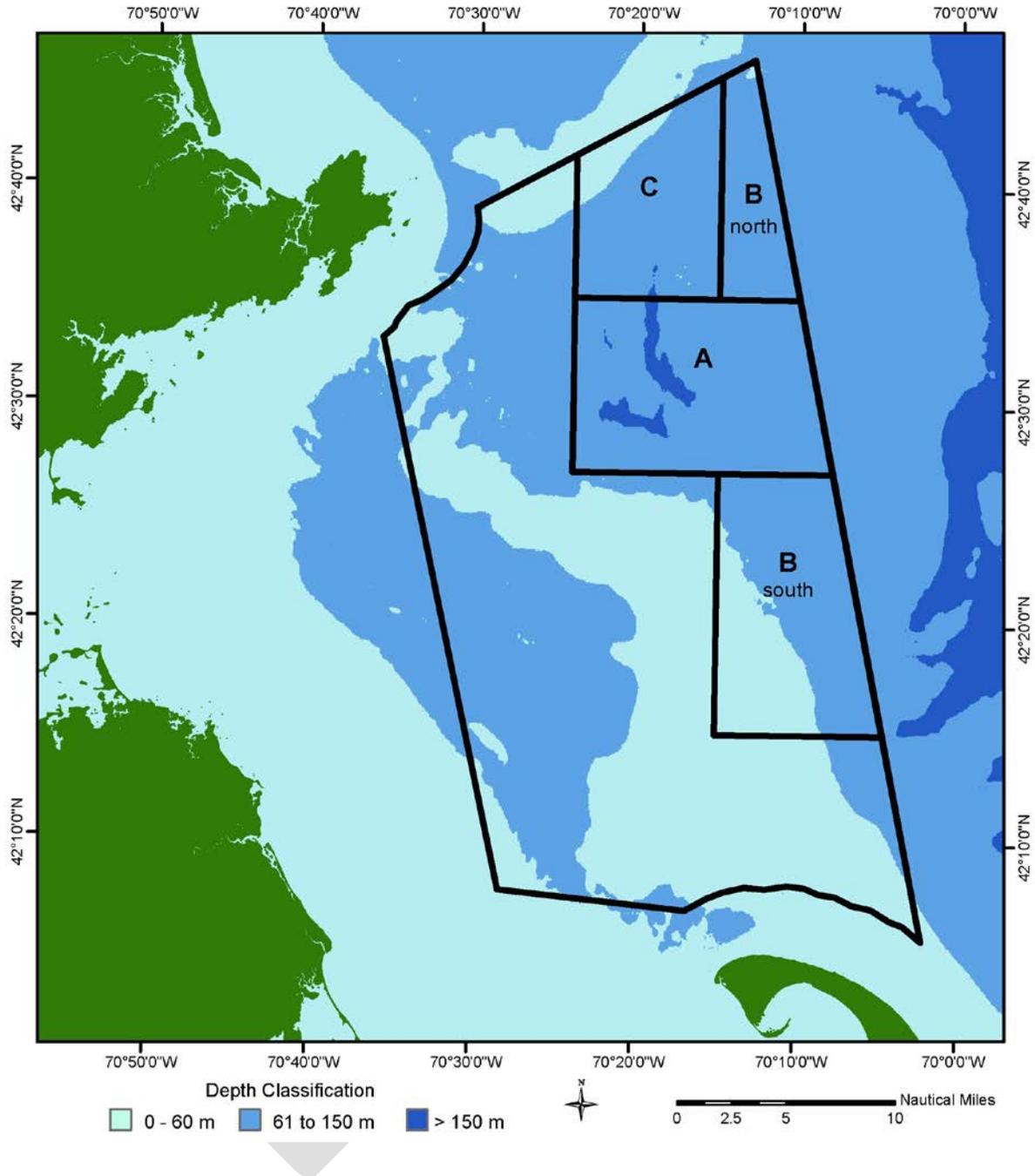


Figure 10. Map showing distribution of the three principal oceanographic regimes within SBNMS. The Maine Surface (0-60m), Intermediate (61-150m) and Deep Water (>150m) regimes are mapped by depth classification (Cook and Auster, 2006). The proposed SERA subareas (indicated) occur predominantly within the Intermediate water regime which encompasses most (63%) of the sanctuary.

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Appendix IV. Step 2 Socioeconomic Analysis of the Stellwagen Bank National Marine Sanctuary proposed Sanctuary Ecological Research Area.

Appendix V. Subarea comparison of vessel trip report (VTR) data and NMFS observer data (May 1, 1998-2009) for the Stellwagen Bank National Marine Sanctuary proposed Sanctuary Ecological Research Area.

NOTE: Vessel Trip Report (VTR) data do not capture all landings of lobster and bluefin tuna (among other highly migratory species, i.e. billfishes, sharks) as indicated previously in this proposal. Fishing effort and landings data for these species are reported from statistical areas (Offshore Area 19 and NOAA Fishing Area 4 respectively) that greatly exceed SBNMS in size (Table 1 in text). VTR data are submitted under provisions of the NEFMC's Northeast Multispecies Fishery Management Plan and are spatially more explicit at the scale of SBNMS and the proposed SERA. Economic impact analyses reported in Appendices I, II and III are based on VTR data. Because not all lobster and bluefin tuna landings are included in the VTR data, some underestimation of the overall economic impact of this proposal, as submitted to the NEFMC for inclusion in the Essential Fish Habitat (EFH) Omnibus Amendment process, is inherent in the results reported here.

APPENDIX I. DIRECT ECONOMIC IMPACT ANALYSIS OF THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY PROPOSED SANCTUARY ECOLOGICAL RESEARCH AREA

I. Introduction

Appendix I. provides a direct economic impact analysis for the proposed Sanctuary Ecological Research Area (proposed SERA) in Stellwagen Bank National Marine Sanctuary (SBNMS). The results are preliminary for reasons explained in the proposal. The analysis is based on Vessel Trip Report (VTR) data submitted under provisions of the Northeast Multispecies Fishery Management Plan and draws from the same data base used by the NEFMC for assessing spatial variation in fishing effort for the EFH Omnibus Amendment.

The assumption of this analysis is that all revenues associated with the proposed SERA subareas are lost. Any factor that could mitigate, offset, or increase the level of impact on any use is not addressed. These impacts are thought of as “**maximum potential losses**” because humans have proven to be very adaptive, resilient and quite ingenious in responding to changes and rarely does society fail to at least mitigate or off-set most losses.

Results of the direct economic impact analysis are presented for the four proposed SERA subareas (Subarea A, Subarea B North, Subarea B South and Subarea C). Area D in this analysis represents the area of SBNMS not included in the proposed SERA. SBNMS as a whole is the sum of Subareas A, B, C and Area D. Total is the sum of all catch from all areas by those vessels that reported catch from SBNMS. Annual average impacts are based on the years 1999 to 2009. This time period was selected to take into account the effects of the Western Gulf of Maine Closure Area, established May 1, 1998.

This analysis presents direct economic impacts based on the VTR data. A full input-output analysis of these data estimating multiplier economic impacts on jobs and income is presented in Appendices II and III. Additional data for lobster and tuna fishing permitted respectively by the Atlantic States Marine Fisheries Commission and NOAA’s NMFS

Highly Migratory Species Division also will be analyzed. These data are supplemental to the VTR data used in the EFH Omnibus Amendment assessment by the NEFMC and are reported at a much greater spatial scale than SBNMS.

II. Data Sources

Data came from the following three sources:

- National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center: Vessel Trip Report (VTR) logbook data contains fishing trip information on gear type, area fished, kept and discarded portions of the catch by species, and effort information, which includes the hull number (and/or permit number) and the port landed. VTR logbooks are mandatory for vessels registered under the Multispecies Fishery Management Plan.
- NMFS Northeast Fisheries Science Center: Dealer data provided the price by species and port.
- Gentner, Brad, and Scott Steinback. 2008. The Economic Contribution of Marine Angler Expenditures in the United States, 2006. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-94. This report provided mean trip expenditures for party/charter anglers.

III. Methodology

Statistical Analysis Software (SAS) was used as the primary data analysis tool. Each record was geo-coded to a proposed SERA subarea using latitude and longitude reported in the VTR data. Each record was binned into commercial mobile, fixed, handline, and recreational party/charter fishing.

Price information from the dealer data for commercial fishing was merged with the VTR catch data by year, port and species for each unique trip. For each unique trip and species,

price per pound was multiplied by pounds retained; the resultant value was converted to 2010 constant dollars using the consumer price index.

Value of recreational party/charter trips used trip expenditure data obtained from the report “The Economic Contribution of Marine Angler Expenditures in the United States, 2006.” Trip expenditures include costs for transportation, food, lodging, fuel, charter fees, tips and tackle. A limitation of the data is that the “charter fees” trip expenditure category only represents party or head boat fees of \$64 per person per trip, not the typical charter fee of \$1,200 per trip. The typical charter boat reported six anglers, so the charter fee expenditure for charter trips was replaced with \$200 per person per trip. That correction resulted in estimated total party trip expenditures of \$129 and total charter trip expenditures of \$265 per person per trip, in 2010 constant dollars. These total trip expenditures were multiplied by number of anglers per unique trip.

IV. Maximum Potential Direct Economic Impact Analysis (1999-2009)

The proposed SERA is composed of three contiguous subareas: Subarea A would be a no-fishing reference area. Subarea B would be limited to hook-and-line fishing (party, charter, private and commercial handline). Subarea C would allow all forms of fishing except bottom-tending mobile fishing gear. Fishing with all of the above gear types would occur in the rest of the sanctuary outside the proposed SERA (i.e., Area D).

Total Proposed SERA Impacts

Table 1 summarizes the estimated direct economic impacts of the three proposed SERA

subareas. The estimated maximum potential direct impact to commercial fishers is \$2.7 million in revenue annually, or approximately 1.76 percent of their total annual revenues. The estimated maximum potential direct impact to party/charter vessel revenues is \$575 thousand annually, or approximately 1.02 percent of their total annual revenues. Hence, the total estimated maximum potential direct impact to fishers is \$3.3 million annually or approximately 1.56 percent of their total annual revenues.

Proposed SERA Subarea A Impacts

The prohibition of all fishing within proposed SERA Subarea A would result in an estimated direct impact to commercial fishing vessels of \$1.3 million (0.84 percent of their total annual revenues) and to party/charter fishing vessels of \$575 thousand (1.02 percent of their total annual revenues). It should be noted that approximately one third of Subarea A has been off limits to commercial groundfish gear since 1998.

Proposed SERA Subarea B Impacts

The prohibition of all fishing with the exception of hook and line within proposed SERA Subarea B would result in an estimated direct impact to commercial fishing vessels of \$598 thousand (0.39 percent of their total annual revenues) and no impact to party/charter fishing vessels. It should be noted that Subarea B has been off limits to commercial groundfish gear since 1998.

Proposed SERA Subarea C Impacts

The prohibition of commercial bottom tending mobile fishing gears within proposed SERA Subarea C would result in an estimated direct impact to commercial fishing vessels of \$820 thousand (0.53 percent of their total annual revenues) and no impact to party/charter fishing vessels.

Table 1. Estimated Annual Maximum Potential Direct Economic Impacts by the Proposed SERA (1999-2009)

Proposed Subarea	Proposed Prohibition	Commercial	Party/Charter	Total	Commercial	Party/Charter	Total
		Impact (2010\$)			Impact (%)		
A	All fishing prohibited	1,305,591	574,855	1,880,446	0.84	1.02	0.89
B (N and S)	All fishing prohibited except hook	597,602		597,602	0.39		0.28
C	Mobile commercial gear prohibited	819,562		819,562	0.53		0.39
Proposed SERA Total		2,722,756	574,855	3,297,611	1.76	1.02	1.56
Total*		154,723,699	56,356,776	211,080,475			

*Explanation of “Total.” Vessels that reported catch within SBNMS were uniquely identified and their catch was totaled for all NMFS statistical areas, the majority of which is represented by areas 512, 513, 514, 515, 521, 522, 525, 537, 538, 539, 561, 562, 611, 612, 613, 615 and 616 for commercial fishing and areas 513, 514, 538 and 539 for party/charter fishing. This total allows impacts of the proposed SERA subareas to be measured against the vessels’ total catch revenue. The shaded areas in Figures 1 and 2 indicate the spatial distribution by statistical area of where the majority of this total fishing activity takes place by these vessels.

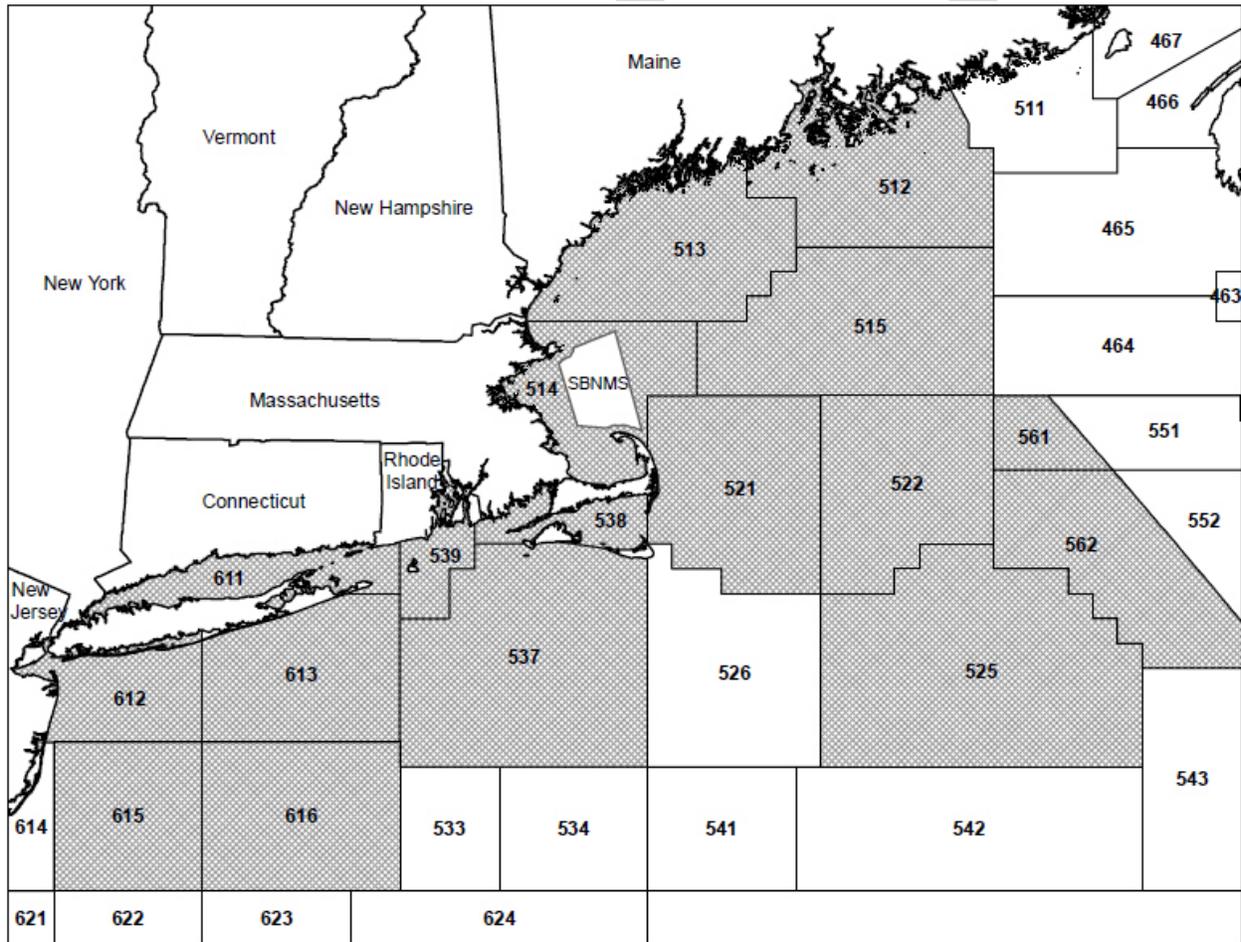


Figure 1. NMFS statistical areas of commercial fishing vessels reporting activity within SBNMS. Shaded areas represent 95 percent of total revenues.

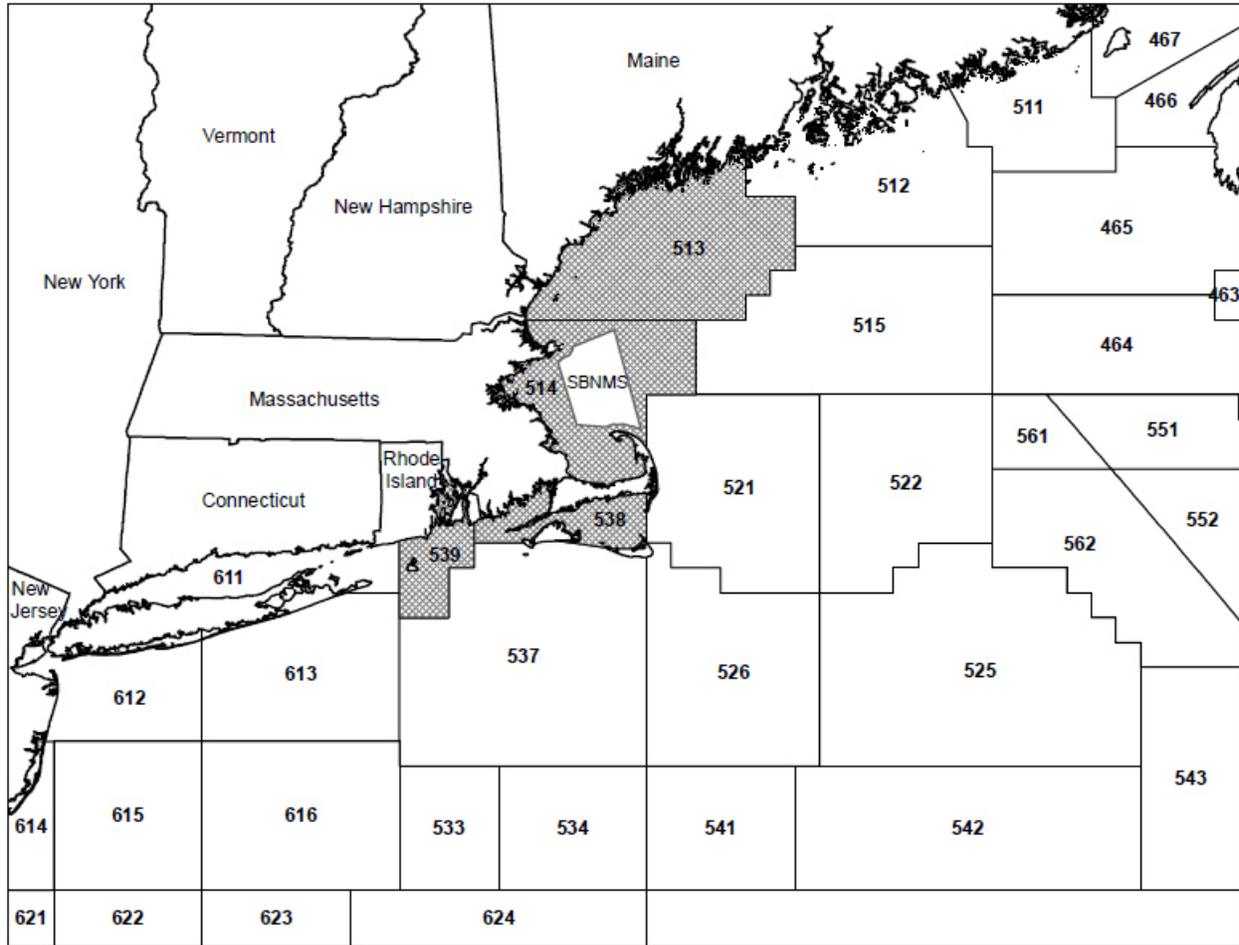


Figure 2. NMFS statistical areas of party/charter fishing vessels reporting activity within SBNMS. Shaded areas represent 91 percent of total trip expenditures.

V. Supplemental Tables

Commercial Fishing Landings Value

Table 2 summarizes landings value of commercial fishing vessels for each of the proposed SERA subareas, for the portion of SBNMS outside of the proposed SERA subareas, SBNMS as a whole, and the total for the vessels reporting catch within SBNMS. Data is presented for 1999 to 2009 as a total, average, and percent of total for each distinct analysis area. Selected landings values were entered into Table 1 as estimated impacts using proposed gear type restrictions. SBNMS rows may not exactly equal the sum of A, B, C and D due to rounding error.

Gear	Proposed SERA Subarea	Summary		
		99-09 Total	99-09 Average	99-09 % of Total
Commercial - Mobile	A	7,049,223	640,838	0.63
	B N	695,369	63,215	0.06
	B S	1,160,864	105,533	0.10
	C	9,015,187	819,562	0.81
	Area D	84,567,873	7,687,988	7.57
	SBNMS	102,488,514	9,317,138	9.17
	TOTAL	1,117,481,916	101,589,265	100.00
Commercial - Fixed	A	6,971,323	633,757	1.41
	B N	2,721,044	247,368	0.55
	B S	1,791,581	162,871	0.36
	C	12,474,407	1,134,037	2.52
	Area D	77,760,210	7,069,110	15.73
	SBNMS	101,718,564	9,247,142	20.58
	TOTAL	494,287,843	44,935,258	100.00
Commercial Handline	A	94,912	8,628	0.44
	B N	34,798	3,163	0.16
	B S	153,958	13,996	0.71
	C	145,345	13,213	0.67
	Area D	2,561,413	232,856	11.80
	SBNMS	2,990,426	271,857	13.78
	TOTAL	21,705,412	1,973,219	100.00
Commercial - All	A	14,361,503	1,305,591	0.84
	B N	3,481,211	316,474	0.20
	B S	3,281,170	298,288	0.19
	C	21,736,232	1,976,021	1.28
	Area D	166,579,127	15,143,557	9.79
	SBNMS	209,439,243	19,039,931	12.31
	TOTAL	1,701,960,690	154,723,699	100.00

Notes:

Commercial – All = All commercial gear types fished in SBNMS (Mobile, Fixed and Handline = 99% of All).

TOTAL = Total of all areas (including, but not limited to, NMFS statistical areas 512, 513, 514, 515, 521, 522, 525, 537, 538, 539, 561, 562, 611, 612, 613, 615 and 616) by commercial vessels reporting activity within SBNMS.

Area D represents the portion of SBNMS not included in the proposed SERA.

Party/Charter Trip Expenditures

Table 3 summarizes trip expenditures of party/charter fishing vessels for each of the proposed SERA subareas, for the portion of SBNMS outside of the proposed SERA subareas, SBNMS as a whole, and the total for the vessels reporting catch within SBNMS. Data is presented for 1999 to 2009 as a total, average, and percent of total for each distinct analysis area. Selected trip expenditures were entered into Table 1 as estimated impacts using proposed gear type restrictions. SBNMS rows may not exactly equal the sum of A, B, C and D due to rounding error.

Gear	Proposed SERA Subarea	Summary		
		99-09 Total	99-09 Average	99-09 % of Total
Party	A	5,098,886	463,535	1.02
	B N	2,011,512	182,865	0.40
	B S	4,283,278	389,389	0.86
	C	2,204,245	200,386	0.44
	Area D	9,646,924	876,993	1.93
	SBNMS	23,244,845	2,113,168	4.65
	TOTAL	500,425,048	45,493,186	100.00
Charter	A	1,224,515	111,320	1.02
	B N	627,202	57,018	0.52
	B S	4,033,649	366,695	3.38
	C	1,124,300	102,209	0.94
	Area D	8,295,579	754,144	6.94
	SBNMS	15,305,245	1,391,386	12.81
	TOTAL	119,499,490	10,863,590	100.00

Notes:

TOTAL = Total of all areas (including, but not limited to, NMFS statistical areas 513, 514, 538 and 539) by party/charter vessels reporting activity within SBNMS.

Area D represents the portion of SBNMS not included in the proposed SERA.

Appendix II. Total Economic Impact of the Stellwagen Bank National Marine Sanctuary Proposed Sanctuary Ecological Research Area to the Commercial Fishing and Seafood Industry

I. Overview

Appendix I summarizes the estimated direct economic impact of the proposed SERA. These direct economic impacts only account for the maximum potential lost sales of the commercial and party/charter fishing vessels for each of the proposed SERA subareas. Appendix II addresses the estimated total economic impacts of the proposed SERA subareas, i.e., the multiplier impacts to sales, employment and income of all businesses associated with the commercial fishing and seafood industry in the Northeast Region (Maine, New Hampshire, Massachusetts, Rhode Island and Connecticut). The results are preliminary for reasons explained in the proposal.

Economists at NMFS’s Northeast Fisheries Science Center developed the Northeast Region Commercial Fishing Input-Output Model (NERIOM) to estimate total economic impacts of policies that potentially alter commercial fish harvest (Steinback and Thunberg, 2006). The model was constructed using the regional input-output system called IMPLAN Pro (Minnesota IMPLAN Group, Inc.). The IMPLAN Pro system software provides the mathematical algorithms to estimate I/O models and their resulting multipliers, as well as a user interface that makes conducting impact assessments and organizing model outputs easier.

The NERIOM is a multiregional input-output model capable of predicting the multiplier effects of proposed fishery management actions in the Northeast. The model is constructed at the regional level and has been designed so that the multiplier effects, expressed in terms of sales by businesses, average annual employment (both full and part-time), and personal income (labor income) can be determined. It explicitly accounts for the interconnections between the fishing-related businesses (commercial harvesters, wholesale seafood dealers, bait suppliers, and seafood processors) in the Northeast region.

Inputs to the NERIOM are the 1999 to 2009 average annual landing values in 2010 constant dollars by gear type, port landed (summarized into NMFS regions) and proposed SERA subareas. These inputs are the direct impacts that were summarized in Appendix I. The model outputs include direct, indirect and induced estimated impacts. These impacts by the proposed SERA are summarized in Table 1 in terms of total sales, income and employment.

Values for total New England sales, income and employment are estimated by NMFS in their 2009 “Fisheries Economics of the U.S.” report.

The interpretation of the estimates provided in this analysis is critical to understanding the “true” impact of the various alternatives proposed for the proposed SERA. The estimates from this analysis for the proposed SERA are simply the sum of each measurement within the boundaries for a given subarea. The estimates therefore represent the **maximum potential total loss from displacement of the commercial fishing activities**. This analysis ignores possible mitigating factors such as gear relocation outside the proposed SERA and the possibility of net benefits that might be derived if the proposed ecological research area has replenishment or spillover effects.

II. Maximum Potential Total Economic Impact Analysis (1999-2009)

The proposed SERA is composed of three contiguous subareas: Subarea A would be a no-fishing reference area. Subarea B would be limited to hook-and-line fishing (party, charter, private and commercial handline). Subarea C would allow all forms of fishing except bottom-tending mobile fishing gear. Fishing with all of the above gear types would occur in the rest of the sanctuary outside the proposed SERA (i.e., Area D).

Table 1. Estimated Maximum Potential Total Economic Impacts (2010\$) by the Proposed SERA (1999-2009) to the Commercial Fishing and Seafood industry

Proposed SERA Area	Sales	Income	Employment	Sales % Impact	Income % Impact	Employment % Impact
A	7,403,422	2,117,006	60	0.07	0.08	0.05
B	3,266,211	899,189	27	0.04	0.05	0.03
C	4,615,530	1,405,007	36	0.04	0.05	0.03
Proposed SERA Total	15,285,162	4,421,202	123	0.15	0.17	0.11
Northeast Region Total	10,262,340,997	2,634,615,918	115,665			

Total Proposed SERA Impacts

Table 1 summarizes the estimated maximum potential economic impacts of the three proposed SERA subareas in terms of sales, income and employment. The estimated impact to the seafood industry sales is \$15.2 million annually, or approximately 0.15 percent of the total Northeast region. The estimated impact to the seafood industry income is \$4.4 million annually, or approximately 0.17 percent of the total Northeast region. The estimated impact to the seafood industry employment is 123 job equivalents, or approximately 0.11 percent of the total Northeast region.

Proposed SERA Subarea A Impacts

The prohibition of all fishing within Subarea A would result in estimated maximum potential impacts to the seafood industry of \$7.4 million in sales (0.07 percent), \$2.1 million in income (0.08 percent) and 60 job equivalents (0.05 percent). It should be noted that approximately one third of Subarea A has been off limits to commercial groundfish gear since 1998.

Proposed SERA Subarea B Impacts

The prohibition of all fishing with the exception of hook and line within Subarea B would result in estimated maximum potential impacts to the seafood industry of \$3.3 million in sales (0.04 percent), \$0.9 million in income (0.05 percent) and 27 job equivalents (0.03 percent). It should

be noted that Subarea B has been off limits to commercial groundfish gear since 1998.

Proposed SERA Subarea C Impacts

The prohibition of commercial bottom tending mobile fishing gears within Subarea C would result in estimated maximum potential impacts to the seafood industry of \$4.6 million in sales (0.04 percent), \$1.4 million in income (0.05 percent) and 36 job equivalents (0.03 percent).

III. References

Kirkley, James, 2009. The NMFS Commercial Fishing & Seafood Industry Input/Output Model, Prepared for the National Marine Fisheries Service, Virginia Institute of Marine Science.

Steinback, Scott R. and Eric M. Thunberg, 2006. Northeast Region Commercial Fishing Input-Output Model, NOAA Technical Memorandum NMFS-NE-188, Woods Hole, MA.

National Marine Fisheries Service, 2011. Fisheries Economics of the United States, 2009. NOAA Technical Memorandum NMFS-F/SPO-118 May 2011, Economics and Social Analysis Division, Office of Science and Technology, Silver Spring, MD.

Appendix III. Estimated Total Impact of the Stellwagen Bank National Marine Sanctuary Proposed Sanctuary Ecological Research Area to the Party/Charter Fishing Industry

I. Overview

Appendix I summarizes the estimated direct economic impact of the proposed SERA on the party /charter recreational fishing industry. These direct economic impacts only account for the maximum potential lost sales of the party/charter recreational fishing vessels for each of the proposed SERA subareas. Appendix III addresses the estimated total economic impacts of the proposed SERA subareas, i.e., the multiplier impacts, to sales, employment and income of all businesses associated with the party/charter recreational fishing industry in the Northeast Region (Maine, New Hampshire, Massachusetts, and Rhode Island). The results are preliminary for reasons explained in the proposal.

The total economic impacts were estimated using the regional input-output system called IMPLAN Pro (Minnesota IMPLAN Group, Inc.). The IMPLAN Pro system software provides the mathematical algorithms and data to estimate input-output (I/O) models and their resulting multipliers, as well as a user interface that makes conducting impact assessments and organizing model outputs easier.

A regional input-output software model capable of predicting the multiplier effects of proposed management actions in the Northeast was constructed using IMPLAN . The model is constructed at the regional level and has been designed so that the multiplier effects, expressed in terms of sales by businesses, average annual employment (both full and part-time), and personal income (labor income) can be determined.

The following counties in the states indicated were identified as the study area for the model:

Maine – York
New Hampshire – Rockingham
Massachusetts – Essex, Suffolk, Plymouth, and Barnstable
Rhode Island – Newport and Washington

Inputs to the model are trip expenditure data obtained from the report “The Economic Contribution of Marine Angler Expenditures in the United States, 2006” (Genter and Steinbeck, 2008). Trip expenditures include costs for transportation, food, lodging, fuel, charter fees, tips and tackle.

A limitation of the data is that the “charter fees” trip expenditure category only represents party or head boat fees of \$64 per person per trip, not the typical charter fee of \$1,200 per trip. The typical charter boat reported six anglers, so the charter fee expenditure for charter trips was replaced with \$200 per person per trip. That correction resulted in estimated total party trip expenditures of \$129 and total charter trip expenditures of \$265 per person per trip, in 2010 constant dollars. Number of anglers per unique trip in each of the proposed SERA subareas based on VTR data was also used as an input to the model.

These inputs are the direct impacts that were summarized in Appendix I. The model outputs include direct, indirect and induced estimated impacts. These impacts by the proposed SERA are summarized in Table 1 in terms of total sales, income and employment.

Values for total New England sales income and employment for the for-hire recreational fishing industry were obtained from (Gentner and Steinbeck, 2008).

The interpretation of the estimates provided in this analysis is critical to understanding the “true” impact of the various alternatives proposed for the SERA. The estimates from this analysis for the proposed SERA areas are simply the sum of each measurement within the boundaries for a given area. The estimates therefore represent the **maximum potential total loss from displacement of the party/charter fishing activities**. This analysis ignores possible mitigating factors such as relocation of fishing effort outside the proposed SERA and the possibility of net benefits that

Table 1. Estimated Maximum Potential Total Economic Impacts (2010\$) by the Proposed SERA (1999-2009) to the Party/Charter Fishing Industry

Proposed SERA Area	Sales (\$2010)	Income (\$2010)	Employment	Sales % Impact	Income % Impact	Employment % Impact
A	628,982	242,733	5.8	0.79	0.89	0.68
B	-	-	-	-	-	-
C	-	-	-	-	-	-
Proposed SERA Total	628,982	242,733	5.8	0.79	0.89	0.68
Total Economic Impacts Generated by Party/Charter Fishing Industry in RI, MA, NH & ME	79,292,805	27,336,211	859.0			

might be derived if the proposed ecological research area has replenishment or spillover effects.

II. Maximum Potential Total Economic Impact Analysis (1999-2009)

The proposed SERA is composed of three contiguous subareas: Subarea A would be a no-fishing reference area. Subarea B would be limited to hook-and-line fishing (party, charter, private and commercial handline). Subarea C would allow all forms of fishing except bottom-tending mobile fishing gear. Fishing with all of the above gear types would occur in the rest of the sanctuary outside the proposed SERA (i.e., Area D).

Total Proposed SERA Impacts

Table 1 summarizes the estimated maximum potential economic impacts of the three proposed SERA subareas in terms of sales, income and employment. The estimated impact to sales is \$628,982 annually, or approximately 0.79 percent of the total Northeast region. The estimated impact to income is \$242,733 annually, or approximately 0.89 percent of the total Northeast region. The estimated impact to employment is 5.8 job equivalents, or approximately 0.68 percent of the total Northeast region.

Proposed SERA Subarea A Impacts

The prohibition of all fishing within Subarea A would result in estimated maximum potential impacts of \$628,982 in sales (0.79 percent), \$242,733 in income (0.89 percent) and 5.8 job equivalents (0.68 percent). These are the same as the total proposed SERA impacts, because party/charter fishing would only be prohibited from Subarea A.

Proposed SERA Subarea B Impacts

Recreational fishing would be allowed in Subarea B, so there would be no economic impact.

Proposed SERA Subarea C Impacts

Recreational fishing would be allowed in Subarea C, so there would be no economic impact.

III. References

Gentner, Brad and Scott Steinback, 2008. The Economic Contribution of Marine Angler Expenditures in the United States, 2006. NOAA Technical Memorandum NMFS-F/SPO-94, Woods Hole, MA.

MIG, Inc., IMPLAN System, 1725 Tower Drive West, Suite 140, Stillwater, MN 55082, www.implan.com.

Appendix IV. Summary of Step 2 Socioeconomic Analysis of the Stellwagen Bank National Marine Sanctuary Proposed Sanctuary Ecological Research Area

I. Introduction

Socioeconomic analyses are provided in two steps. Step 1 analysis, as presented in Appendices I, II and III, add-up all activities displaced from the proposed SERA subareas and assume that all are lost, i.e., there is no mitigation or offsets through behavioral responses. Substitution, relocation and replenishment effects, the effects of other regulations, current and future status of fishing stocks, and the benefits of proposed SERA subareas are not addressed in Step 1 analyses. While results of Step 1 analyses are labeled “*maximum potential loss*,” it is rare for there not being possibilities for substitution and relocation to mitigate or offset impacts.

Step 2 analysis is less quantitative. Because all benefits and costs of the proposed SERA subareas cannot be quantified, a formal benefit-cost analysis is not conducted. Instead, the benefit-cost framework is used and all potential benefits and costs are listed and quantified where possible. Where benefits or costs cannot be quantified, we evaluate them qualitatively and indicate the direction we believe benefits or costs will move (under various conditions) from the point of the estimate of losses from Step 1 analysis. Theoretical models from socioeconomic literature were used to guide the Step 2 analysis and establish under what conditions and which direction we could expect benefits and/or costs to go.

Within this framework, the socioeconomic impact analysis will seem weighted more toward economic and less towards social impacts. To address potential social impacts, some information on the extent of impacts on individual fishermen (e.g., percent of total fishing revenues for commercial fishermen and percent of person-days of effort for “for hire” recreational fishing operations) were considered. This is the best that can be done with existing information and lays the foundation for adaptive management in the face of uncertainty. Greater assessment of social impacts would require detailed surveys.

II. Consumptive Use Analysis

The following is a list of the factors that were evaluated in the consumptive use analysis:

Status of Exploited Fishery Stocks. A basic assumption of the Step 1 analysis for the consumptive activities is that the baseline estimates of impact can be used as an approximation of the average impact in the future. This assumes that the current levels of exploitation are sustainable in the future.

Replenishment Effects/Stock Effects. This factor refers to the notion that stocks of currently exploited species will increase in biomass if the stocks are protected by proposed SERA subareas. The issues can be complex, but for current purposes it only matters if there is a net increase in biomass and aggregate harvest in the remaining open areas due to the proposed SERA subareas.

Substitution/Relocation. A mitigating or offsetting factor would be the ability to relocate effort to other areas and be just as successful (no loss) or be able to at least mitigate losses to some degree. Mitigating factors include finding perfect substitutes by relocating to other sites (no loss) or finding less than perfect substitutes involving either increased costs (travel to more distant sites) or reduced quality (catch per unit of effort, different species mix, rougher or less protected waters).

Crowding/Congestion Effects. This factor relates to fishing activities that would be displaced from a proposed SERA subarea(s) to other subareas or elsewhere. The resulting quality of fishing in these other areas could affect their suitability as alternative sites.

Quality Increases in proposed SERA Subareas. A considerable amount of research shows increases in many dimensions of the quality of sites that have been protected by no-take regulations. Increases in numbers, average size and age of animals are a common finding. Changes in biodiversity, community structure,

and general habitat conditions have been known to take place even in the short-term and could be expected to improve further over time.

Other Regulations. This factor can work towards mitigating, offsetting, and avoiding costs, or conversely increasing costs. Some regulations are known to have short-term costs with long-term benefits to fishermen. However, because many fisheries are open access, fishermen that suffer the short-term costs (make an investment) are not guaranteed that they will receive the benefits (the return on investment).

III. Potential Benefits

The following are examples of values that were evaluated in the analysis of potential benefits:

Nonuse or Passive Economic Use Values. Even though the proposed SERA subareas are relatively small, there could be significant benefits relative to the small costs to consumptive users. There would not be a benefit to local/regional economies because by definition there is no direct use and no spending associated with this value in the local/regional economies. Instead, the net benefit comes in the form of consumer's surplus or the willingness-to-pay to see natural resources protected in a certain condition.

Scientific and Education Values. This is expected to be the main benefit of the proposed SERA subareas and it is hard to quantify. There would be both net economic benefits in terms of consumer's surplus as people might have willingness-to-pay for the scientific and educational values generated. There likely will also be relatively significant market economic impacts due to the impacts of scientific research conducted in the proposed SERA subareas.

Over the past ten years, SBNMS attracted \$700K - \$1M annually in external funding for partnered research and monitoring of sanctuary resources. It is likely that the proposed SERA could attract research funding in that range considering there are over 40 academic research institutions in the region, many with specialized

marine expertise. It likely will also attract education activity although this is more difficult to quantify. General kinds of benefits to science and education include:

Scientific

- Provides long-term monitoring sites
- Provides focus for studies
- Provides continuity of knowledge in relatively undisturbed sites
- Provides opportunity to discern explicit effects of fishing gear on habitat
- Assures tenure for long-term experiments

Education

- Provides sites for enhanced primary and adult education
- Provides sites for high-level graduate education

IV. Net Assessment

The overall assessment is that net benefits are likely to derive from the proposed SERA subareas with little to no impacts on income and employment (Tables 1, 2). Impacts were judged relative to the estimates from the Step 1 analysis.

A neutral score means no change to the Step 1 estimates. A score of increased costs means we would expect the factor to increase the estimates of impact beyond what was estimated in Step 1 or that the impacts in Step 1 were underestimates. A score of decreased costs mean this factor would be expected to decrease the expected impact from what was estimated in the Step 1 analysis or that the impacts in Step 1 were overestimated. Finally, a score indicating benefits means this factor would contribute to net benefits (no losses) and that the impacts estimated in Step 1 are not real or would not be expected to occur. There is a time dimension to the evaluation: short-term (1 to 5 years) and long-term (5 to 20 years). Results for commercial fisheries are summarized in Table 1; Table 2 presents the results for recreational fisheries.

APPENDIX V. SUBAREA COMPARISON OF VESSEL TRIP REPORT DATA AND OBSERVER DATA (MAY 1, 1998-2009) FOR THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY PROPOSED SANCTUARY ECOLOGICAL RESEARCH AREA

ALL GEAR					
	VTR Trips	VTR %	OBS Trips	OBS %	Difference (%)
SBNMS Total	118,174		10,794		
A	8,228	7.0%	837	7.8%	0.8%
B North	1,975	1.7%	279	2.6%	0.9%
B South	4,689	4.0%	307	2.8%	1.2%
C	10,339	8.7%	1,613	14.9%	6.2%
MOBILE					
	VTR Trips	VTR %	OBS Trips	OBS %	Difference (%)
SBNMS Total	39,849		3,629		
A	2,240	5.6%	170	4.7%	0.9%
B North	163	0.4%	22	0.6%	0.2%
B South	256	0.6%	12	0.3%	0.3%
C	2,816	7.1%	325	9.0%	1.9%
FIXED					
	VTR Trips	VTR %	OBS Trips	OBS %	Difference (%)
SBNMS Total	58,608		7,159		
A	3,986	6.8%	662	9.2%	2.4%
B North	925	1.6%	257	3.6%	2.0%
B South	796	1.4%	295	4.1%	2.7%
C	6,035	10.3%	1,288	18.0%	7.7%

Table 1 compares the percent of trips fished within the proposed SERA subareas based on Vessel Trip Report (VTR) data and NMFS Observer data for May 1, 1998-2009 (i.e., since the Western Gulf of Maine Closure Area was established). Shading denotes the number and percent of mobile and fixed gear trips affected by subarea restrictions. The difference between the VTR data and the Observer data varied by 0.8% - 6.2% for all gear across all subareas and by 0.2% - 2.7% for mobile and fixed gear affected by subarea restrictions.