DRAFT

Omnibus Essential Fish Habitat Amendment 2
Volume 1: Executive summary, Background and purpose, and Description of the affected environment

Amendment 14 to the Northeast Multispecies FMP
Amendment 14 to the Atlantic Sea Scallop FMP
Amendment 4 to the Monkfish FMP
Amendment 3 to the Atlantic Herring FMP
Amendment 2 to the Red Crab FMP
Amendment 2 to the Skate FMP
Amendment 3 to the Atlantic Salmon FMP

Including a

Draft Environmental Impact Statement

Prepared by the
New England Fishery Management Council
In cooperation with the
National Marine Fisheries Service

Updated December 5, 2013
Draft for Council review on December 18, 2013

1 Executive summary

To be completed later

1.1 Purpose and need for action

1.2 Alternatives considered

1.3 Environmental consequences including cumulative effects

2 Contents

2.1 Table of contents

2.2 Tables

2.3 Figures

2.4 Maps

2.5 Acronyms

ASM – At-sea monitoring
ASMFC – Atlantic States Marine Fisheries Commission
CAI – Closed Area I
CAII – Closed Area II
CATT – Closed Area Technical Team
cdf – cumulative distribution function
DAS – Days at sea
EFH – Essential Fish Habitat
EIS – Environmental impact statement, Draft or Final
F – Fishing mortality
FMP – Fishery Management Plan
GARM – Groundfish Assessment Review Meeting
GB – Georges Bank
GOM – Gulf of Maine
GSC – Great South Channel
HAPC – Habitat Area of Particular Concern
ICNAF – International Commission for Northwest Atlantic Fisheries
MAB – Mid-Atlantic Bight
MARMAP – Marine Resource Monitoring and Assessment Program
MAFMC – Mid-Atlantic Fishery Management Council
MBTG – Mobile bottom-tending gear
MSA – Magnuson-Stevens [Fishery Conservation and Management] Act
MSY – Maximum sustainable yield
    B_{MSY} – Biomass at MSY
    F_{MSY} – Fishing mortality rate at MSY
NAFO – Northwest Atlantic Fisheries Organization
NEFMC – New England Fishery Management Council
NEFOP – Northeast Fisheries Observer Program
NEPA – National Environmental Policy Act
NLCA – Nantucket Lightship Closed Area
PDT – Plan Development Team
SASI – Swept Area Seabed Impact
SNE – Southern New England
TMGC – Transboundary Management Guidance Committee
TRAC – Transboundary Resource Assessment Committee

3 Background and purpose

3.1 Need and purpose for action

There are several needs and purposes for developing Omnibus EFH Amendment 2 (Table 1).

Purposes include designating EFH (A) and minimizing adverse fishery effects on EFH (B). These actions are needed to meet requirements of the Magnuson Stevens Fishery Conservation and Management Act. Specific recommendations for EFH designation and adverse effects minimization are provided in the EFH regulatory guidelines, published in their final form in January 2002. The guidelines specify to meet Purpose A, the Councils should designate EFH for all managed species of finfish and shellfish, by life history stage, using both text descriptions and maps delimiting potential EFH areas. Although some designations, specifically skates, wolffish, and red crab, are more recent, many of the New England designations were developed for the 1998 Omnibus EFH Amendment and the new designations proposed in this action include additional years of distribution data as well as information about depth and temperature preferences. The species managed by the New England Fishery Management Council are listed in Table 2.

EFH designations help the Council identify habitats where adverse impacts should be minimized (Purpose B). Prior efforts to minimize the adverse effects of Council-managed fisheries on EFH have been largely developed and implemented plan by plan, although fishery effects on EFH are cumulative across FMPs because fish and fishery distributions are overlapping across species and plans. This action is needed to reevaluate and integrate habitat management measures across the fisheries managed by the Council, and to update these measures given new scientific information about habitat distributions and fishing impacts.

EFH designations also inform fisheries management decision making generally, helping the Council and its stakeholders to understand species' distributions and habitat requirements. Finally, EFH designations facilitate outside consultations between NMFS and other ocean users regarding non-fishing projects that may impact fish habitats. Habitat consultations help minimize impacts on EFH, particularly impacts of non-fishery activities. Purpose C of the amendment is to identify other actions to encourage conservation and enhancement of such habitat. One set of alternatives related to this purpose is to designate Habitat Areas of Particular Concern (HAPC). An HAPC is a subset of EFH that represents particularly unique, ecologically important, and/or vulnerable habitat types. This is action is needed to highlight these special areas, as HAPCs help inform and receive elevated consideration for both fishery management and EFH consultations. Another set of alternatives that relates to Purpose C is the designation of Dedicated Habitat Research Areas, which will help the Council to better understand how habitat management measures influence stock productivity, to allow for the design of more effective conservation measures in future actions.

Another purpose of this amendment is to review and consider revising the rolling closures and year round groundfish closed areas. This is needed to ensure that spatial management measures are contributing to the realization of optimum yield in the groundfish fishery. Spatial overlaps between habitat and groundfish management areas make the EFH amendment an appropriate venue for this review. Specifically, the Council was concerned that the continued existence of the year-round groundfish closures could potentially undermine the practicality of new EFH management areas. In addition, changes to spatial management measure may be appropriate given substantial shifts in groundfish management strategy since the implementation of Amendment 16 to the Northeast Multispecies Fishery Management Plan, which implemented Annual Catch Limits in the fishery and significantly expanded the sector program.

There are two elements to this overall purpose. The first groundfish-specific purpose of this amendment is to increase protection for juvenile groundfish (Purpose D). Success at younger ages can have positive productivity benefits for managed resources, and therefore action is needed to protect juvenile groundfish, particularly for commercially valuable species. Scientific data indicate that the year-round habitat management areas and habitats most vulnerable to fishing are not optimally sited to encompass concentrations of juvenile groundfish. A second groundfish-specific purpose of this amendment is to identify seasonal closed areas in the NE Multispecies FMP that would reduce impacts on spawning groundfish and on the spawning activity of key groundfish species, since the protection of spawning fish is needed in order to sustainably manage stocks (Purpose E). Therefore additional alternatives were needed to meet this need.

Table 1 – Needs for action, with related purposes and management alternatives

Need	Purpose	Alternatives that address this purpose
Meet Magnuson Stevens Act EFH requirements	A. Designate EFH for each species and lifestage	Volume 2, Section 2.1
	B. Minimize the adverse effects of fishing on EFH to the extent practicable	Volume 3, Section 2.1
	C. Identify other actions to encourage conservation and enhancement of such habitat	Habitat Areas of Particular Concern (Volume 2, Section 2.2); Dedicated Habitat Research Areas (Volume 3, Section 2.3)
Achieve optimum yield from the groundfish fishery	D. Improve protection of habitats on which juvenile groundfish depend	Volume 3, Section 2.1
	E. Improve protection of spawning groundfish	Volume 3, Section 2.2

Table 2 – Species managed by the New England Fishery Management Council, by plan, with common names.

FMP	Species	Common Names
Multispecies	*Anarhichus lupus*	Atlantic wolffish
Multispecies	*Gadus morhua*	Atlantic cod (official), rock cod
Multispecies	*Glyptocephalus cynoglossus*	witch flounder (official), gray sole, Craig fluke, pole flounder
Multispecies	*Hippoglossus hippoglossus*	Atlantic halibut (official)
Multispecies	*Hippoglossoides platessoides*	American plaice (official), American dab, Canadian plaice, long rough dab

FMP	**Species**	**Common Names**
Multispecies	*Limanda ferruginea*	yellowtail flounder (official), rusty flounder
Multispecies	*Macrozoarces americanus*	ocean pout (official), eelpout, Congo eel, muttonfish
Multispecies	*Melanogrammus aeglefinus*	haddock (official)
Multispecies	*Merluccius bilinearis*	silver hake (official), whiting, New England hake
Multispecies	*Pollachius virens*	pollock (official), Boston bluefish, coalfish, green cod
Multispecies	*Pleuronectes americanus*	winter flounder (official), blackback, Georges Bank flounder, lemon sole, sole, flatfish, rough flounder, mud dab, black flounder
Multispecies	*Scophthalmus aquosus*	windowpane flounder (official), sand flounder, spotted flounder, New York plaice, sand dab, spotted turbot
Multispecies	*Sebastes spp.*	redfish (official), rosefish, ocean perch, red sea perch, red bream, Norway haddock
Multispecies	*Urophycis chuss*	red hake (official), squirrel hake
Multispecies	*Urophycis tenuis*	white hake (official), Boston hake, black hake, blue hake, mud hake, ling
Multispecies	*Merluccius albidus*	Offshore hake (official), blackeye whiting
Monkfish	*Lophius americanus*	monkfish (official), American goosefish, angler, allmouth, molligut, fishing frog
Sea Scallop	*Placopecten magellanicus*	Atlantic sea scallop (official), giant scallop, smooth scallop, deep sea scallop, Digby scallop, ocean scallop
Skates	*Amblyraja radiata*	Thorny skate (official), mud skate, starry skate, Spanish skate
Skates	*Dipturus laevis*	Barndoor skate (official)
Skates	*Leucoraja erinacea*	Little skate (official), common skate, summer skate, hedgehog skate, tobacco box skate
Skates	*Leucoraja garmani*	Rosette skate (official), leopard skate
Skates	*Malacoraja senta*	Smooth skate (official), smooth-tailed skate, prickly skate
Skates	*Leucoraja ocellata*	Winter skate (official), big skate, spotted skate, eyed skate
Skates	*Raja eglanteria*	Clearnose skate (official), brier skate
Deep-Sea Red Crab	*Chaceon quinquedens*	Deep-Sea red crab (official)
Atlantic Herring	*Clupea harengus*	Atlantic sea herring (official), Labrador herring, sardine, sperling, brit
Atlantic Salmon	*Salmo salar*	Atlantic salmon (official), sea salmon, silver salmon, black salmon

3.2 Goals and objectives

The Council adopted the following habitat and groundfish management goals and objectives to address the purpose and need for this action. The Council adopted goals 1-8 and objectives A-J in 2004, in relation to the EFH designation and adverse effects minimization requirements of the MSA. Much of the language of these goals and objectives is taken from the EFH regulations. In

April 2011, the Council voted to expand the scope of Omnibus EFH Amendment 2 to include modification of groundfish closed areas. Specific goals and objectives related to this expansion of scope were approved in November 2012. These include goals 9 and 10 and objectives K-N.

GOALS:

1. Redefine, refine or update the identification and description of all EFH for those species of finfish and mollusks managed by the Council, including the consideration of HAPCs;
2. Identify, review and update the major fishing activities (MSA and non-MSA) that may adversely affect the EFH of those species managed by the Council;
3. Identify, review and update the major non-fishing activities that may adversely affect the EFH of those species managed by the Council;
4. Identify and implement mechanisms to protect, conserve, and enhance the EFH of those species managed by the Council to the extent practicable;
5. Define metrics for achieving the requirements to minimize adverse impacts to the extent practicable;
6. Integrate and optimize measures to minimize the adverse impacts to EFH across all Council managed fishery management plans;
7. Update research and information needs;
8. Review and update prey species information;
9. Enhance groundfish fishery productivity;
10. Maximize societal net benefits from the groundfish stocks while addressing current management needs

OBJECTIVES:

A. Identify new data sources and assimilate into the process to meet goals (state, federal and other data sources);
B. Implement review of existing HAPCs and consider modified or additional HAPCs (Goal 1);
C. Review EFH designations and refine or redefine where appropriate as improved data and analysis become available (Goal l);
D. Develop analytical tools for designation of EFH, minimization of adverse impacts, and monitoring the effectiveness of measures designed to protect habitat (Goal l, Goal 3 and Goal 5);
E. Modify fishing methods and create incentives to reduce the impacts on habitat associated with fishing (Goal 4);
F. Support restoration and rehabilitation of fish habitat which have already been degraded (by fishing and non-fishing activities) (Goal 4);
G. Support creation and development of fish habitat where appropriate and when increased fishery resources would benefit society (Goal 4);
H. Develop a strategy for prioritizing habitat protection (Goal 4);
I. Develop criteria for establishing and implementing dedicated habitat research areas (Goal 7);

J. Design a system for monitoring and evaluating the benefits of EFH management actions including dedicated habitat research areas (Goal 7);
K. Improved groundfish spawning protection; including protection of localized spawning contingents or sub-populations of stocks (Goals 9 and 10);
L. Improved protection of critical groundfish habitats (Goals 9 and 10);
M. Improved refuge for critical life history stages (Goals 9 and 10);
N. Improved access to both the use and non-use benefits arising from closed area management across gear types, fisheries, and groups. These benefits may arise from areas designed to address the other three groundfish closed area objectives. (Goals 9 and 10).

The Council also requested a mechanism for reviewing and updating spatial management areas.

3.3 Management background

The following sections outline major events in habitat and groundfish management, with a particular focus on seasonal and year-round area closure measures, especially current areas that are part of the No Action alternative for this amendment. In many cases, the general locations of management areas have remained consistent, but with adjustments over time to area boundaries, seasons, and prohibited vs. exempted gears. This summary is by no means a complete accounting of every area management measure, as the management system is fairly complex and has undergone many changes over time. The intent is to provide an overall sense of how the current measures were arrived at, as well as references to the original Council action so the reader can seek out additional details if desired. The dates listed in the following sections are typically the year in which the Council submitted an action, which is not necessarily the implementation date, which is generally 3-6 months later. All FMP documents are available from the Council, and most are posted online in PDF format by Amendment or Framework number.

3.3.1 EFH designations and habitat closed areas

Prior efforts to minimize the adverse effects of Council-managed fisheries on EFH have been largely developed and implemented plan by plan, although fishery effects on EFH are cumulative across FMPs because fish and fishery distributions are overlapping across species and plans. In proposing this omnibus action, NEFMC specified a desire to integrate adverse effects minimization measures across plans through actions that will apply to all New England Council-managed fishing activities.

Omnibus EFH Amendment 1 (OA1) identified and described EFH for all 18 species managed by the Council at that time of its development through the following FMP amendments: Northeast Multispecies Amendment 11, Atlantic Sea Scallop Amendment 9, and Atlantic Salmon Amendment 1. OA1 also identified the major threats to EFH from both fishing and non-fishing related activities and proposed conservation and enhancement measures and designated Habitat Areas of Particular Concern (HAPC) for Atlantic salmon and Atlantic cod. As the regulatory guidelines were not yet finalized, the Council relied on preliminary NMFS guidance when developing OA1. The Council approved the final amendment and environmental assessment in September 1998 and the MSA/NEPA document was submitted to NMFS in October 1998. The Secretary of Commerce approved the amendments to all FMPs, with the exception of the

Monkfish FMP, on March 1999. The EFH requirements of FMPs that were not included in the Omnibus Amendment of 1998 were completed on the following schedule: Monkfish FMP (April 1999), Red Crab FMP (October 2002), and Skate FMP (July 2003). Amendment 16 (2010) added Atlantic wolffish to the NE Multispecies FMP and designated EFH for the species. The EFH designation for offshore hake was implemented in Amendment 12 to the Multispecies FMP in 2000.

A ruling on a lawsuit brought by several environmental organizations (American Oceans Campaign et al. v. Daley et al.) required the Department of Commerce and the Council to perform "a new and thorough EA or EIS" for each of the EFH amendments, in compliance with NEPA. The lawsuit challenged the adequacy of the fishing impact analysis in OA1 and the absence of any mitigation measures to minimize the adverse effects of fishing in the document. Although the EFH and HAPC designations for the 18 species included in OA1 went into effect once OA1 was approved by the Secretary of Commerce, the Court instructed the Department of Commerce and the Councils to:

- Prepare EISs for all fisheries challenged in the lawsuit.
- Comply with the requirements of all applicable statues, including NEPA; the Council on Environmental Quality (CEQ) NEPA implementing regulations, 40 C.F.R. Parts 1500-1508; and the National Oceanic and Atmospheric Administration (NOAA) Administrative Order 216-6.
- Include analyses of environmental impacts of fishing on EFH, including direct and indirect effects, as defined in the EFH regulations at 50 C.F.R. 600.810, and analyses of the environmental impacts of alternatives for implementing the requirement of the M-S Act, that the FMP "minimize, to the extent practicable, adverse effects on [EFH] caused by fishing."
- Consider a range of reasonable alternatives for minimizing the adverse effects (as defined by the EFH regulations) of fishing on EFH, including potential adverse effects. This range of alternatives will include "no action" or no action alternatives and alternatives set forth specifying fishery management actions that can be taken by NMFS under the M-S Act. The alternatives may include a suite of fishery management measures, and the same fishery management measures may appear in more than one alternative.
- Identify one preferred alternative, except that, in the draft EIS, NMFS may elect, if it deems appropriate, to designate a subset of the alternatives considered in the draft EIS, as the preferred range of alternatives, instead of designating only one preferred alternative.
- Present the environmental impacts of the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among the options, as set forth in CEQ regulation 40 C.F.R. 1502.14.

In response, the Council determined that the analysis and subsequent management alternatives required by the Court Order would be presented within separate NEPA documents currently being developed by NMFS and the Council for the Northeast Multispecies and Atlantic Sea Scallops FMPs. According to the terms of a negotiated settlement with the plaintiffs, the Northeast Regional Office also agreed to prepare a separate EFH amendment for the Atlantic herring FMP. The fishing effects analysis for the monkfish fishery was completed in Amendment 2 to the Monkfish FMP in 2004. These documents were completed in 2004 and

2005, and included extensive analyses of the adverse effects of fishing on EFH, and a range of alternatives to address such effects. They included descriptions of regional fishing gears and habitats, and summaries of the existing knowledge on the effects of fishing gears on habitats utilized by the 37 species managed by the New England and Mid-Atlantic Fishery Management Councils. The overall conclusion of the gear effects evaluations conducted in these amendments was that EFH for a number of species with benthic life stages was vulnerable to the adverse effects of mobile bottom-tending gear and that the effects were more than minimal and not temporary in nature, and, therefore, required mitigation. The following is a list of species and life stages that were determined to be adversely affected according to gear type (E=eggs, L=larvae, J=juveniles, A=adults):

- Otter trawls: American plaice (J, A), Atlantic cod (J, A), Atlantic halibut (J, A), Atlantic sea scallop (J), haddock (J, A), ocean pout (E, L, J, A), red hake (J, A), redfish (J, A), white hake (J), silver hake (J), winter flounder (A), witch flounder (J, A), yellowtail flounder (J, A), red crab (J, A), black sea bass (J, A), scup (J), tilefish (J, A), barndoor skate (J, A), clearnose skate (J, A), little skate (J, A), rosette skate (J, A), smooth skate (J, A), thorny skate (J, A), and winter skate (J, A).
- New Bedford scallop dredge: Acadian redfish (J, A), American plaice (J, A), Atlantic cod (J, A), Atlantic halibut (J, A), Atlantic sea scallop (J), haddock (J, A), ocean pout (E, L, J, A), red hake (J, A), white hake (J), silver hake (J), winter flounder (J, A), yellowtail flounder (J, A), black sea bass (J, A), scup (J), barndoor skate (J, A), clearnose skate (J, A), little skate (J, A), rosette skate (J, A), smooth skate (J, A), thorny skate (J, A), and winter skate (J, A).
- Hydraulic clam dredges: Atlantic sea scallop (J), ocean pout (E, L, J, A), red hake (J), silver hake (J), winter flounder (A), yellowtail flounder (J, A), black sea bass (J, A), scup (J), clearnose skate (J, A), little skate (J, A), rosette skate (J, A), and winter skate (J, A).

Building on these conclusions, the documents proposed and evaluated a suite of measures designed to minimize the adverse effects of fishing on EFH. Specifically, they included the following management options:

- **Incidental benefits of other Amendment 10 and 13 measures:** Because management measures that were designed to reduce fishing mortality may also provide benefits to fish habitat, such management measures were explicitly considered as part of a formal strategy to reduce impacts on habitat.
- **Modification of current groundfish closed areas to protect habitat:** Modifications to the boundaries of the existing closed areas were proposed to better protect sensitive habitat. Some entirely new closed areas were proposed.
- **Identification of important habitat areas within current groundfish closures:** Areas within currently existing closed area containing important habitat were identified. Such areas may be subject to more severe restrictions in order protect the habitat.
- **Closed areas designed to protect habitat and minimize impact on fisheries:** This alternative was proposed to close areas with important habitat elements that are of low value to the multispecies, scallop, and monkfish fisheries in terms of productivity.
- **Current closed areas, with the exception of scallop access areas:** The then-current year round closed areas were considered for designation as habitat closures, with the

exception of portions of those areas that have been made accessible to the scallop fishery through time-limited openings.

- **Expand list of prohibited gears in closed areas:** This alternative would have expanded the number of types of fishing gears that may not be used in the closed areas to include shrimp trawls, herring mid-water trawls, clam dredges, and pots and traps.
- **Restrictions on the use of rockhopper and roller gear:** This alternative was proposed to restrict the use of rockhopper and roller trawl gear. Various alternatives with respect to the maximum size of the gear allowed were evaluated.

To assess the impacts of management alternatives on fish habitats, Amendments 10 (Sea Scallop FMP) and 13 (Multispecies FMP) used a suite of different metrics to evaluate the management areas. Alternatives were ranked based primarily on various methods of summing the raw values provided by these metrics:

- Days at Sea use
- Days absent, as reported in the Vessel Trip Reports (VTRs)
- Percent overlap with areas designated EFH
- Biomass inside/outside area closure alternatives for five trophic guilds and five spatio-temporal species assemblages
- Biomass inside/outside area closure alternative for six species with high levels of association with benthic habitats: longhorn sculpin, sea raven, redfish, ocean pout, jonah crab and American lobster
- Sediment composition inside/outside area closure alternatives based on the Poppe et al. (1989) dataset

Ultimately, Amendment 13 to the Northeast Multispecies FMP adopted the following measures to minimize the adverse effects of fishing on EFH to the extent practicable:

- Effort reductions, by significantly reducing DAS reductions and including seasonal closures
- Area closure, by designating new areas both inside and outside then-existing year-round closures as “habitat closure areas” to reduce the effect of fishing on benthic habitats

Amendment 10 to the Atlantic Sea Scallop FMP adopted the following measures:

- Effort reductions, by significantly reducing DAS reductions and including seasonal closures
- Area closure, by designating new areas both inside and outside then-existing year-round closures as “habitat closure areas” to reduce the effect of fishing on benthic habitats
- Gear modifications that increased dredge ring size to 4” throughout fishery, which were shown through analysis to be more efficient than 3.5” rings and therefore minimized bottom contact time

The following year, Monkfish Amendment 2 was finalized, which implemented two EFH areas closed to vessels fishing on a monkfish DAS in Lydonia and Oceanographer canyons.

3.3.2 Groundfish management history, with a focus on area closures

Spatial management of groundfish fishing has a long and complicated history in New England. Seasonal and year round closed areas have been used to meet many objectives, including to protect spawning cod and haddock on Georges Bank, reduce discards of small yellowtail flounder in Southern New England, as a means to reduce mortality on certain overfished groundfish stocks and make day-at-sea management more effective, and in the Gulf of Maine to reduce discards caused by cod possession limits established to rebuild Gulf of Maine cod.

In 1974, the International Commission for Northwest Atlantic Fisheries (ICNAF), precursor to the Northwest Atlantic Fisheries Organization (NAFO), implemented bottom-trawling closures on Georges Bank to protect large mesh species, particularly cod and haddock (Halliday and Pinhorn, 1996). These restrictions at first applied to large vessels over 155 ft. and eventually to smaller 130 ft. vessels, reducing foreign factory trawl activity.

In 1977, the Council's Fishery Management Plan for Atlantic Groundfish was implemented via emergency secretarial action (42 FR 13998). This plan included two area closures on Georges Bank that were closed to fishing gears other than pelagic gears during March, April, and May (Map 1). Fishing with hook gear larger than 3 cm, scallop dredges, and lobster pots was exempted.

The 1981 Interim Fishery Management Plan for Atlantic Groundfish modified the boundaries of Closed Area I (Map 1). In 1985, the Council incorporated the Closed Area I and Closed Area II spawning closures with the 1981 boundaries into the Northeast Multispecies FMP. The CAI season started in February, a month earlier than under the interim plan, and extended into May, opening after April 30 at the RA's discretion. The season for the CAII spawning area was coordinated with Canada. The SNE Yellowtail Flounder closure (west of the current Nantucket Lightship Area, see Map 1) was also adopted in the 1985 amendment. This area was closed seasonally to provide reduced mortality and enhanced spawning opportunity for yellowtail flounder. Specifically, areas east of 71°30' W closed March 1, while areas west of 71°30' W closed April 1. The areas remained closed as far into May as the Council determined was appropriate to achieve objectives of FMP.

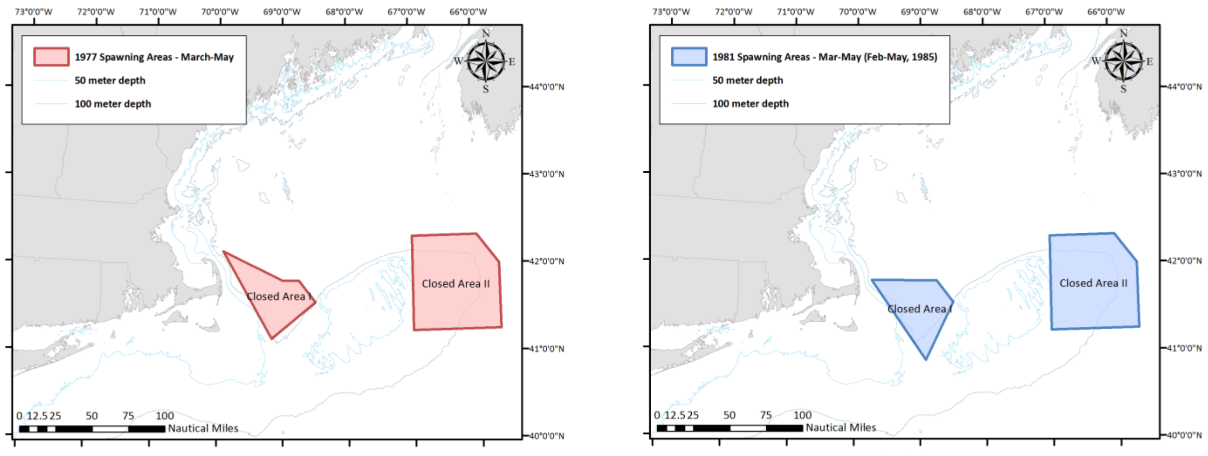
In 1987, the Council's Technical Monitoring Group (TMG) evaluated these spawning closures and removed the northwest corner of CAI, and recommended moving the area south and east via a subsequent action. This change was implemented via Amendment 1 (Map 1). For the SNE closed area, Amendment 1 added a prohibition on scallop dredge gear in the due to yellowtail bycatch concerns, and an exemption for hook and line fishing with zero possession of yellowtail.

Amendment 2 (1989) established a seasonal large-mesh area on Nantucket Shoals to protect cod and excluded trawlers from Closed Area II during the closure to improve enforcement of the closure.

Amendment 3 (1989) implemented the Flexible Area Action System, designed to rapidly identify and implement spatial management in response to changing resource conditions. However, this management framework went largely unused and was eventually eliminated by Amendment 13 (2003). Amendment 4 (1990) implemented three areas related to juvenile groundfish protection, the Nantucket Lightship Area in SNE for yellowtail, and the Jeffreys Ledge and Stellwagen Bank areas for juvenile cod (Map 1). The Nantucket Lightship area closure was triggered by large concentrations of juvenile yellowtail in the sea sampling data. The Jeffreys and Stellwagen areas were triggered by high juvenile cod discard rates in the sea sampling data. Measures were taken in two stages, with large (at the time) 5.5 inch mesh required first, and a mobile bottom-tending gear closure if high discards persisted.

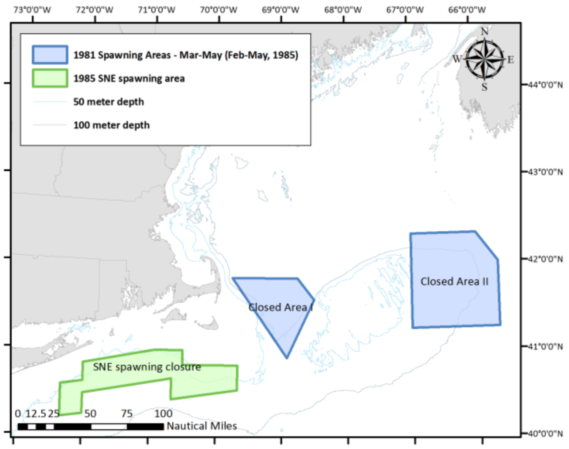
The Council developed Amendment 5 (submitted September 1993) to the NE Multispecies FMP to reduce fishing effort below overfishing limits with the introduction of limited access and day-at-sea limits. In the western Gulf of Maine, Amendment 5 implemented a six-inch square mesh requirement in the Jeffreys Ledge Juvenile Protection Area (fifth panel on Map 1). This L-shaped area extended from the northern-most part of Jeffreys Ledge, including the fingers, and down nearly to the state waters boundary off Cape Ann, Massachusetts. In addition, Amendment 5 suspended Closed Area I, expanded the size of Closed Area II to its current footprint, and created the Nantucket Lightship Closure as it exists today (Map 1). Secretarial action in late 1994 implemented all three areas year round on an emergency basis, modifying the boundaries of CAI to what they are today (Map 2). The Council adopted these areas year round via Framework 9 (1995) to rebuild Georges Bank fish stocks. Except for tightly defined special access programs to target healthy stocks (starting in 2004) and access programs for scallop fishing (starting in 1999), these areas have remained closed to gears capable of catching regulated groundfish. Currently, recreational and party/charter fishing for groundfish is prohibited in CAI and CAII but allowed in the Nantucket Lightship Closed Area.

Map 1 – Groundfish spatial management, 1977-1993

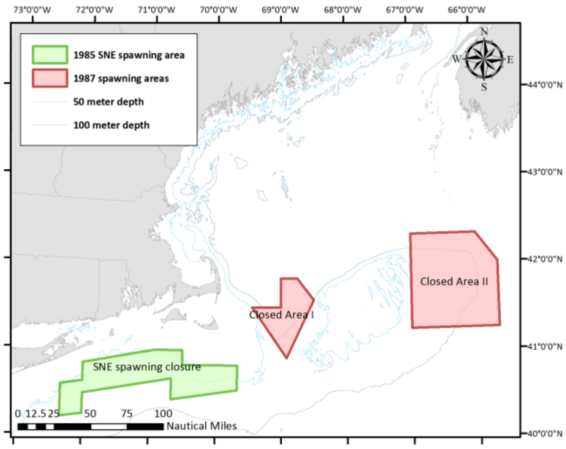


WGS 1984 UTM Zone 19N projection; map updated July 15, 2013

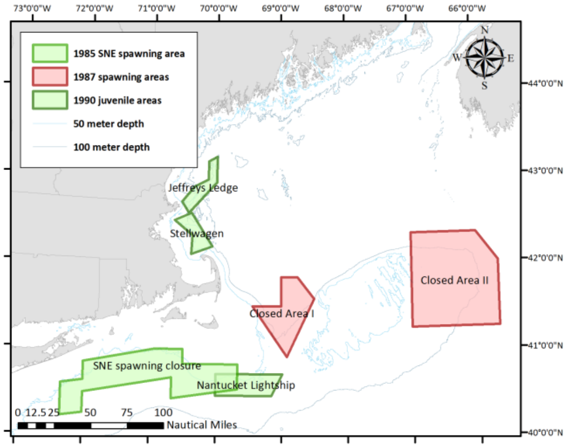
WGS 1984 UTM Zone 19N projection; map updated July 15, 2013



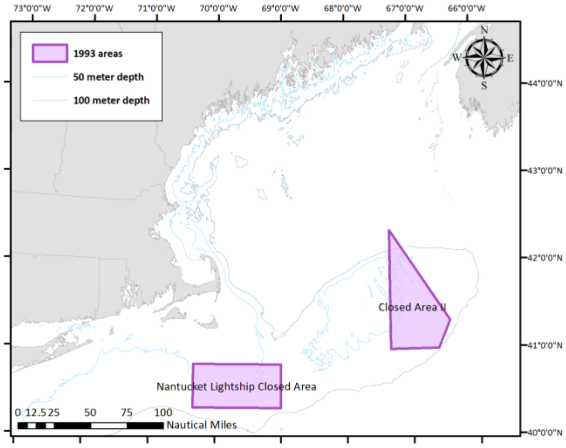
WGS 1984 UTM Zone 19N projection; map updated July 15, 2013



WGS 1984 UTM Zone 19N projection; map updated July 15, 2013



WGS 1984 UTM Zone 19N projection; map updated July 15, 2013



WGS 1984 UTM Zone 19N projection; map updated July 15, 2013

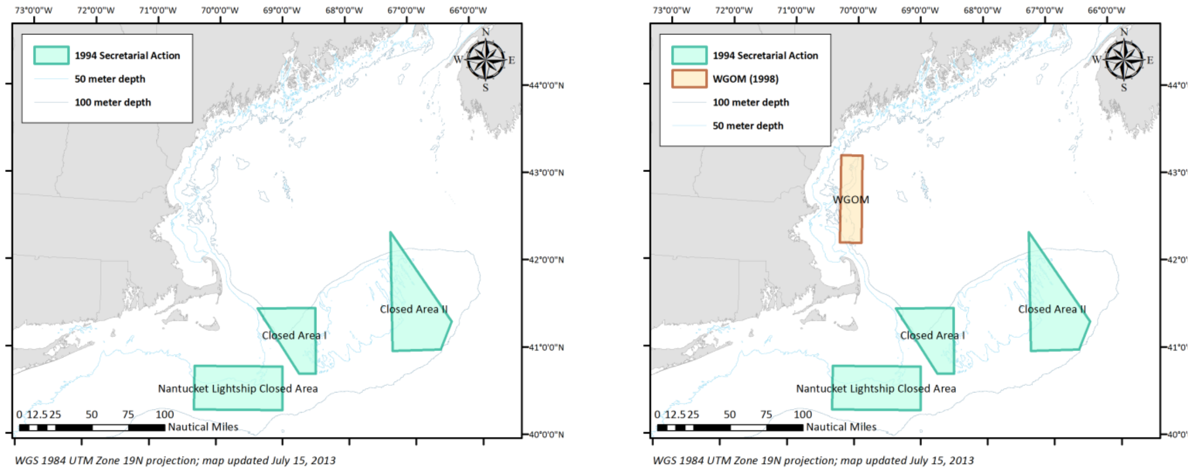
Amendment 7 (1996) recognized that area closures would eventually be developed in the GOM on a year round basis. As an interim measure, this amendment extended two seasonal closures that were previously to gillnets only for harbor porpoise protection to all vessels. These were the Massachusetts Bay closure during March and the Mid-Coast Closure during November and December. These were fairly unpopular and efforts to modify them began almost immediately. Framework 19 (October 1996) adopted a March closure of the two thirty-minute squares over Jeffreys Ledge; the plan was to revert to the Mid-Coast Closure during the 1998 fishing year, and change the dates to May, but the Western Gulf of Maine Closed Area was implemented instead, as described below.

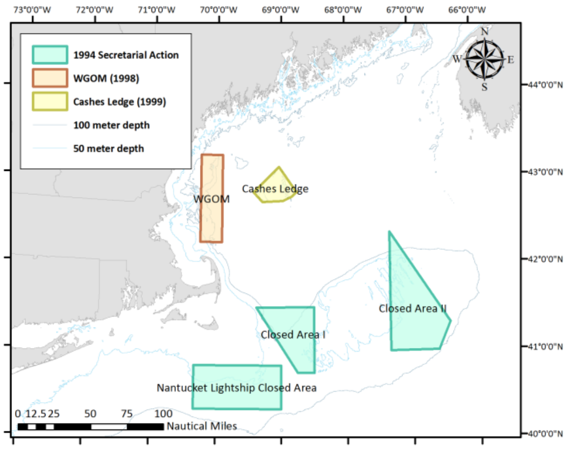
Up until 1998, there were no year-round groundfish closed areas in the Gulf of Maine. During the late 1990s, it became apparent that the Amendment 4 day-at-sea allocation to limited access groundfish vessels of 88 days was too high to prevent overfishing, particularly for cod. Fishermen were opposed to reducing day-at-sea allocations because it would limit their ability to target and catch healthier stocks. Therefore in addition to other measures like possession limits to reduce the incentive to target certain species, Framework Adjustment 25 (1998) included year-round closure of the Western Gulf of Maine Closed Area as it is currently configured (Map 2), as well as one month rolling closures during March and June. Most of the rolling closure blocks were inshore, but block 129 that overlaps Cashes Ledge was closed during June. The intent of the rolling closures was to preserve a day-at-sea allocation to allow vessels to fish on healthy stocks and on Georges Bank, while reducing Gulf of Maine cod mortality and cod discards. Note that the Western Gulf of Maine area was originally intended as a temporary year-round closure; it was extended via various actions including Framework 33 (2000), a court order lawsuit filed in response to Framework 33, and finally indefinitely via Amendment 13 (2003). During Amendment 13 development, many alternate versions of the Western Gulf of Maine closure were discussed, but none were formally analyzed in the DEIS.

Framework 26 (1998) modified the months and blocks of the rolling closures, increasing the amount of area closed to groundfishing on a monthly basis. There was also a Northeast Closure area in effect in the eastern GOM during this time. In 1999, Framework 27 reconfigured block 129 to the current boundaries of the Cashes Ledge groundfish area (Map 2), and the closure period was expanded to four months (July-October). Framework 27 also enacted the 12 inch maximum roller gear size in the WGOM as a measure to reduce fishing effort on GOM cod, and to achieve some separation between offshore and inshore vessels. It was expected that the roller gear size limit would “limit the ability of mobile gear vessels to fish in hard bottom areas inshore, where cod and other species aggregate” (Framework 27, p 16).

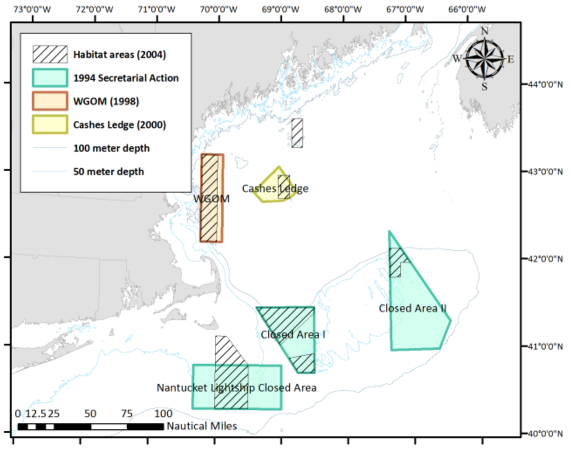
In 2000, Framework 33 added a November conditional closure for Cashes Ledge, which was triggered if 50% of the Target Total Allowable Catch (TTAC) for GOM cod was reached by July 31 of that year. Cashes Ledge was closed to groundfishing year-round by Secretarial action on May 1, 2002 as a result of a settlement agreement among certain parties in Conservation Law Foundation et al. v. Evans. The year-round closure was extended by the Council in 2003 as part of Amendment 13 to the NE Multispecies FMP. This action also designated the habitat closures described in the previous section, including one on Cashes Ledge. Like Closed Area I, Closed Area II, and the Nantucket Lightship Area, the Western Gulf of Maine and Cashes Ledge Closed Areas prohibit fishing by gears capable of catching groundfish. Recreational fishing for groundfish was and is allowed.

Map 2 – Groundfish spatial management, 1994-present. GOM rolling closures in effect from 1998 onward are not shown on these figures.





WGS 1984 UTM Zone 19N projection; map updated July 15, 2013



WGS 1984 UTM Zone 19N projection; map updated July 15, 2013

Despite (or because of) day-at-sea management, all these various restrictions became increasingly onerous to the groundfish fleet, reducing the flexibility to make sound fishing and business decisions. Day-at-sea leasing adopted under Amendment 13 helped, but did not resolve the conundrum and day-at-sea management was being seen as ineffective. In response, the Council developed and adopted a new form of catch share management in Amendment 16 (2010). Catch share management allocates specific percentages of allowable catch to individual limited access groundfish vessels, which are allowed to join together with other limited access groundfish vessels in “sectors”. The sectors submit for approval operational plans that specify which vessels belong to each sector and how they would operate and monitor their vessels catch and landings. This form of management made the sectors accountable for their overages of groundfish catches, but also allowed them to pool groundfish allocations amongst member vessels.

Catch share management with accountability measures was seen as being more effective at keeping mortality below acceptable levels, thereby preventing overfishing. The sector vessels were also often exempted from cod possession limits and rolling closures were no longer as relevant to managing mortality. Thus, for sector vessels, Amendment 16 rolled back the size and temporal extent of the rolling closures to the most critical blocks during April, May, and June. Sectors were allowed to and many did apply for exemptions to these smaller areas, but to date no rolling closure exemption requests have been approved as part of a sector operations plan.

The Gulf of Maine Cod Spawning Protection Area was developed in Framework 45 and implemented at the start of the 2011 fishing year. The area is closed between April 1 and June 30 to all groundfishing. The primary effect was to restrict recreational vessels, except those fishing exclusively with pelagic hook and line gear, from an area south of Isle of Shoals off the coast of New Hampshire. Except for sector vessels in June, commercial groundfish vessels were already excluded from fishing in the area as a result of the rolling closures.

Low Annual Catch Limits for certain groundfish stocks proposed for fishing year 2013 led the Council to consider measures that might mitigate economic and social impacts of such reductions. NE Multispecies Framework 48 (final Council action December 2012) included a measure that allows sector vessels to request exemptions from parts of the year round groundfish closed areas that are not within existing habitat closures or new habitat management areas proposed via OA2. As is the case with other types of sector exemption requests, requests to access these exemption areas are made and analyzed annually via sector operations plans. In July 2013, NMFS described the range of exemption requests they would grant and under what conditions.

3.4 Notices of intent, scoping, and the amendment development process

The Council published the original Notice of Intent to prepare EFH Omnibus Amendment 2 in February 2004, and in September 2005 the Council declared its intent to complete the Omnibus Amendment in two phases, due to issues of public clarity and management complexity. Phase 1 included a review and update of EFH designations and consideration of HAPCs (not including consideration of management measures or restrictions), an update of prey species list, an update of non-fishing impacts, and an update of research and information needs (since moved to Phase 2). The Phase 1 work was published as a draft Environmental Impact Statement in April 2007. The Council approved the preferred EFH and HAPC designations, as well as the prey species and non-fishing impacts summaries, in June 2007. An additional HAPC in the Great South Channel was approved in September 2007.

Phase 2 included a review and update of a gear effects evaluation and alternatives to optimize management measures for minimizing the adverse effects of fishing on EFH across all FMPs. In late 2007, the Habitat Committee and Plan Development Team commenced work on Phase 2. From late 2007 through early 2010, the group worked to develop an updated approach (the Swept Area Seabed Impact model) for estimating the magnitude and distribution of the adverse effects of fishing on EFH. In 2009, the Council clarified via an additional notice of intent that it would not publish a final version of the Phase I EIS, but would instead incorporate all Phase 1 elements in a single EIS covering both phases. In spring 2010, the committee used the model outputs and related information to begin development of alternatives to optimize and integrate adverse effects minimization measures across all Council-managed fisheries. These alternatives were substantially developed by August 2011, although additional modifications were made up until the Council approved the alternatives for analysis in June 2013. Dedicated habitat research areas were developed during 2011 and 2012. Minor adjustments to the EFH designations approved during Phase 1 were also completed between 2009 and 2011.

Meanwhile, mitigation of fishing impacts to deep-sea corals was added to the amendment shortly after the deep-sea coral discretionary authority was added to the MSA via the 2007 reauthorization. The range of alternatives for analysis was approved by the Council in April 2012, but removed into a separate omnibus plan amendment in September 2012. Work on this plan amendment will be completed once OA2 is submitted, although relevant data gathering efforts are ongoing.

In April 2011, the Council added evaluation of groundfish management areas, which have substantial spatial overlap with existing habitat management areas, to the scope of the amendment. A notice of intent seeking comments on this issue was published in June, 2011. Other Council priorities related to groundfish prevented significant progress on this evaluation and the development of new measures until a dedicated, ad hoc technical team (the Closed Area Technical Team) was convened in August 2012. The technical team drafted goals and objectives for the groundfish elements of the amendment. These were review by the Groundfish PDT and

Committee and approved by the Council in November 2012. After completing analyses of the sector groundfish closed area exemption alternative for NE Multispecies Framework 48, the technical team turned its attention to development of OA2 measures in January 2013.

In May and June 2013, the habitat and groundfish technical teams and committees began meeting jointly to finalize a range of spatial management alternatives for Council approval. These alternatives were developed for spawning protection, adverse effects minimization, protection of juvenile groundfish habitats, and designation of dedicated habitat research areas. The Council approved a set of management alternatives for analysis at their June meeting.

In August 2013, Council staff convened a series of informational meetings to gather information and feedback on the alternatives from industry members, focusing on those who had not previously engaged in the process.

In September 2013, the Council made a series of relatively minor adjustments to the spatial management alternatives.

4 Description of the affected environment

The purpose of this section of the document is to describe the physical, biological, and human elements of the environment as they relate to the management alternatives being analyzed.

4.1 Physical and biological environment including benthic habitats

The Northeast U.S. Shelf Ecosystem has been described as the Gulf of Maine south to Cape Hatteras, extending from the coast seaward to the edge of the continental shelf, plus the slope sea offshore to the Gulf Stream, out to a depth of 2000 m (Sherman et al. 1996). Four distinct sub-regions comprise the ecosystem: the Gulf of Maine (GOM), Georges Bank (GB), the Mid-Atlantic Bight (MAB), and the continental slope. Essential Fish Habitats for NEFMC-managed species are identified throughout this entire region, although spatial management alternatives focus on the continental shelf, particularly the Gulf of Maine and Georges Bank regions. This section of the document describes the oceanography, geology, and biology of these regions, with a particular focus on benthic habitats. Biological information is focused on non-target resources including benthic invertebrates and non-managed species of fish; managed fishery species and protected resources including turtles, mammals, sturgeon, and salmon are discussed separately in sections 4.1.2 and 4.2.2, respectively.

Much of this summary was extracted from Stevenson et al. (2004), which is based primarily on the following sources: Backus 1987, Schmitz et al. 1987, Tucholke 1987, Wiebe et al. 1987, Cook 1988, Reid and Steimle 1988, Stumpf and Biggs 1988, Abernathy 1989, Townsend 1992, Mountain 1994, Beardsley et al. 1996, Brooks 1996, Sherman et al. 1996, Dorsey 1998, Kelley 1998, NEFMC 1998, and Steimle et al. 1999.

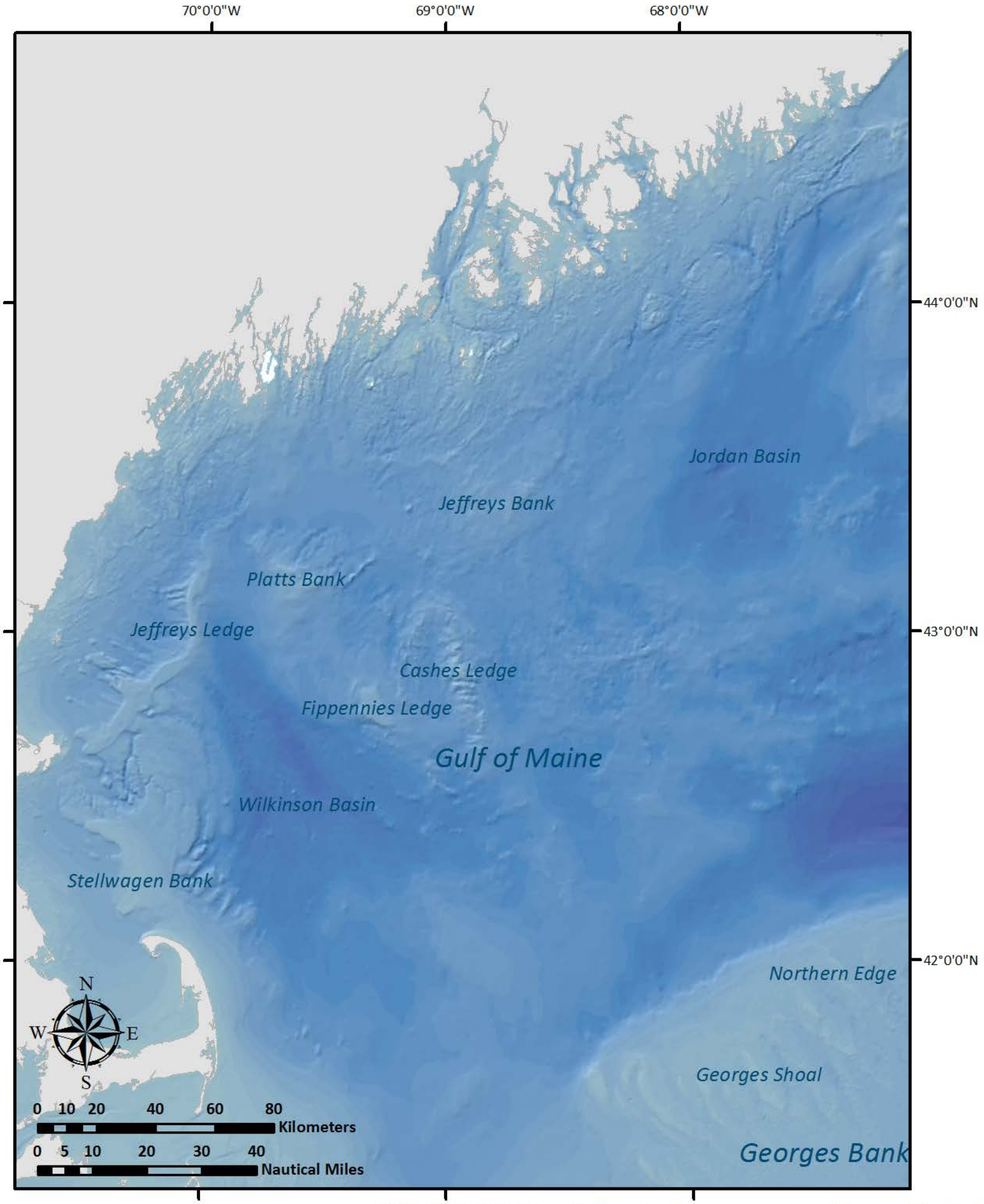
4.1.1 Oceanographic and sedimentary features and benthic fauna

4.1.1.1 Gulf of Maine

The Gulf of Maine (Map 3) is an enclosed coastal sea, bounded on the east by Browns Bank, on the north by the Nova Scotian Shelf, on the west by the New England states, and on the south by Cape Cod and Georges Bank. The GOM is glacially derived, and is characterized by a system of deep basins, moraines and rocky protrusions with limited access to the open ocean. This geomorphology influences complex oceanographic processes that in turn produce a rich biological community.

The GOM’s geologic features, when coupled with vertical variations in water properties, result in a great diversity of habitat types. There are twenty-one distinct basins separated by ridges, banks, and swells. The three largest basins are Wilkinson, Georges, and Jordan. Depths in the basins exceed 250 m, with a maximum depth of 350 m in Georges Basin, just north of Georges Bank. The Northeast Channel between Georges Bank and Browns Bank leads into Georges Basin, and is one of the primary avenues for exchange of water between the GOM and the North Atlantic Ocean.

Map 3 – Bathymetric features of the Gulf of Maine. Data are from the Nature Conservancy's Northwest Atlantic Marine Ecoregional assessment.



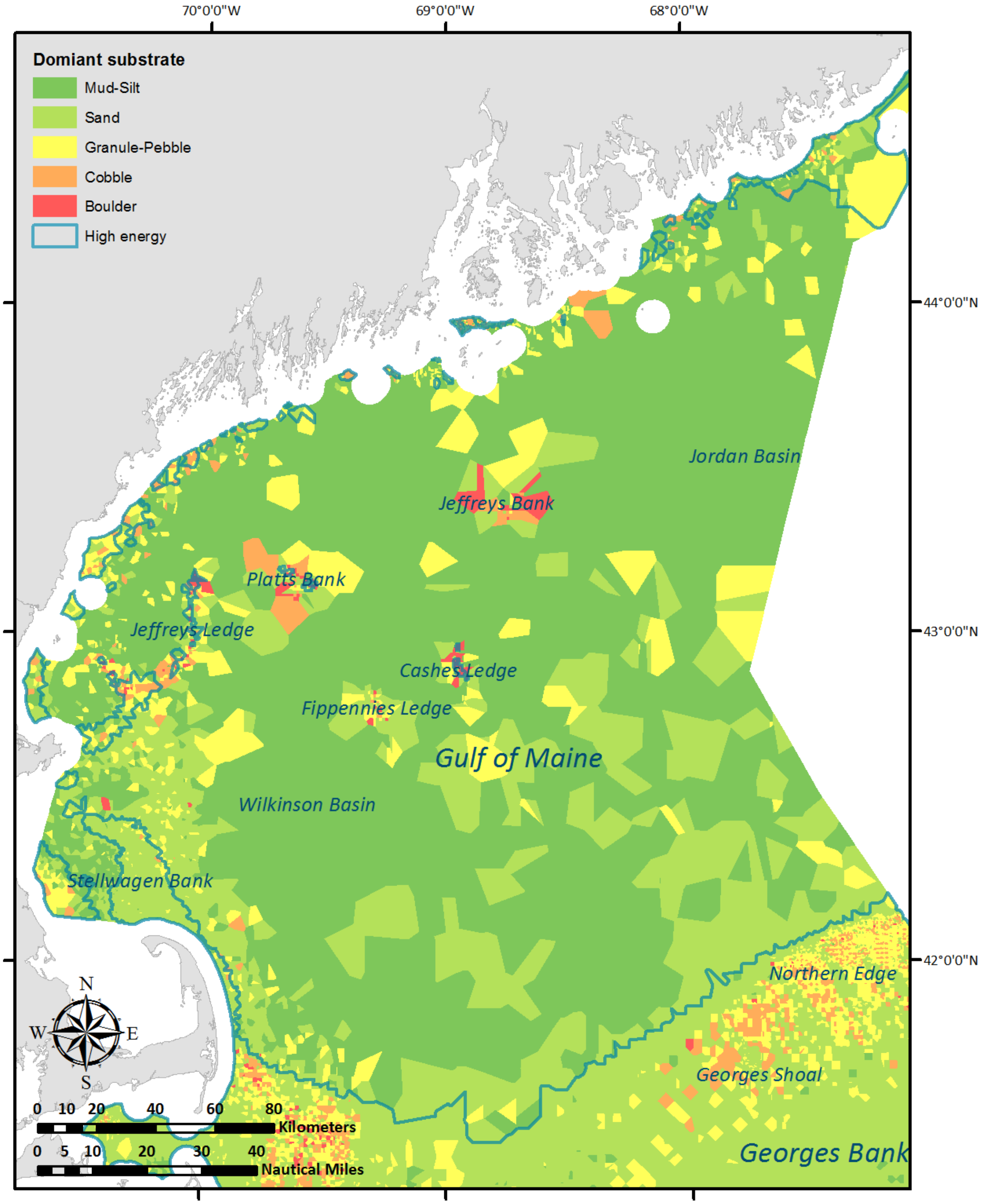
WGS 1984 UTM Zone 19N projection; map updated August 30, 2013

Sediment types

High points within the Gulf include irregular ridges, such as Cashes Ledge, which peaks at 9 m below the surface, as well as deeper flat topped banks, ridges, and gentle swells. Some of these rises are remnants of the sedimentary shelf that was left after most of it was removed by the glaciers. Others are glacial moraines and a few, like Cashes Ledge, are outcroppings of bedrock. Very fine sediment particles created and eroded by the glaciers have collected in thick deposits over much of the GOM, particularly in its deep basins. These mud deposits can blanket and obscure the irregularities of the underlying bedrock, forming topographically smooth terrains. In some areas bedrock protrudes above the sediment layer forming isolated habitats. Some shallower basins are covered with mud as well, including some in coastal waters. In the rises between the basins, other materials are usually at the surface. Unsorted glacial till covers some moraines, as on Sewell Ridge to the north of Georges Basin and on Truxton Swell to the south of Jordan Basin. Sand predominates on some high areas and gravel, sometimes with boulders, predominates on others.

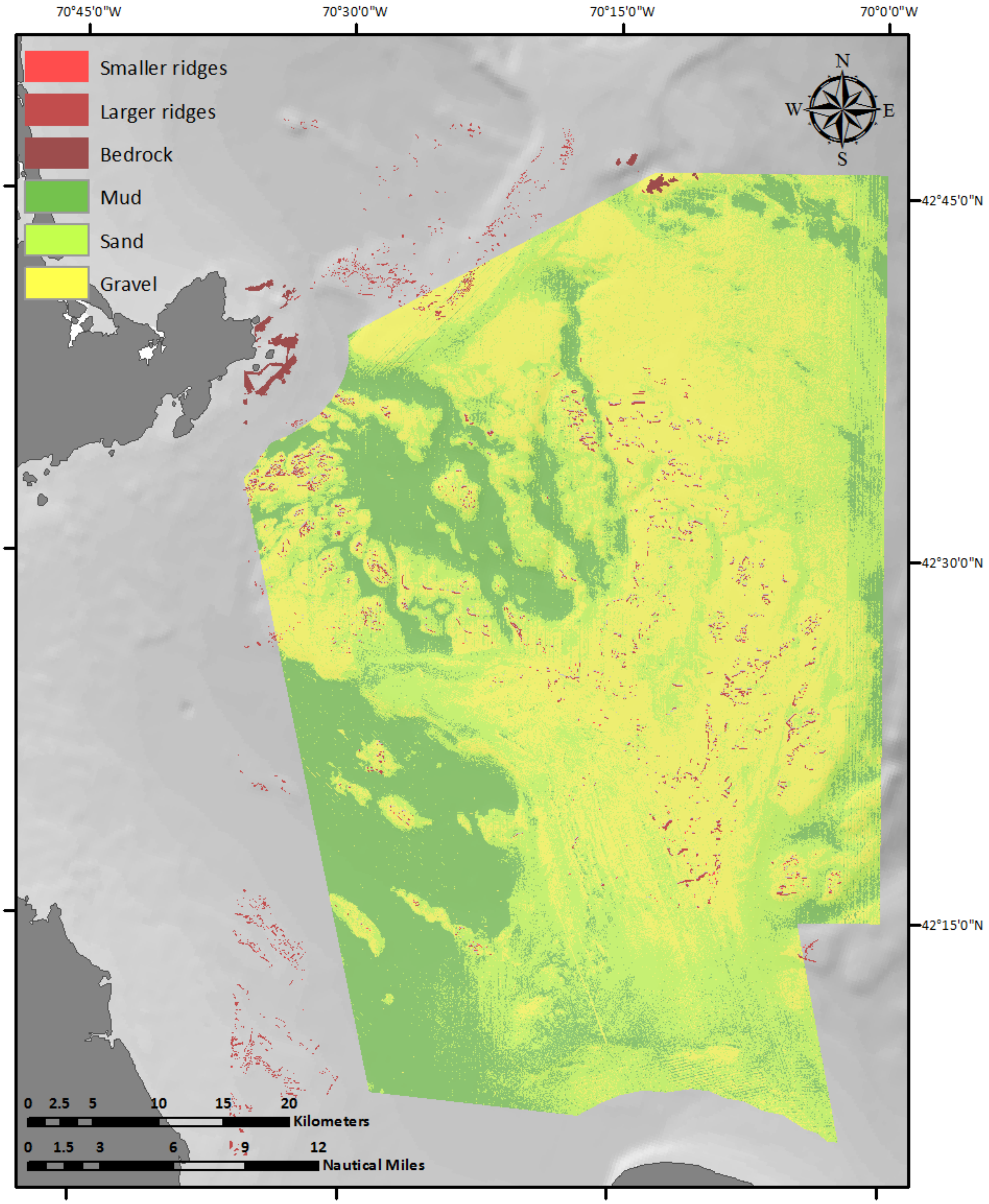
Map 4 depicts dominant sediment type mapped as an unstructured or Voronoi grid, where polygon size reflects data density. This sediment map was developed for use in the Swept Area Seabed Impact model and details can be found in the SASI appendix. The muddier basins as well as hard-substrate shallower areas are shown in dark green to red coloration. Higher versus lower energy habitats are delimited by the blue line, with higher energy habitats inshore and on the tops of features including Cashes Ledge, Platts Bank, Jeffreys Ledge, and Stellwagen Bank. In the Gulf of Maine, a depth cut-off of 60 m was used to distinguish high versus low energy habitats. In general, sediment data are fairly low resolution in many parts of the Gulf of Maine. However, one feature that has been mapped in detail is Stellwagen Bank (Map 5).

Map 4 – Sedimentary features of the Gulf of Maine. Data sources include usSEABED and SMAST video.



WGS 1984 UTM Zone 19N projection; map updated August 30, 2013

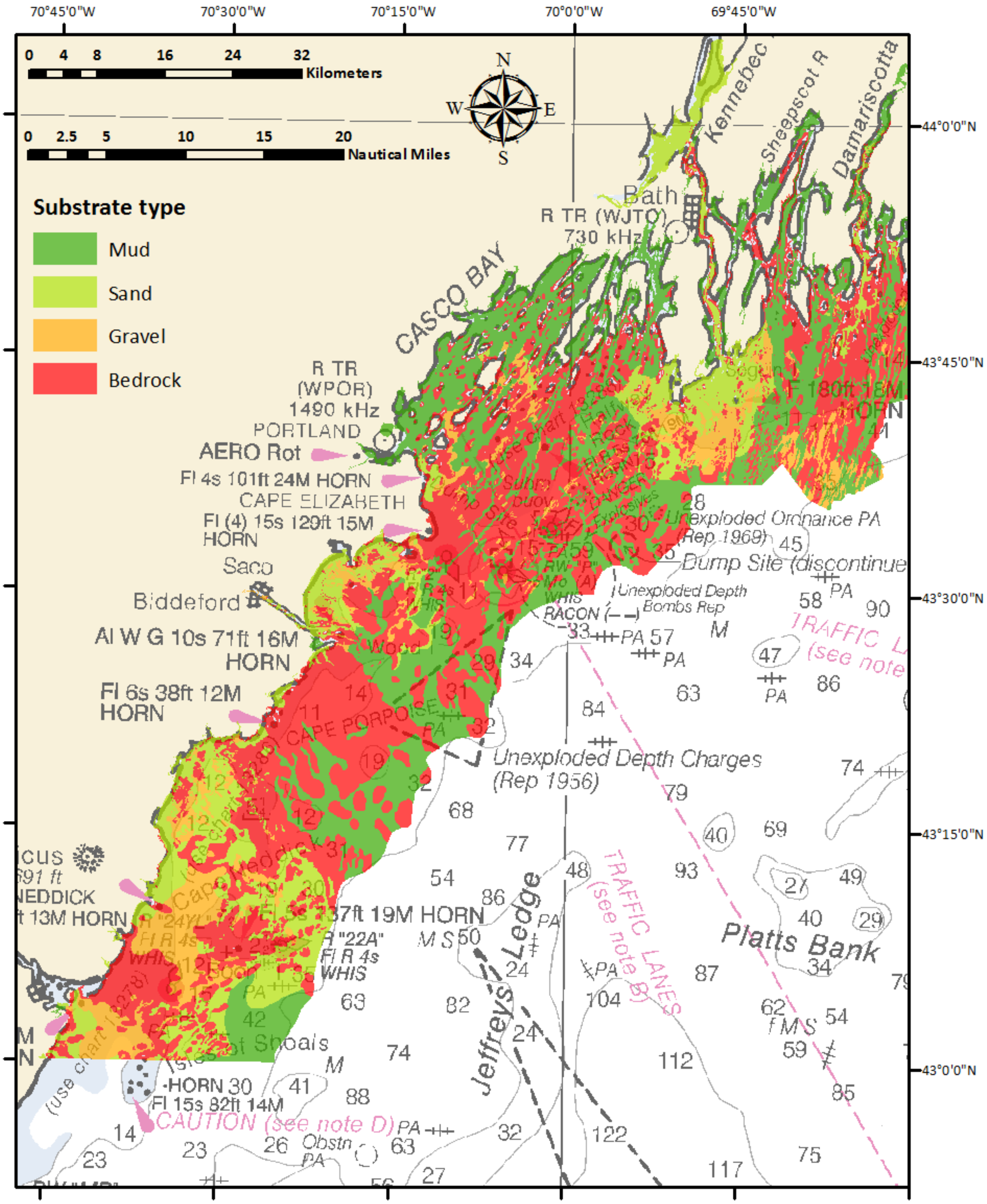
Map 5 – Sedimentary features of Stellwagen Bank. Source: US Geological Survey



WGS 1984 UTM Zone 19N projection; map updated October 1, 2013

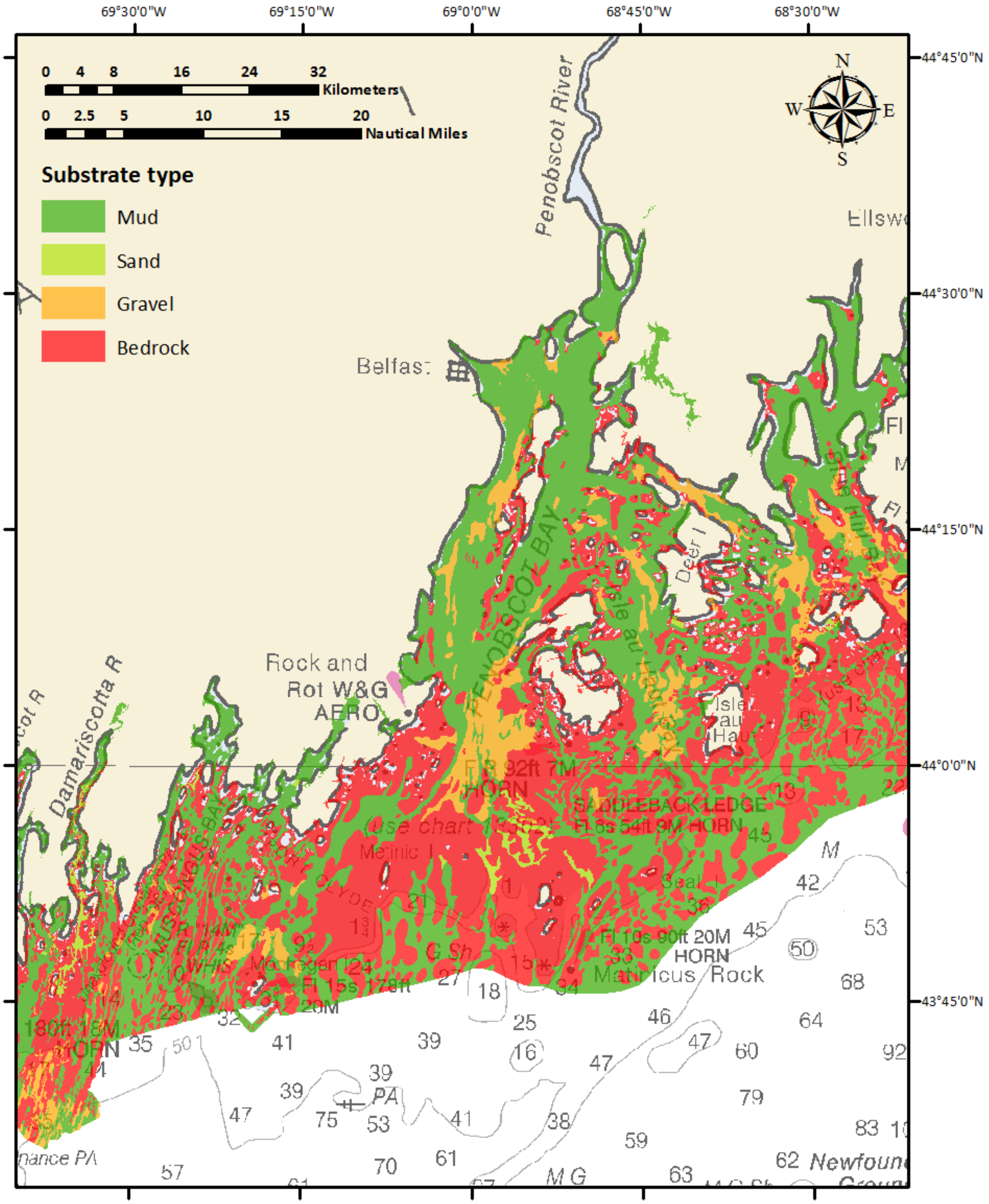
Coastal sediments exhibit a high degree of small-scale variability. Bedrock is the predominant substrate along the western edge of the GOM north of Cape Cod in a narrow band out to a depth of about 60 m. Rocky areas become less common with increasing depth, but some rock outcrops poke through the mud covering the deeper sea floor. On the inner continental shelf, mud is the second most common substrate, and it predominates in coastal valleys and basins that often abruptly border rocky substrates. Many of these basins extend without interruption into deeper water. Gravel, often mixed with shell, is common adjacent to bedrock outcrops and in fractures in the rock. Large expanses of gravel are not common, but do occur near reworked glacial moraines and in areas where the seabed has been scoured by bottom currents. Gravel and bedrock are most abundant at depths of 20-40 m, except in eastern Maine where a gravel-covered plain exists to depths of at least 100 m (and in some areas beyond 200 m, for example in western Jordan Basin and at Schoodic Ridges). Bottom currents are stronger in eastern Maine where the mean tidal range exceeds 5 m. Sandy areas are relatively rare along the inner shelf of the western GOM, but are more common south of Casco Bay, especially offshore of sandy beaches. The best sediment map of the inshore GOM is the Maine Bottom Type map developed by Barnhardt et al (1998). These sedimentary features to roughly 100 m depth were delineated using acoustic backscatter data. The four primary classifications, mud, sand, gravel, and rock, are shown in Map 6 (western Maine coast), Map 7 (central Maine coast), and Map 8 (eastern Maine coast).

Map 6 – Sediment type along the western Maine coast from the New Hampshire boundary to the Damariscotta River. Source: Barnhardt et al 1998.



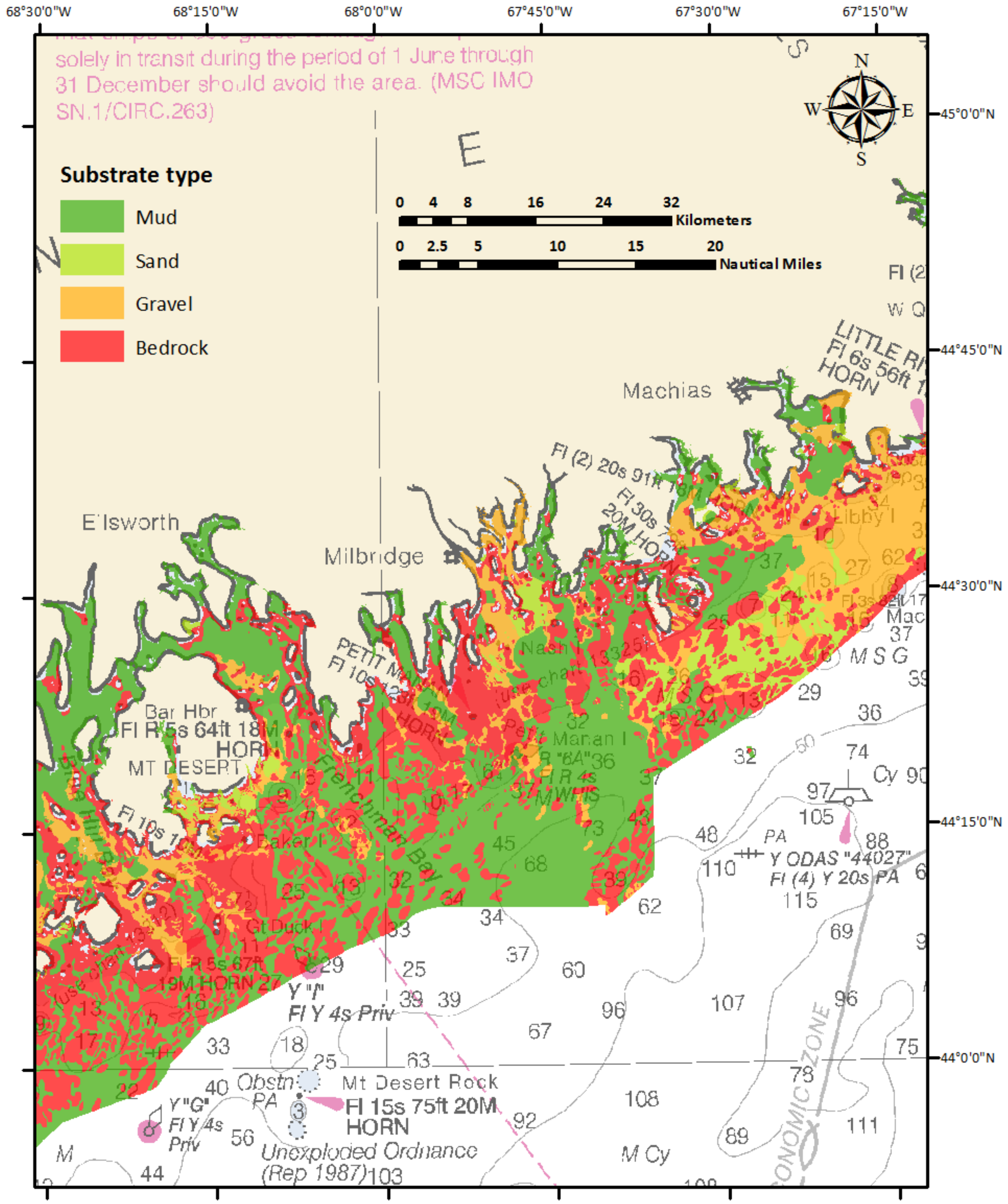
WGS 1984 UTM Zone 19N projection; map updated October 1, 2013

Map 7 – Sediment type along mid-coast Maine from the Damariscotta River to Blue Hill Bay. Source: Barnhardt et al 1998.



WGS 1984 UTM Zone 19N projection; map updated October 1, 2013

Map 8 – Sediment type along the eastern Maine coast from Blue Hill Bay to Machias. Source: Barnhardt et al 1998.



WGS 1984 UTM Zone 19N projection; map updated October 1, 2013

Oceanography

An intense seasonal cycle of winter cooling and turnover, springtime freshwater runoff, and summer warming influences oceanographic processes in the GOM (Map 9). The Gulf has a general counterclockwise non-tidal surface current that flows around its coastal margin. It is primarily driven by fresh, cold Scotian Shelf water that enters over the Scotian Shelf and through the Northeast Channel, and freshwater river runoff, which is particularly important in the spring. Dense, relatively warm, and saline slope water entering through the bottom of the Northeast Channel from the continental slope also influences gyre formation. Counterclockwise gyres generally form in Jordan, Wilkinson, and Georges Basins and the Northeast Channel as well. These surface gyres are more pronounced in spring and summer; in winter, they weaken and become more influenced by the wind.

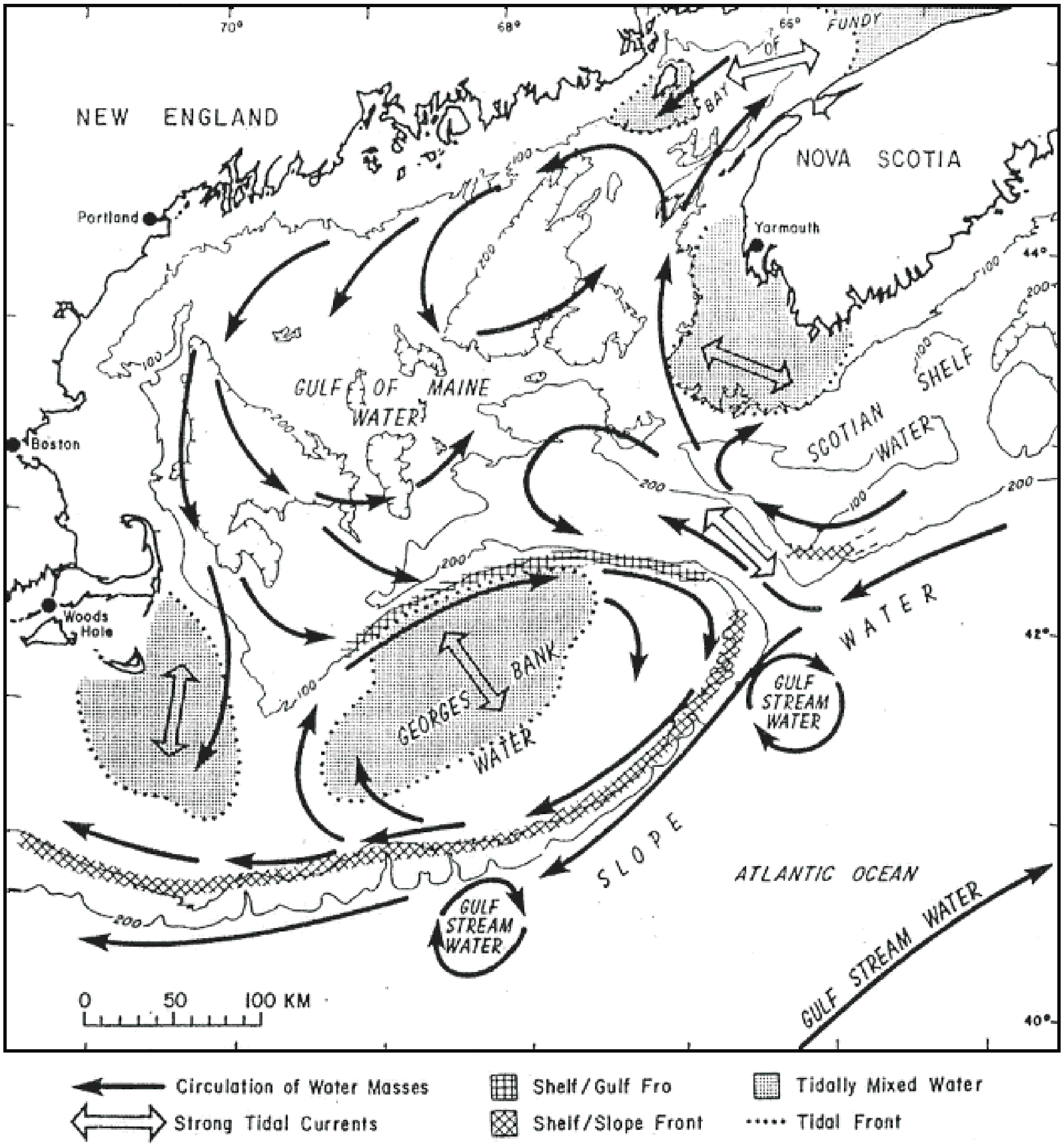
Stratification of surface waters during spring and summer seals off a mid-depth layer of water that preserves winter salinity and temperatures. This cold layer of water is called Maine Intermediate Water and is located between more saline Maine Bottom Water and the warmer, stratified Maine Surface Water. The stratified surface layer is most pronounced in the deep portions of the western GOM. Tidal mixing of shallow areas prevents thermal stratification and results in thermal fronts between the stratified areas and cooler mixed areas. Mixed areas include Georges Bank, the southwest Scotian Shelf, eastern Maine coastal waters, and the narrow coastal band surrounding the remainder of the Gulf.

The Northeast Channel provides an exit for cold Maine Intermediate Water and outgoing surface water while it allows warmer, more saline slope water to move in along the bottom and spill into the deeper basins. The influx of water occurs in pulses, and appears to be seasonal, with lower flow in late winter and a maximum flow in early summer.

GOM circulation and water properties can vary significantly from year to year. Notable episodic events include shelf-slope interactions such as the entrainment of shelf water by Gulf Stream rings, and strong winds that can create currents as high as 1.1 m/s over Georges Bank. Warm core Gulf Stream rings can influence upwelling and nutrient exchange on the Scotian shelf, and affect the water masses entering the GOM. Annual and seasonal inflow variations also affect water circulation.

Internal waves are episodic and can greatly affect the biological properties of certain habitats. Internal waves can shift water layers vertically, so that habitats normally surrounded by cold Maine Intermediate Water are temporarily bathed in warm, organic-rich, surface water. On Cashes Ledge, it is thought that deeper nutrient rich water is driven into the photic zone, providing for increased productivity. Localized areas of upwelling interaction occur in numerous places throughout the Gulf.

Map 9 – Circulation patterns in the Gulf of Maine/Georges Bank region.



Benthic invertebrates and fish

Based on 303 benthic grab samples collected in the GOM during 1956-1965, Theroux and Wigley (1998) reported that, in terms of numbers, the most common groups of benthic invertebrates in the GOM were annelid worms (35%), bivalve mollusks (33%), and amphipod crustaceans (14%). Biomass was dominated by bivalves (24%), sea cucumbers (22%), sand dollars (18%), annelids (12%), and sea anemones (9%). Watling (1998) used numerical classification techniques to separate benthic invertebrate samples into seven bottom assemblages (Map 10). Further, Watling and Skinder (2007) identified epi- and emergent-fauna from underwater video and used multivariate approaches to classify this fauna into groups based on depth and substrate, corresponding to water masses (Maine surface, intermediate and deep-water) and coarse gradations of sediments (mud, sand, gravel). This classification system considers predominant taxa, substrate types, and seawater properties.

(1) Comprises all sandy offshore banks, most prominently Jeffreys Ledge, Fippennies Ledge, and Platts Bank; depth on top of banks about 70 m; substrate usually coarse sand with some gravel; fauna characteristically sand dwellers with an abundant interstitial component.

(2) Comprises the rocky offshore ledges, such as Cashes Ledge, Sigsbee Ridge and Three Dory Ridge; substrate either rock ridge outcrop or very large boulders, often with a covering of very fine sediment; fauna predominantly sponges, tunicates, bryozoans, hydroids, and other hard bottom dwellers; overlying water usually cold Gulf of Maine Intermediate Water.

(3) Probably extends all along the coast of the Gulf of Maine in water depths less than 60 m; bottom waters warm in summer and cold in winter; fauna rich and diverse, primarily polychaetes and crustaceans, probably consists of several (sub-) assemblages due to heterogeneity of substrate and water conditions near shore and at mouths of bays.

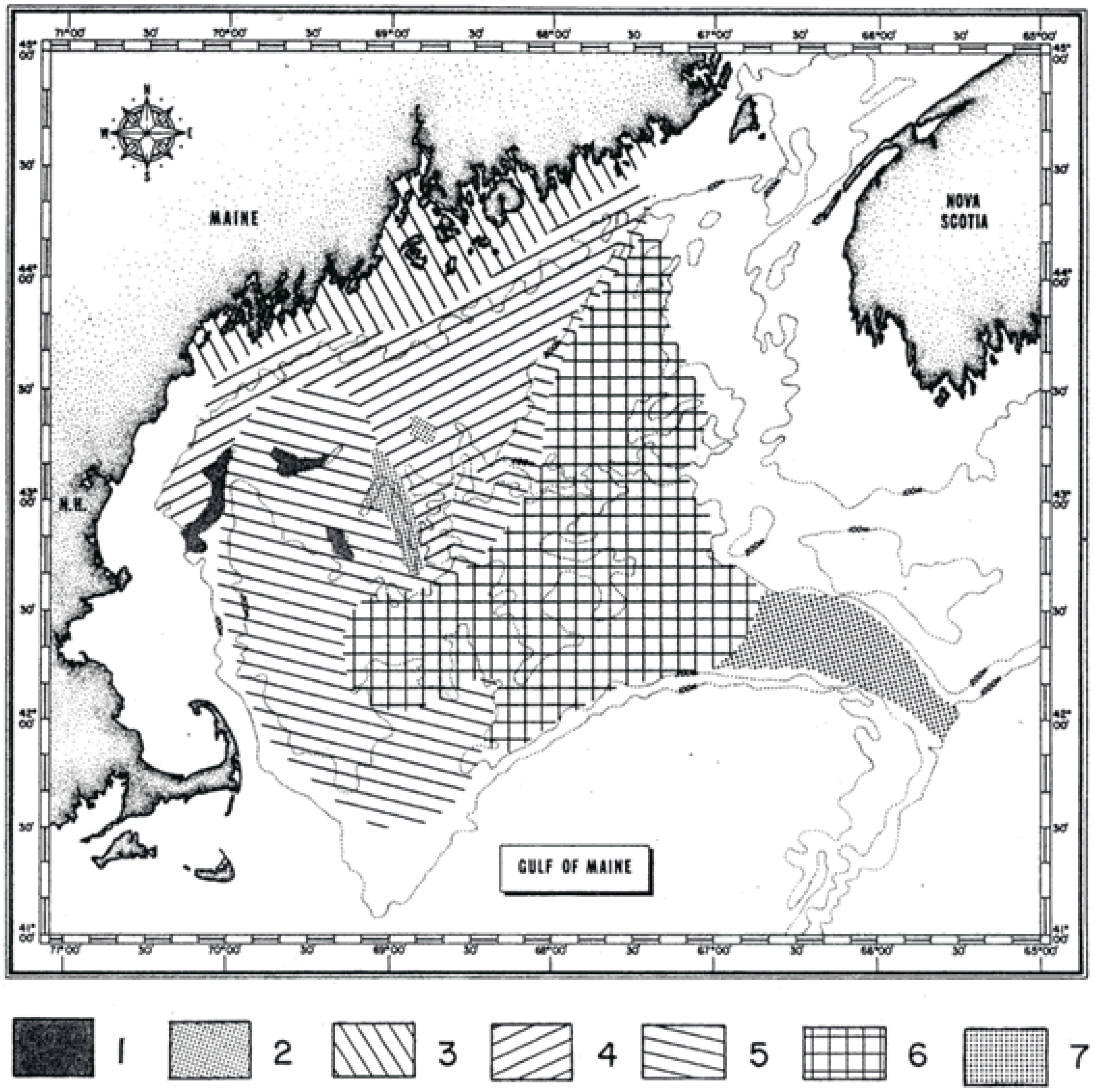
(4) Extends over the soft bottom at depths of 60 - 140 m, well within the cold Gulf of Maine Intermediate Water; bottom sediments primarily fine muds; fauna dominated by polychaetes, shrimp, and cerianthid anemones.

(5) A mixed assemblage comprising elements from the cold water fauna as well as a few deeper water species with broader temperature tolerances; overlying water often a mixture of Intermediate Water and Bottom Water, but generally colder than 7°C most of the year; fauna sparse, diversity low, dominated by a few polychaetes, with brittle stars, sea pens, shrimp, and cerianthids also present.

(6) Comprises the fauna of the deep basins; bottom sediments generally very fine muds, but may have a gravel component in the offshore morainal regions; overlying water usually 7 - 8°C, with little variation; fauna shows some bathyal affinities but densities are not high, dominated by brittle stars and sea pens, and sporadically by a tube-making amphipod.

(7) The true upper slope fauna that extends into the Northeast Channel; water temperatures are always above 8°C and salinities are at least 35 ppt; sediments may be either fine muds or a mixture of mud and gravel.

Map 10 – Seven major benthic assemblages of the Gulf of Maine. Source: Watling 1988, in Babb and De Luca, eds. Benthic Productivity and Marine Resources of the Gulf of Maine



Demersal fish assemblages for the GOM and Georges Bank were part of broad scale geographic investigations conducted by Gabriel (1992) and Mahon et al. (1998). Both these studies and more limited studies by Overholtz and Tyler (1985) and Auster (2002) found assemblages that were consistent over space and time in this region (Table 3 – Fish assemblages of Table 3). In her analysis, Gabriel (1992) found that the most persistent feature over time in assemblage structure from Nova Scotia to Cape Hatteras was the boundary separating assemblages between the GOM and Georges Bank, which occurred at approximately the 100 m isobath on northern Georges Bank. Overholtz and Tyler (1985) identified five assemblages for this region. The Gulf of Maine-deep assemblage included a number of species found in other assemblages, with the exception of American plaice and witch flounder, which was unique to this assemblage. Gabriel's approach did not allow species to co-occur in assemblages, and classified these two species as unique to the deepwater Gulf of Maine-Georges Bank assemblage. It is important to note that these analyses did not attempt to identify associations of these species with particular seafloor features/structures.

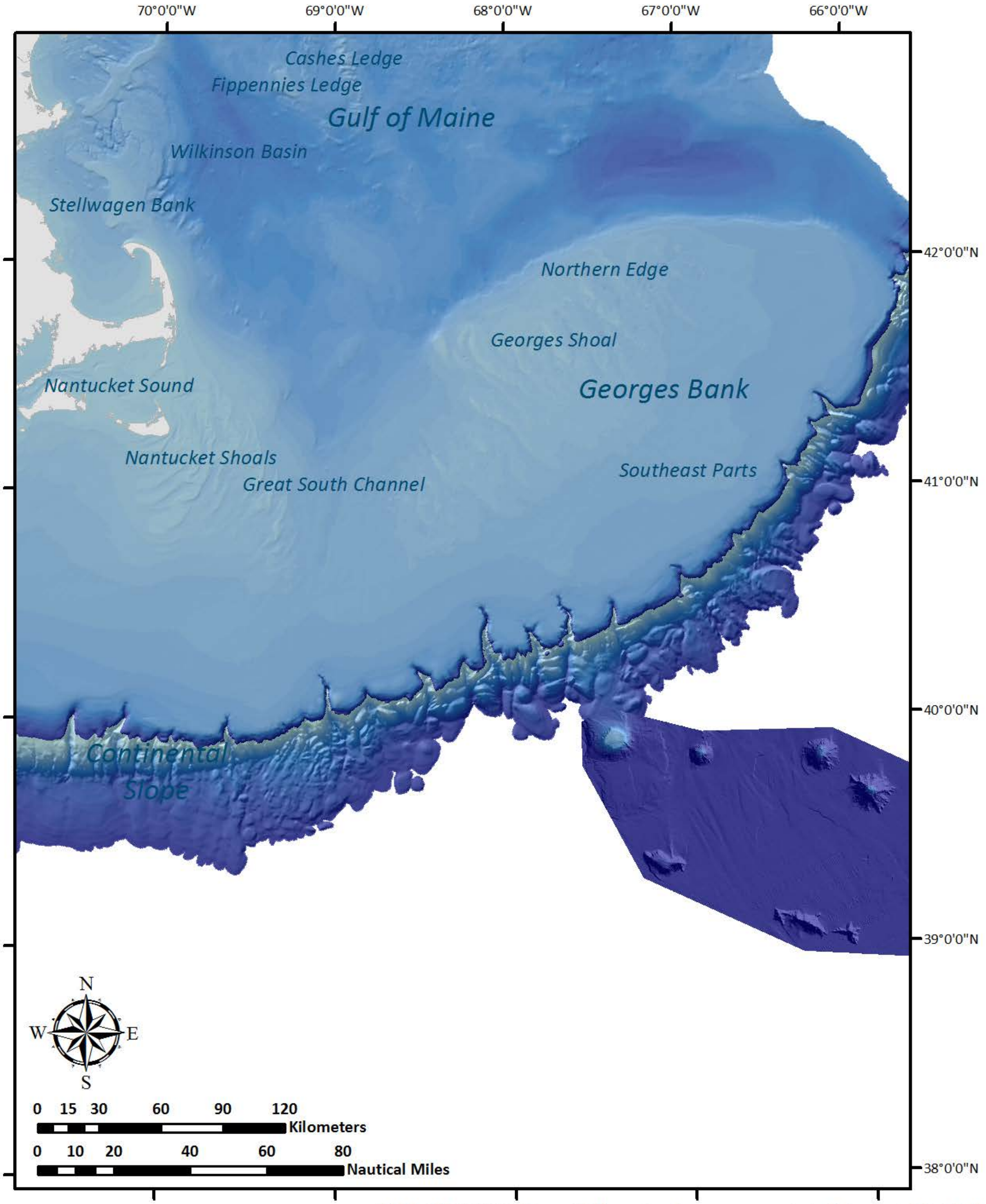
Table 3 – Fish assemblages of the Gulf of Maine and their associated species

Overholtz and Tyler (1985)		**Gabriel (1992)**	
Slope and Canyon	Offshore hake, blackbelly rosefish, Gulf stream flounder, fourspot flounder, monkfish, silver hake, white hake, red hake	Offshore hake, blackbelly rosefish, Gulf stream flounder, fawn cusk-eel, longfin hake, armored sea robin	***Deepwater***
Intermediate	Silver hake, red hake, monkfish, Atlantic cod, haddock, ocean pout, yellowtail flounder, winter skate, little skate, sea raven, longhorn sculpin	Silver hake, red hake, monkfish, northern shortfin squid, spiny dogfish, cusk	***Combination of Deepwater Gulf of Maine/Georges Bank and Gulf of Maine-Georges Bank Transition***
Shallow	Atlantic cod, haddock, pollock, silver hake, white hake, red hake, monkfish, ocean pout, yellowtail flounder, windowpane, winter flounder, winter skate, little skate, longhorn sculpin, summer flounder, sea raven, sand lance	Atlantic cod, haddock, pollock, yellowtail flounder, windowpane, winter flounder, winter skate, little skate, longhorn sculpin	***Gulf of Maine-Georges Bank Transition Zone and Shallow Water Georges Bank-Southern New England***
Gulf of Maine-Deep	White hake, American plaice, witch flounder, thorny skate, silver hake, Atlantic cod, haddock, cusk, Atlantic wolffish	White hake, American plaice, witch flounder, thorny skate, redfish	***Deepwater Gulf of Maine-Georges Bank***
Northeast Peak	Atlantic cod, haddock, pollock, ocean pout, winter flounder, white hake, thorny skate, longhorn sculpin	Atlantic cod, haddock, pollock	***Gulf of Maine-Georges Bank Transition Zone***

4.1.1.2 Georges Bank, Great South Channel and Nantucket Shoals

Georges Bank is a shallow, elongate extension of the continental shelf that was formed during the Wisconsinian glacial episode (Map 11). It is characterized by a steep slope on its northern edge and a broad, flat, gently sloping southern flank. The Great South Channel lies to the west. Bottom topography on eastern Georges Bank is characterized by linear ridges in the western shoal areas; a relatively smooth, gently dipping sea floor on the deeper, easternmost part; a highly energetic peak in the north with sand ridges up to 30 m high; and steeper and smoother topography incised by submarine canyons on the southeastern margin (see the "Continental Slope" section, below, for more on canyons).

Map 11 – Bathymetric features of Georges Bank and the adjacent continental slope, including the New England seamount chain.



WGS 1984 UTM Zone 19N projection; map updated August 30, 2013

Oceanography

Oceanographic frontal systems separate water masses of the Gulf of Maine and Georges Bank from oceanic waters south of the bank. These water masses differ in temperature, salinity, nutrient concentration, and planktonic communities, which influence productivity and may influence fish abundance and distribution. Currents on Georges Bank include a weak, persistent clockwise gyre around the Bank, a strong semidiurnal tidal flow predominantly northwest and southeast, and very strong, intermittent storm induced currents, which all can occur simultaneously. Tidal currents over the shallow top of Georges Bank can be very strong, and keep the waters over the Bank well mixed vertically. This results in a tidal front that separates the cool waters of the well mixed shallows of the central Bank from the warmer, seasonally stratified shelf waters on the seaward and shoreward sides of the Bank. The clockwise gyre is instrumental in distribution of plankton, including fish eggs and larvae, and the strong, erosive currents affect the character of the biological community.

Bathymetric and sedimentary features

Map 12 depicts dominant sediment types on the bank mapped as an unstructured or Voronoi grid, where polygon size reflects data density.

Northeastern Georges Bank is composed of a series of parallel northwest-southeast trending sand waves with intervening troughs of coarser gravel (granule-pebble and cobble) substrate. There are also some areas dominated by boulders (diameter >10 inches). Strong tidal currents constantly move the sand back and forth and the shallower portions of the bank are also periodically affected by wave action, particularly during winter storms. The coarser gravel substrate is much more stable and provides a more suitable substrate for attached epifaunal organisms (e.g., sponges, bryozoans). Using substrate data derived from systematic video camera surveys of the bank (Harris and Stokesbury 2010, upper panel Map 13) and model estimates of maximum tidal current velocities at the bottom (Chen et al. 2003, 2011, and Cowles et al. 2008), Harris et al (2012) calculated spatially-explicit sediment stability indices for Georges Bank (lower panel Map 13). On the flanks of the bank between 60 and 100 m, where the tidal currents are weaker, sediment movement is less frequent and transport is primarily associated with strong winter storms. The sediment here is somewhat finer than on the crest of the bank and the seafloor is largely featureless.

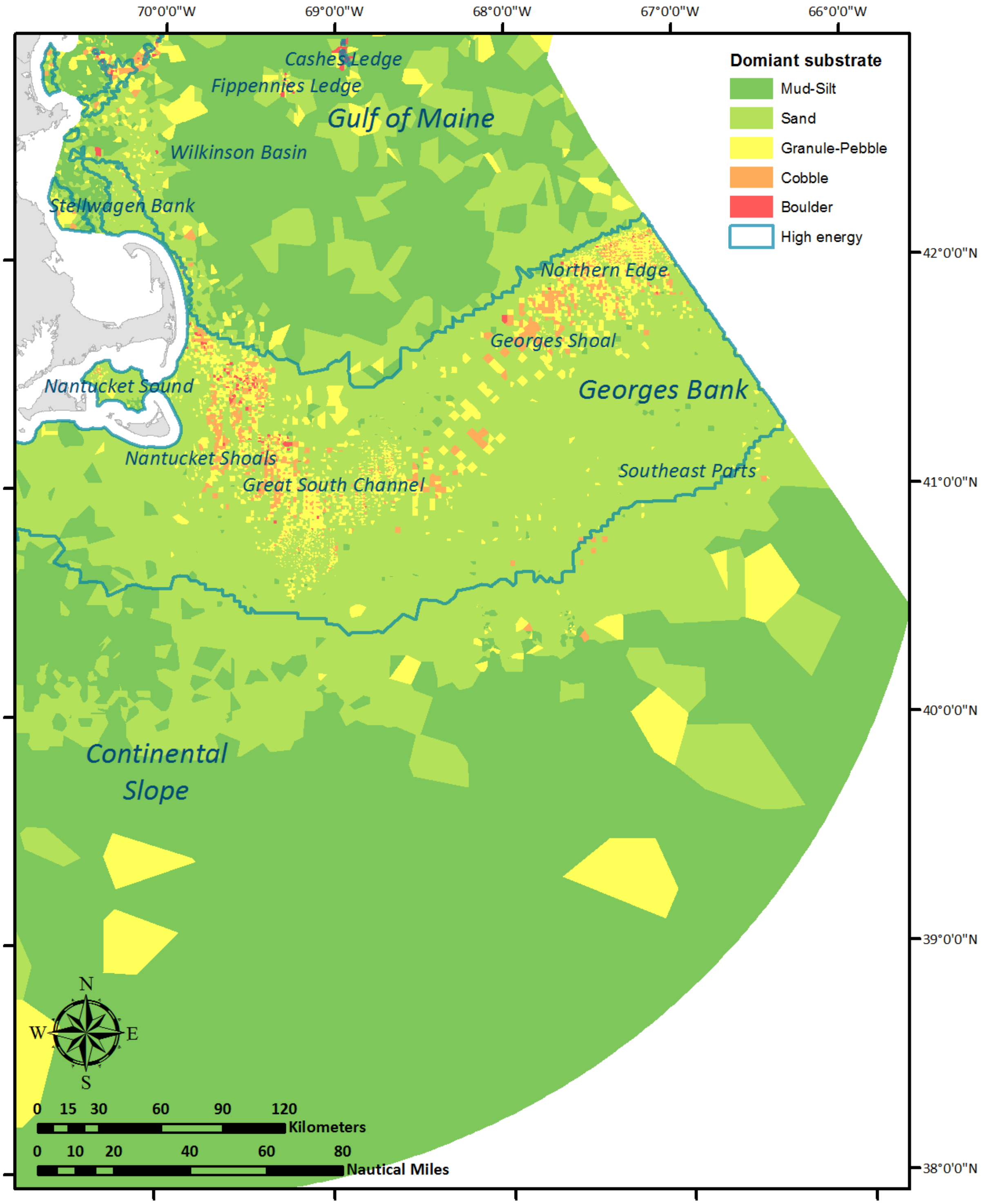
The central region of the Bank is shallow, and the bottom is characterized by shoals and troughs, with sand dunes superimposed upon them. The two most prominent elevations on the ridge and trough area are Cultivator and Georges Shoals. This shoal and trough area is a region of strong currents, with average flood and ebb tidal currents greater than 4 km/h, and as high as 7 km/h. The dunes migrate at variable rates, and the ridges may also move. In an area that lies between the central part and Northeast Peak, Almeida et al. (2000) identified high-energy areas as between 35 - 65 m deep, where sand is transported on a daily basis by tidal currents, and a low-energy area at depths > 65 m that is affected only by storm currents.

The Great South Channel separates the main part of Georges Bank from Nantucket Shoals. Just east of the Great South Channel, the depth is approximately 50-70 m with dominant sand, granule-pebble, cobble, and boulder substrates, transitioning to deeper water and mud substrates in the Channel. Strong southward-flowing tidal and residual currents on the western side of this area have produced 5-15 m high sand waves that run east and west with steeper slopes on their southern sides (Richard Taylor, personal communication). Critical bottom shear stress values ranging from >2 to <0.5 indicate that the coarser sediments are stable under typical tidal currents whereas the finer sediments are not stable. Bottom disturbance can be significant during episodic storms.

Further to the west, Nantucket Shoals is similar in nature to the central region of the Bank. Currents in these areas are strongest where water depth is shallower than 50 m. This type of travelling dune and swale morphology is also found in the Mid-Atlantic Bight, and further described in section 4.1.1.3. Sediments in this region include gravel pavement and mounds, some scattered boulders, sand with storm generated ripples, and scattered shell and mussel beds. Tidal and storm currents range from moderate to strong, depending upon location and storm activity (Valentine, pers. comm.). Sediment mobility thresholds on Nantucket Shoals are exceeded over 50% of the time (annually) due to the combined effects of currents and wave action (Dalyander et al. 2013).

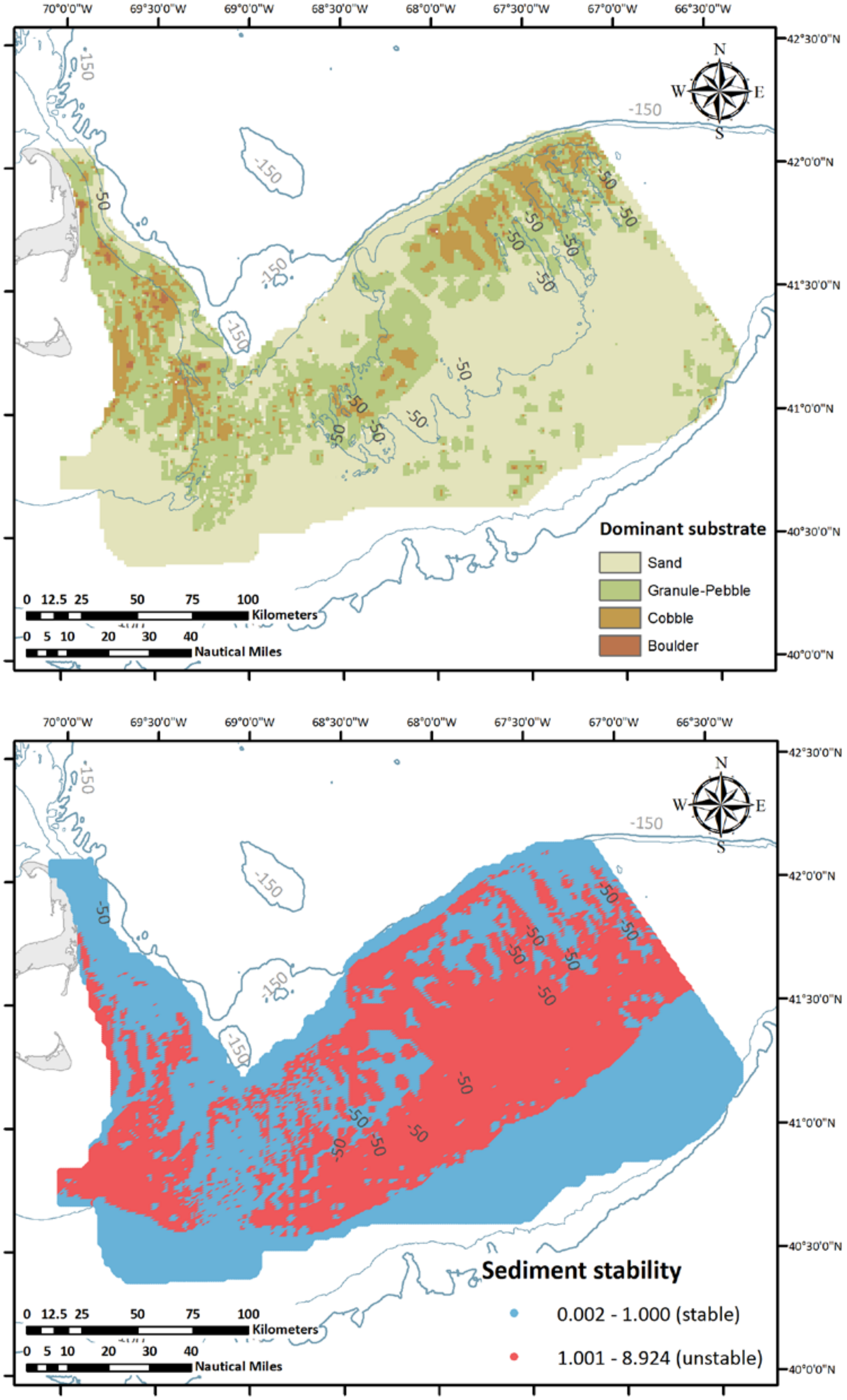
The benthic environment south of Cape Cod is less dynamic. Bottom contours trend east-west with depths increasing from 20-30 m to over 100 m near the shelf break. Sediments in this area are dominated by sand, mixed to varying degrees with silt. Critical shear stress at the bottom resulting from current and wave action in the region was evaluated by Dalyander et al. (2013) using a different methodology than Harris and Stokesbury (2012) used for Georges Bank. Their results clearly show how tidal currents diminish in intensity west of Nantucket Shoals and are replaced by wave action as the primary source of sediment suspension and transport in the Mid-Atlantic region. The effect of waves is much greater in the winter due to the action of winter storms.

Map 12 – Sedimentary features of Georges Bank



WGS 1984 UTM Zone 19N projection; map updated August 30, 2013

Map 13 – Dominant sediment (Harris and Stokesbury 2010) and sediment stability (Harris et al 2012). Depth contours in meters.



Benthic invertebrates and fish

Amphipod crustaceans (49%) and annelid worms (28%) numerically dominated the contents of 211 samples collected on Georges Bank during 1956-1965 (Theroux and Wigley 1998). Biomass was dominated by sand dollars (50%) and bivalves (33%). Glacial retreat during the late Pleistocene deposited the bottom sediments currently observed on the eastern section of Georges Bank. The interaction of several environmental factors, including availability and type of sediment, current speed and direction, and bottom topography, has formed seven sedimentary provinces on eastern Georges Bank (Map 14 and Table 4). Theroux and Grosslein (1987) utilized the Theroux and Wigley database to identify four macrobenthic invertebrate assemblages on the bank (Table 4), noting that the boundaries between assemblages were not well defined because there is considerable intergrading between adjacent assemblages.

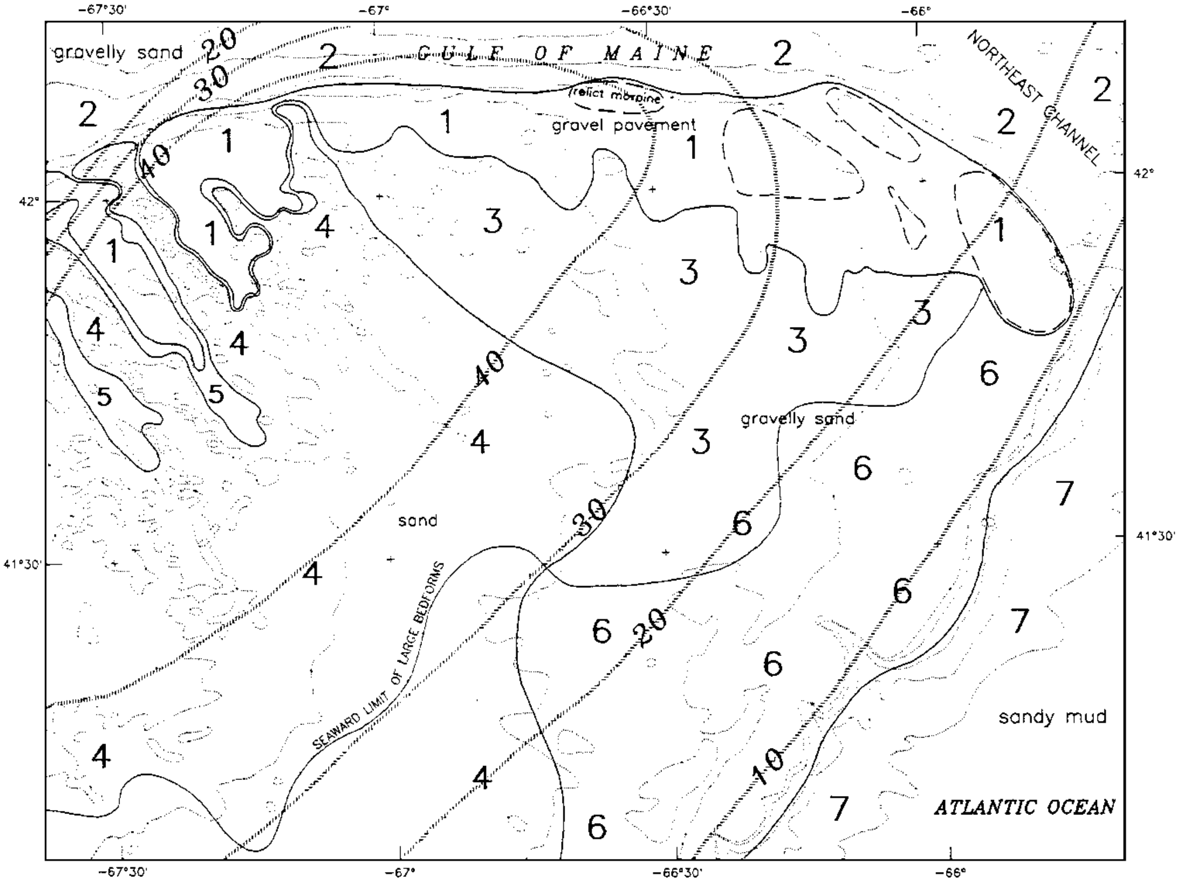
Along with high levels of primary productivity and a diverse and abundant benthic invertebrate fauna, Georges Bank has been historically characterized by high levels of fish production. Several studies have attempted to identify demersal fish assemblages over large spatial scales. Overholtz and Tyler (1985) found five depth related groundfish assemblages for Georges Bank and the GOM that were persistent temporally and spatially. Depth and salinity were identified as major physical influences explaining assemblage structure. Gabriel (1992) identified six assemblages, which are compared with the results of Overholtz and Tyler (1985) in Table 3. Mahon et al. (1998) found similar results. As noted in the Gulf of Maine section, these fish assemblage studies do not attempt to associate individual species with particular seafloor features/structures.

Table 4 – Sedimentary provinces and benthic assemblages of Georges Bank. Sources: Valentine and Lough (1991) and Theroux and Grosslein (1987).

Sedimentary province	Depth (m)	Description	Benthic assemblage
Northern Edge / Northeast Peak (1)	40 - 200	Dominated by gravel with portions of sand, common boulder areas, and tightly packed pebbles. Representative epifauna (bryozoa, hydrozoa, anemones, and calcareous worm tubes) are abundant in areas of boulders. Strong tidal and storm currents.	The Northeast Peak assemblage is found along the Northern Edge and Northeast Peak, which varies in depth and current strength and includes coarse sediments, consisting mainly of gravel and coarse sand with interspersed boulders, cobbles, and pebbles. Fauna tend to be sessile (coelenterates, brachiopods, barnacles, and tubiferous annelids) or free-living (brittle stars, crustaceans, and polychaetes), with a characteristic absence of burrowing forms.
Northern Slope and Northeast Channel (2)	200 - 240	Variable sediment type (gravel, gravel-sand, and sand) scattered bedforms. This is a transition zone between the northern edge and southern slope. Strong tidal and storm currents.	
North /Central Shelf (3)	60 - 120	Highly variable sediment type (ranging from gravel to sand) with rippled sand, large bedforms, and patchy gravel lag deposits. Minimal epifauna on gravel due to sand movement. Representative epifauna in sand areas includes amphipods, sand dollars, and burrowing anemones.	The Central Georges Bank assemblage occupies the greatest area, including the central and northern portions of the Bank in depths less than 100 m. Medium grained shifting sands predominate this dynamic area of strong currents. Organisms tend to be small to moderately large with burrowing or motile habits.
Central and	10 - 80	Dominated by sand (fine and medium	

Southwestern Shelf - shoal ridges (4)		grain) with large sand ridges, dunes, waves, and ripples. Small bedforms in southern part. Minimal epifauna on gravel due to sand movement. Representative epifauna in sand areas includes amphipods, sand dollars, and burrowing anemones.	
Central and Southwestern Shelf - shoal troughs (5)	40 - 60	Gravel (including gravel lag) and gravel-sand between large sand ridges. Patchy large bedforms. Strong currents. (Few samples – submersible observation noted presence of gravel lag, rippled gravel-sand, and large bedforms.) Minimal epifauna on gravel due to sand movement. Representative epifauna in sand areas includes amphipods, sand dollars, and burrowing anemones.	
Southeastern Shelf (6)	80 - 200	Rippled gravel-sand (medium and fine grained sand) with patchy large bedforms and gravel lag. Weaker currents; ripples are formed by intermittent storm currents. Representative epifauna includes sponges attached to shell fragments and amphipods.	The Southern Georges Bank assemblage is found on the southern and southwestern flanks at depths from 80 - 200 m, where fine grained sands and moderate currents predominate. Many southern species exist here at the northern limits of their range.
Southeastern Slope (7)	400 - 2000	Dominated by silt and clay with portions of sand (medium and fine) with rippled sand on shallow slope and smooth silt-sand deeper.	None
Western Basin			The Western Basin assemblage is found in the upper Great South Channel region at the northwestern corner of the Bank, in comparatively deepwater (150 - 200 m) with relatively slow currents and fine bottom sediments of silt, clay and muddy sand. Fauna are comprised mainly of small burrowing detritivores and deposit feeders, and carnivorous scavengers.

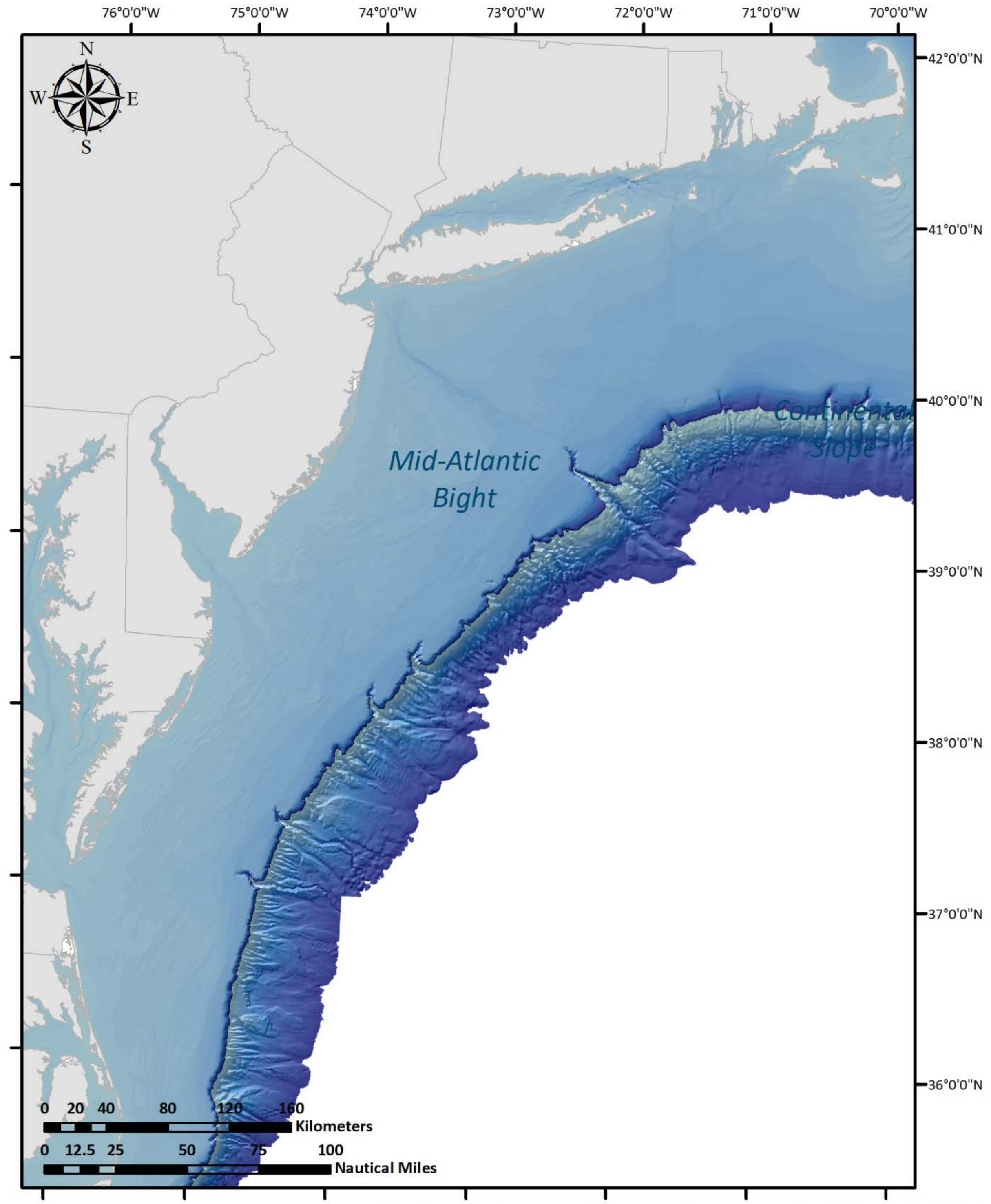
Map 14 – Sedimentary provinces of eastern Georges Bank. Based sea floor morphology, texture, sediment movement and bedforms, and mean tidal bottom current speed (cm/s). Relict moraines (bouldery seafloor) are enclosed by dashed lines. Source: Valentine and Lough (1991).



4.1.1.3 Mid-Atlantic Bight

The Mid-Atlantic Bight (Map 15) is comprised of the sandy, relatively flat, gently sloping continental shelf from southern New England to Cape Hatteras, NC. Like the rest of the continental shelf, the topography of the Mid-Atlantic Bight was shaped largely by sea level fluctuations caused by past ice ages. The shelf's basic morphology and sediments derive from the retreat of the last ice sheet, and the subsequent rise in sea level. Since that time, currents and waves have modified this basic structure.

Map 15 – Bathymetric features of the Mid-Atlantic Bight



WGS 1984 UTM Zone 19N projection; map updated August 22, 2013

Oceanography

Shelf and slope waters of the Mid-Atlantic Bight have a slow southwestward flow that is occasionally interrupted by warm core rings or meanders from the Gulf Stream. On average, shelf water moves parallel to bathymetry isobars at speeds of 5-10 cm/s at the surface and 2 cm/s or less at the bottom. Storm events can cause much more energetic variations in flow. Tidal currents on the inner shelf have a higher flow rate of 20 cm/s that increases to 100 cm/s near inlets.

Seasonal temperature variation is more pronounced in shallower, nearshore waters. Stratification of the water column occurs over the shelf and the top layer of slope water during the spring-summer and is usually established by early June. Fall mixing results in homogenous shelf and upper slope waters by October in most years. A permanent thermocline exists in slope waters from 200-600 m deep. Temperatures decrease at the rate of about 0.02ºC per meter and remain relatively constant except for occasional incursions of Gulf stream eddies or meanders. Below 600 m, temperature declines, and usually averages about 2.2ºC at 4000 m. A warm, mixed layer approximately 40 m thick resides above the permanent thermocline.

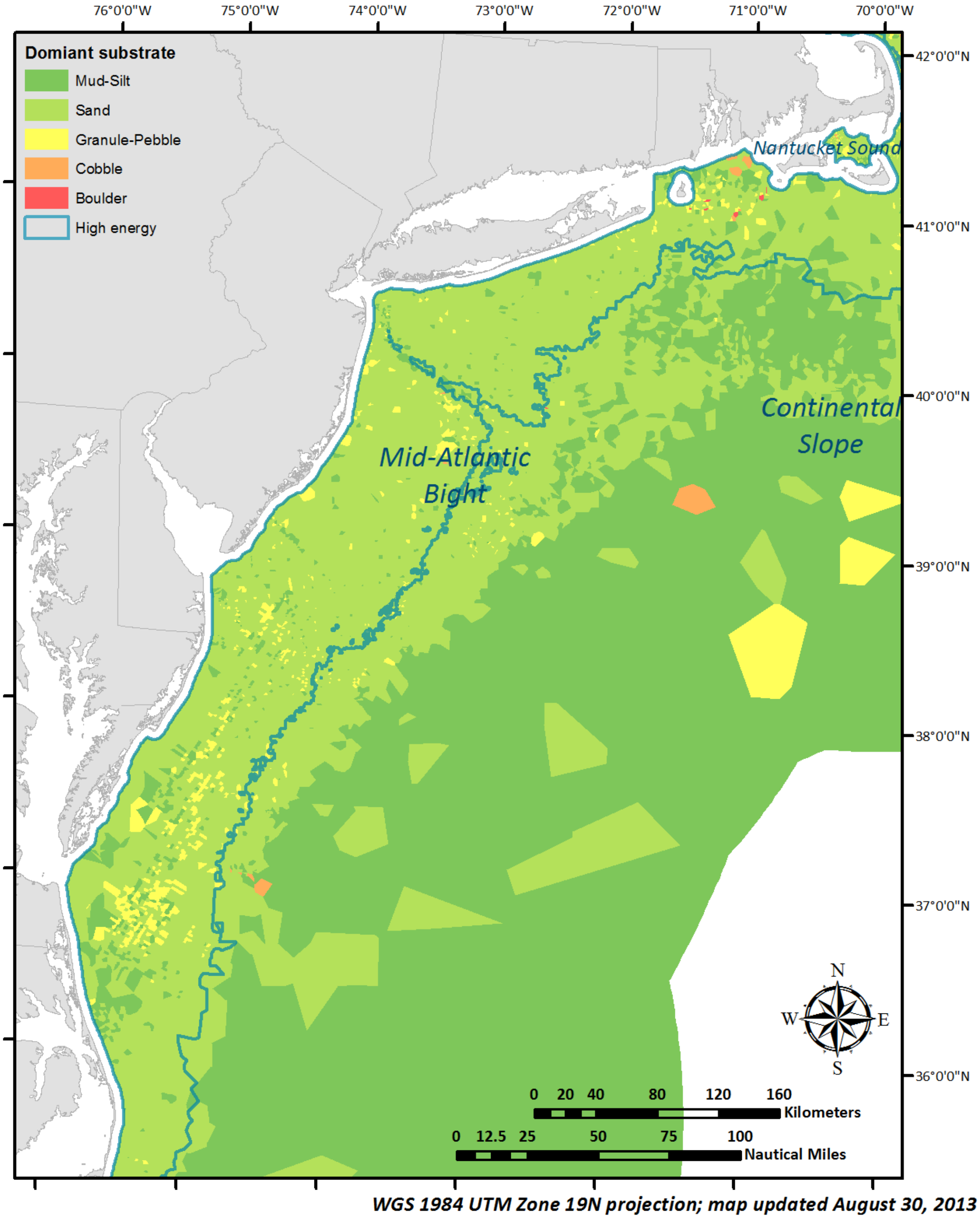
The “cold pool” is an annual phenomenon particularly important to the Mid-Atlantic Bight. It stretches from the Gulf of Maine along the outer edge of Georges Bank and then southwest to Cape Hatteras. It becomes identifiable with the onset of thermal stratification in the spring and lasts into early fall until normal seasonal mixing occurs. It usually exists along the bottom between the 40 and 100 m isobaths and extends up into the water column for about 35 m, to the bottom of the seasonal thermocline. The cold pool usually represents about 30% of the volume of shelf water. Minimum temperatures for the cold pool occur in early spring and summer, and range from 1.1-4.7ºC.

Sedimentary features

The predominant sediment type covering most of the shelf in the Mid-Atlantic Bight is sand, with some relatively small, localized areas of sand-shell and sand-gravel (Map 16). From a broad scale perspective, sediments are uniformly distributed over the shelf in this region. A sheet of sand and gravel varying in thickness from 0-10 m covers most of the shelf. The mean bottom flow from the constant southwesterly current is not fast enough to move sand, so sediment transport must be episodic. Net sediment movement is in the same southwesterly direction as the current. The sands are mostly medium to coarse grains, with finer sand in the Hudson Shelf Valley and on the outer shelf.

Mud is rare over most of the shelf, but is common in the Hudson Shelf Valley. In addition, an area known as the mud patch is located just southwest of Nantucket Shoals and southeast of Long Island and Rhode Island. Tidal currents in this area slow significantly, which allows silts and clays to settle out. The mud is mixed with sand, and is occasionally resuspended by large storms. This habitat is an anomaly of the outer continental shelf. Occasionally relic estuarine mud deposits are re-exposed in the swales between sand ridges. Fine sediment content increases rapidly at the shelf break, which is sometimes called the “mud line”, and sediments transition to 70-100% fines on the slope.

Map 16 – Sedimentary features of the Mid-Atlantic Bight



WGS 1984 UTM Zone 19N projection; map updated August 30, 2013

The primary morphological features of the shelf include shelf valleys and channels, shoal massifs, scarps, and sand ridges and swales. Most of these structures are relic except for some sand ridges and smaller sand-formed features. Submarine canyons (described further in section 4.1.1.4) were formed by rivers of glacial outwash that deposited sediments on the outer shelf edge as they entered the ocean. Most canyons cut about 10 km into the shelf, with the exception of the Hudson Canyon that incises the shelf about 35 km. The valleys were partially filled as the glacier melted and retreated across the shelf. The glacier also left behind a lengthy scarp near the shelf break from Chesapeake Bay north to the eastern end of Long Island. Shoal retreat massifs were produced by extensive deposition at a cape or estuary mouth. Massifs were also formed as estuaries retreated across the shelf.

Some sand ridges are more modern in origin than the shelf's glaciated morphology. Their formation is not well understood; however, they appear to develop from the sediments that erode from the shore face. They maintain their shape, so it is assumed that they are in equilibrium with modern current and storm regimes. They are usually grouped, with heights of about 10 m, lengths of 10 - 50 km and spacing of 2 km. Ridges are usually oriented at a slight angle towards shore, running in length from northeast to southwest. The seaward face usually has the steepest slope. Sand ridges are often covered with smaller similar forms such as sand waves, megaripples, and ripples. Swales occur between sand ridges. Since ridges are higher than the adjacent swales, they are exposed to more energy from water currents, and experience more sediment mobility than swales. Ridges tend to contain less fine sand, silt and clay while relatively sheltered swales contain more of the finer particles. Swales have greater benthic macrofaunal density, species richness and biomass, due in part to the increased abundance of detrital food and the physically less rigorous conditions.

Sand waves are usually found in patches of 5-10 with heights of about 2 m, lengths of 50-100 m and 1-2 km between patches. Sand waves are primarily found on the inner shelf, and often observed on sides of sand ridges. They may remain intact over several seasons. Megaripples occur on sand waves or separately on the inner or central shelf. During the winter storm season, they may cover as much as 15% of the inner shelf. They tend to form in large patches and usually have lengths of 3-5 m with heights of 0.5-1 m. Megaripples tend to survive for less than a season. They can form during a storm and reshape the upper 50 - 100 cm of the sediments within a few hours. Ripples are also found everywhere on the shelf, and appear or disappear within hours or days, depending upon storms and currents. Ripples usually have lengths of about 1-150 cm and heights of a few centimeters.

Artificial reefs are a significant Mid-Atlantic habitat, formed much more recently on the geologic time scale than other regional habitat types. These localized areas of hard structure have been formed by shipwrecks, lost cargoes, disposed solid materials, shoreline jetties and groins, submerged pipelines, cables, and other materials (Steimle and Zetlin 2000). While only some of these materials have been deposited specifically for use as fish habitat, all have become an integral part of the coastal and shelf ecosystem. It is expected that the increase in these materials has had an impact on living marine resources and fisheries, but these effects are not well known. In general, reefs are important for attachment sites, shelter, and food for many species, and fish predators such as tunas may be attracted by prey aggregations, or may be behaviorally attracted to the reef structure. The overview by Steimle and Zetlin (2000) used NOAA hydrographic surveys to plot rocks, wrecks, obstructions, and artificial reefs, which together were considered a fairly complete list of non-biogenic reef habitat in the Mid-Atlantic estuarine and coastal areas.

Benthic invertebrates and fish

Wigley and Theroux (1981) reported on the faunal composition of 563 bottom grab samples collected in the Mid-Atlantic Bight during 1956-1965. Amphipod crustaceans and bivalve mollusks accounted for most of the individuals (41% and 22%, respectively), whereas mollusks dominated the biomass (70%). Three broad faunal zones related to water depth and sediment type were identified by Pratt (1973). The “sand fauna” zone was defined for sandy sediments (1% or less silt) that are at least occasionally disturbed by waves, from shore out to 50 m. The “silty-sand fauna” zone occurred immediately offshore from the sand fauna zone, in stable sands containing a small amount of silt and organic material. Silts and clays become predominant at the shelf break and line the Hudson Shelf Valley, and support the “silt-clay fauna”.

Building on Pratt’s work, the Mid-Atlantic shelf was further divided by Boesch (1979) into seven bathymetric/morphologic subdivisions based on faunal assemblages. Sediments in the region studied (Hudson Shelf Valley south to Chesapeake Bay) were dominated by sand with few finer materials. Ridges and swales are important morphological features in this area. Sediments are coarser on the ridges, and the swales have greater benthic macrofaunal density, species richness, and biomass. Faunal species composition differed between these features, and Boesch (1979) incorporated this variation in his subdivisions. Much overlap of species distributions was found between depth zones, so the faunal assemblages represented more of a continuum than distinct zones.

Table 5 – Mid-Atlantic habitat types. As described by Pratt (1973) and Boesch (1979) with characteristic macrofauna as identified in Boesch (1979).

Habitat Type [after Boesch (1979)]	**Description**		
	Depth (m)	**Characterization [Pratt (1973) faunal zone]**	**Characteristic benthic macrofauna**
Inner shelf	0 - 30	characterized by coarse sands with finer sands off MD and VA (sand zone)	Polychaetes: *Polygordius, Goniadella, Spiophanes*
Central shelf	30 - 50	(sand zone)	Polychaetes: *Spiophanes, Goniadella,* Amphipod: *Pseudunciola*
Central and inner shelf swales	0 - 50	occurs in swales between sand ridges (sand zone)	*Polychaetes: Spiophanes, Lumbrineris, Polygordius*
Outer shelf	50 - 100	(silty sand zone)	Amphipods: *Ampelisca vadorum, Erichthonius* Polychaetes: *Spiophanes*
Outer shelf swales	50 - 100	occurs in swales between sand ridges (silty sand zone)	Amphipods: *Ampelisca agassizi, Unciola, Erichthonius*
Shelf break	100 - 200	(silt-clay zone)	not given
Continental slope	> 200	(none)	not given

Demersal fish assemblages were described at a broad geographic scale for the continental shelf and slope from Cape Chidley, Labrador to Cape Hatteras, North Carolina (Mahon et al.1998) and from Nova Scotia to Cape Hatteras (Gabriel 1992). Factors influencing species distribution included latitude and depth. Results of these studies were similar to an earlier study confined to the Mid-Atlantic Bight continental shelf (Colvocoresses and Musick 1984). In this study, there were clear variations in species abundances, yet they demonstrated consistent patterns of community composition and distribution among demersal fishes of the Mid-Atlantic shelf. This is especially true for five strongly recurring species associations that varied slightly by season (Table 4). The boundaries between fish assemblages generally followed isotherms and isobaths. The assemblages were largely similar between the spring and fall collections, with the most notable change being a northward and shoreward shift in the temperate group in the spring. As noted in the previous Gulf of Maine and Georges Bank sections, these fish assemblage studies did not attempt to associate species with specific seabed features/structures.

Table 6 – Major recurrent demersal finfish assemblages of the Mid-Atlantic Bight during spring and fall. Source: Colvocoresses and Musick (1984).

Season	**Species Assemblage**				
	Boreal	**Warm temperate**	**Inner shelf**	**Outer shelf**	**Slope**
Spring	Atlantic cod, little skate, sea raven, monkfish, winter flounder, longhorn sculpin, ocean pout, silver hake, red hake, white hake, spiny dogfish	Black sea bass, summer flounder, Butterfish, scup, spotted hake, northern searobin	Windowpane	Fourspot flounder	Shortnose greeneye, offshore hake, blackbelly rosefish, white hake
Fall	White hake, silver hake, red hake, monkfish, longhorn sculpin, winter flounder, yellowtail flounder, witch flounder, little skate, spiny dogfish	Black sea bass, summer flounder, butterfish, scup, spotted hake, northern searobin, smooth dogfish	Windowpane	Fourspot flounder, fawn cusk eel, gulf stream flounder	Shortnose greeneye, offshore hake, blackbelly rosefish, white hake, witch flounder

4.1.1.4 Continental slope, canyons and seamounts

The shelf slopes gently from shore out to between 100 and 200 km offshore where it transforms to the slope at the shelf break (100-200 m water depth), continuing eastward with increasing depth until it becomes the continental rise, and finally the abyssal plain. The width of the slope varies from 10-50 km, with an average gradient of 3-6°; however, local gradients can be nearly vertical. The base of the slope is defined by a marked decrease in seafloor gradient where the continental rise begins. The slope is cut by at least 70 large canyons between Georges Bank and Cape Hatteras and numerous smaller canyons and gullies, many of which may feed into the larger canyon systems. Volcanically-derived underwater mountains called seamounts emerge from the abyssal plain. The New England Seamount Chain including Bear, Mytilus, and Balanus Seamounts occurs on the slope southwest of Georges Bank. Two smaller isolated seamounts to the west (i.e., Caryn, Knauss) occur in deeper water. The canyon and seamount features are shown on Map 11 and Map 15.

Oceanography

Slope water tends to be warmer than shelf water because of its proximity to the Gulf Stream, and tends to be more saline. The abrupt gradient where these two water masses meet is called the shelf-slope front. This front is usually located at the edge of the shelf and touches bottom at about 75-100 m, and then slopes up to the east toward the surface. It reaches surface waters approximately 25-55 km further offshore. The position of the front is highly variable, and can be influenced by many physical factors. Vertical structure of temperature and salinity within the front can develop complex patterns because of the interleaving of shelf and slope waters; e.g., cold shelf waters can protrude offshore, or warmer slope water can intrude up onto the shelf.

The water masses of the Atlantic continental slope and rise are essentially the same as those of the North American Basin (defined in Wright and Worthington (1970)). Worthington (1976) divided the water column of the slope into three vertical layers: deepwater (colder than 4°C), the thermocline (4-17°C), and surface water (warmer than 17°C). In the North American Basin, deepwater accounts for two-thirds of all the water, the thermocline for about one-quarter, and surface water the remainder. In the slope water north of Cape Hatteras, the only warm water occurs in the Gulf Stream and in seasonally influenced summer waters.

The principal cold water mass in the region is the North Atlantic Deep Water. North Atlantic Deep Water is comprised of a mixture of five sources: Antarctic Bottom Water, Labrador Sea Water, Mediterranean Water, Denmark Strait Overflow Water, and Iceland-Scotland Overflow Water.

The thermocline represents a straightforward water mass compared with either the deepwater or the surface water. Nearly 90% of all thermocline water comes from the water mass called the Western North Atlantic Water. This water mass is slightly less saline northeast of Cape Hatteras due to the influx of southward flowing Labrador Coastal Water. Seasonal variability in slope waters penetrates only the upper 200 m of the water column.

In the winter months, cold temperatures and storm activity create a well-mixed layer down to about 100-150 m, but summer warming creates a seasonal thermocline overlain by a surface layer of low density water. The seasonal thermocline, in combination with reduced storm activity in the summer, inhibits vertical mixing and reduces the upward transfer of nutrients into the photic zone.

Two currents found on the slope, the Gulf Stream and Western Boundary Undercurrent, together represent one of the strongest low frequency horizontal flow systems in the world. Both currents have an important influence on slope waters. Warm and cold core rings that spin off the Gulf Stream are a persistent and ubiquitous feature of the northwest Atlantic Ocean. The Western Boundary Undercurrent flows to the southwest along the lower slope and continental rise in a stream about 50 km wide. The boundary current is associated with the spread of North Atlantic

Deep Water, and it forms part of the generally westward flow found in slope water. North of Cape Hatteras it crosses under the Gulf Stream in a manner not yet completely understood.

Shelf and slope waters of the northeast region are intermittently affected by the Gulf Stream. The Gulf Stream begins in the Gulf of Mexico and flows northeastward at an approximate rate of 1 m/s (2 knots), transporting warm waters north along the eastern coast of the United States, and then east towards the British Isles. Conditions and flow of the Gulf Stream are highly variable on time scales ranging from days to seasons. Intrusions from the Gulf Stream constitute the principal source of variability in slope waters off the northeastern shelf.

The location of the Gulf Stream's shoreward, western boundary is variable because of meanders and eddies. Gulf Stream eddies are formed when extended meanders enclose a parcel of seawater and pinch off. These eddies can be cyclonic, meaning they rotate counterclockwise and have a cold core formed by enclosed slope water (cold core ring), or anticyclonic, meaning they rotate clockwise and have a warm core of Sargasso Sea water (warm core ring). The rings are shaped like a funnel, wider at the top and narrower at the bottom, and can have depths of over 2000 m. They range in size from approximately 150-230 km in diameter. There are 35% more rings and meanders near Georges Bank than in the Mid-Atlantic region. A net transfer of water on and off the shelf may result from the interaction of rings and shelf waters. These warm or cold core rings maintain their identity for several months until they are reabsorbed by the Gulf Stream. The rings and the Gulf Stream itself have a great influence over oceanographic conditions all along the continental shelf.

Sedimentary features

On the slope, silty sand, silt, and clay predominate. A "mud line" occurs on the slope at a depth of 250-300 m, below which fine silt and clay-size particles predominate. Localized coarse sediments and rock outcrops are found in and near canyon walls, and occasional boulders occur on the slope because of glacial rafting. Sand pockets may also be formed because of downslope movements. The morphology of the present continental slope appears largely to be a result of sedimentary processes that occurred during the Pleistocene, including, 1) slope upbuilding and progradation by deltaic sedimentation principally during sea-level low stands; 2) canyon cutting by sediment mass movements during and following sea-level low stands; and 3) sediment slumping.

Gravity induced downslope movement is the dominant sedimentary process on the slope, and includes slumps, slides, debris flows, and turbidity currents, in order from thick cohesive movement to relatively nonviscous flow. Slumps may involve localized, short, down-slope movements by blocks of sediment. However, turbidity currents can transport sediments thousands of kilometers.

Submarine canyons are not spaced evenly along the slope, but tend to decrease in areas of increasing slope gradient. Canyons are typically "v" shaped in cross section and often have steep walls and outcroppings of bedrock and clay. The canyons are continuous from the canyon heads to the base of the continental slope. Some canyons end at the base of the slope, but others continue as channels onto the continental rise. Larger and more deeply incised canyons are generally significantly older than smaller ones, and there is evidence that some older canyons have experienced several episodes of filling and re-excavation. Many, if not all, submarine canyons may first form by mass-wasting processes on the continental slope, although there is evidence that some canyons were formed because of fluvial drainage (e.g., Hudson Canyon). Canyons form by erosion of the sediments and sedimentary rocks of the continental margin. They can be classed as high or low relief. Canyons with high relief that are deeply eroded into the continental margin may be U-shaped or V-shaped. Erosion by glaciers produces U-shaped canyons. These include canyons in Canadian waters in the glacially-eroded Northeast Channel that separates Georges Bank and the Scotian Shelf. These U-shaped canyons contain the following sediment types:

- Glacial gravel (boulders, cobbles, pebbles) that was transported onto canyon rims, walls, and floors by glaciers and floating ice
- Gravel (boulders, cobbles, pebbles) that was transported into canyons by glaciers and floating ice
- Outcropping rocks exposed on canyon walls
- Rock rubble on canyon walls and floor from rock falls

Erosion by rivers, mass wasting, and turbidity currents produces V-shaped canyons. These include the Georges Bank canyons on the bank’s southern margin. These canyons did not experience direct glacial erosion because the glaciers terminated on the bank’s northern margin. These V-shaped canyons contain the following sediment types:

- Gravel in canyons that was transported by floating ice
- Outcropping rocks exposed on canyon walls
- Rock rubble on canyon walls and floor from rock falls
- Stiff Pleistocene clay exposed on canyon walls; burrowed by crabs and fish to form “pueblo villages”; burrowed clay can collapse to form rubble on canyon walls and floors
- Veneer of modern sediment partly covering canyon walls
- Modern sediment covering canyon floors
- Modern sand transported onto the canyon floor from the shelf can be formed into bedforms by strong tidal currents in some canyons

Canyons shallowly eroded into the continental margin are produced by erosion/mass wasting events such as slumping or landslides. These shallow canyons are found on the shelf edge and upper slope of the southern margin of Georges Bank. Shallow canyons are less likely than deep canyons to have a well-defined canyon axis and floor, and because their walls are not steep, they are less likely than deep canyons to have outcropping rocks. They may contain the following sediment types:

- Gravel in canyons that was transported by floating ice
- Veneer of modern sediment covering canyon walls

Inter-canyon areas on the southern margin of Georges Bank are gently sloping seabed between canyons on the continental slope. They are characterized by both erosional (mass wasting) and depositional processes. Sediment types include:

- Gravel that was transported by floating ice
- Modern sediment

Note that the inter-canyon slope area south of Hudson Canyon is regionally unique and distinct from the Georges Bank areas in that in contains limestone outcrops.

The continental shelf edge (shelf-slope break) represents a transition from a gently sloping shelf (1-2 degrees) to a somewhat steeper continental slope (3-6) degrees and from coarser-grained shelf sediment to finer-grained upper slope sediment. Sediment types include:

- Modern sediment
- Gravel that was transported by floating ice
- Pebble gravel substrate in areas where sandy sediment has been eroded.

Canyons can alter the physical processes in the surrounding slope waters. Fluctuations in the velocities of the surface and internal tides can be large near the heads of the canyons, leading to enhanced mixing and sediment transport in the area. Shepard et al. (1979) concluded that the strong turbidity currents initiated in study canyons were responsible for enough sediment erosion and transport to maintain and modify those canyons. Since surface and internal tides are ubiquitous over the continental shelf and slope, it can be anticipated that these fluctuations are important for sedimentation processes in other canyons as well. In Lydonia Canyon, Butman et al. (1982) found that the dominant source of low frequency current variability was related to passage of warm core Gulf Stream rings rather than the atmospheric events that predominate on the shelf.

Benthic invertebrates and fish

Polychaete annelids represent the most important slope faunal group in terms of numbers of individuals and species (Wiebe et al. 1987). Ophiuroids (brittle stars) are considered to be among the most abundant slope organisms, but this group is comprised of relatively few species. The taxonomic group with the highest species diversity is the peracarid crustaceans (which includes amphipods, cumaceans, and isopods). Some species of the slope are widely distributed, while others appear to be restricted to particular ocean basins. The ophiuroids and bivalves appear to have the broadest distributions, while the peracarid crustaceans appear to be highly restricted because they brood their young, and lack a planktonic stage of development. In general, gastropods do not appear to be very abundant; however, past studies are inconclusive since they have not collected enough individuals for large-scale community and population studies.

In general, slope inhabiting benthic organisms are strongly zoned by depth and/or water temperature, although these patterns are modified by the presence of topography, including canyons, channels, and current zonations (Hecker 1990). Moreover, at depths of less than 800 m, the fauna is extremely variable and the relationships between faunal distribution and substrate, depth, and geography are less obvious (Wiebe et al. 1987). Fauna occupying hard surface sediments are not as dense as in comparable shallow water habitats (Wiebe et al. 1987), but there is an increase in species diversity from the shelf to the intermediate depths of the slope. Diversity then declines again in the deeper waters of the continental rise and plain. Hecker (1990) identified four megafaunal zones on the slope of Georges Bank and southern New England (Table 7).

Table 7 – Faunal zones of the continental slope of Georges Bank and Southern New England. Source: Hecker 1990.

Zone	Approximate Depth (m)	Gradient	Current	Fauna
Upper Slope	300 - 700	Low	Strong	Dense filter feeders; Scleratinians (*Dasmosmilia lymani, Flabellum alabastrum*), quill worm (*Hyalinoecia*)
Upper Middle Slope	500 - 1300	High	Moderate	Sparse scavengers; red crab (*Chaceon quinqueidens*), long-nosed eel (*Synaphobranchus*), common grenadier (*Nezumia*). Alcyonarians (*Acanella arbuscula*, *Eunephthya florida*) in areas of hard substrate
Lower Middle Slope/Transition	1200 - 1700	High	Moderate	Sparse suspension feeders; cerianthids, sea pens (*Distichoptilum gracile*)
Lower Slope	> 1600	Low	Strong	Dense suspension and deposit feeders; ophiurid (*Ophiomusium lymani*), cerianthids, sea pens

One group of organisms of interest because of the additional structure they can provide for habitat and their potential long life span are the Alcyonarian soft corals. Soft corals can be bush or treelike in shape; species found in this form attach to hard substrates such as rock outcrops or gravel. These species can range in size from a few millimeters to several meters, and the trunk diameter of large specimens can exceed 10 cm. Other Alcyonarians found in this region include sea pens and sea pansies (Order Pennatulacea), which are found in a wider range of substrate types.

As opposed to most slope environments, canyons may develop a lush epifauna. Hecker et al. (1983) found faunal differences between the canyons and slope environments. Hecker and Blechschmidt (1979) suggested that faunal differences were due at least in part to increased environmental heterogeneity in the canyons, including greater substrate variability and nutrient enrichment. Hecker et al. (1983) found highly patchy faunal assemblages in the canyons, and also found additional faunal groups located in the canyons, particularly on hard substrates, that do not appear to occur in other slope environments. Canyons are also thought to serve as nursery areas for a number of species (Cooper et al. 1987; Hecker 2001).

Most finfish identified as slope inhabitants on a broad spatial scale (Colvocoresses and Musick 1984, Overholtz and Tyler 1985, Gabriel 1992) are associated with canyon features as well (Cooper et al. 1987). Finfish identified by broad studies that were not included in Cooper et al. (1987) include offshore hake, fawn cusk-eel, longfin hake, witch flounder, and armored searobin. Canyon species (Cooper et al. 1987) that were not discussed in the broad scale studies include squirrel hake, conger eel, and tilefish. Cusk and ocean pout were identified by Cooper et al. (1987) as canyon species, but classified in other habitats by the broad scale studies.

Table 8 – Habitat types and faunal assemblages of the Georges Bank Canyons. Faunal characterization is for depths < 230 m only. Source: Cooper et al 1987.

Habitat Type	Geologic Description	Canyon Locations	Most Commonly Observed Fauna
I	Sand or semiconsolidated silt substrate (claylike consistency) with less than 5% overlay of gravel. Relatively featureless except for conical sediment mounds.	Walls and axis	Cerianthid, pandalid shrimp, white colonial anemone, Jonah crab, starfishes, portunid crab, greeneye, brittle stars, mosaic worm, red hake, fourspot flounder, shellless hermit crab, silver hake, gulf stream flounder
II	Sand or semiconsolidated silt substrate (claylike consistency) with more than 5% overlay of gravel. Relatively featureless.	Walls	Cerianthids, galatheid crab, squirrel hake, white colonial anemone, Jonah crab, silver hake, sea stars, ocean pout, brittle stars, shellless hermit crab, greeneye
III	Sand or semiconsolidated silt (claylike consistency) overlain by siltstone outcrops and talus up to boulder size. Featured bottom with erosion by animals and scouring.	Walls	White colonial anemone, pandalid shrimp, cleaner shrimp, rock anemone, white hake, sea stars, ocean pout, conger eel, brittle stars, Jonah crab, lobster, blackbelly rosefish, galatheid crab, mosaic worm, tilefish
IV	Consolidated silt substrate, heavily burrowed/excavated. Slope generally more than 5º and less than 50º. Termed "pueblo village" habitat.	Walls	Sea stars, blackbelly rosefish, Jonah crab, lobster, white hake, cusk, ocean pout, cleaner shrimp, conger eel, tilefish, galatheid crab, shellless hermit crab
V	Sand dune substrate.	Axis	Sea stars, white hake, Jonah crab, monkfish

4.1.2 Linkages between habitat and fishery productivity

Information relating managed species of fish to the habitats they occupy and the functional value of those habitats in enhancing resource productivity is crucial in order to identify habitat management measures that will minimize the adverse effects of fishing to the extent practicable. The productivity of an exploited resource population is a function of recruitment, the process by which younger age groups that are below harvestable size are added to the population, and growth. Natural processes that increase the number of small fish that reach a size at which they enter, or recruit to, the exploited population and/or the rate at which they reach the size at recruitment, build stock biomass and enable higher catches. Mortality caused by natural processes reduces the numbers and biomass of fish that can be harvested. Recruitment is affected by a number of factors, including the number and sizes of spawning fish, the feeding success of young fish, predation, and environmental variables such as temperature and the availability of suitable habitat that affect the survival of eggs, larvae, and pre-recruit age groups of fish (i.e., for shelter from predators, from currents, and for access to prey).

Because it is affected by so many factors, it is very difficult to quantify the link between recruitment and habitat protection. There are many cases in which large year classes of fish are produced and sustain exploited populations for years once they reach harvestable sizes without any clear explanation as to what processes caused such high survival of the early life history stages (e.g. the 2003 year class of haddock in the GB-GOM region). However, because recruitment is a function of growth and survival, information that demonstrates that the survival and/or growth rates of juvenile fish are higher in certain habitat types serves to identify habitats that would benefit from conservation measures designed to minimize the adverse effects of fishing. If recruitment rates increase as a result of habitat protection measures implemented in this amendment, the productivity of managed species with life stages that rely heavily on benthic habitat for their survival and growth can be expected to increase.

There are a number of studies demonstrating the importance of complex bottom habitats in providing optimum conditions that enhance the survival of recently-settled and older juvenile fish. Complex, highly-structured benthic habitats are relatively rare in continental shelf waters and are used by many species to reduce predation risk and provide food (Caddy 2008, 2013). If suitable habitats are limited, or if the abundance of juveniles that rely on these critical habitats exceeds the amount of suitable habitat that is available, ecological “bottlenecks” to recruitment are created. Fishing gears and practices that reduce the quality and quantity of suitable habitat for these species can be expected to reduce recruitment rates and stock productivity.

Atlantic cod have been the subject of a considerable amount of research in the Northwest Atlantic aimed at defining the affinity of different life stages with complex bottom habitats and the effect of habitat type on growth and survival, particularly for the younger age groups. Several studies in U.S. and Canadian waters have shown that cod move into deeper water as they grow (refs). A number of field studies conducted in shallow water show that survival rates of juvenile cod were higher in more structured habitats (e.g., in vegetation or rocky reefs and on cobble bottoms) where they find refuge from predators (Linehan et al. 2001, Tupper and Boutilier 1995). In one of these studies, growth rates were also higher in vegetated habitats. Laboratory experiments performed in habitat types of varying complexity with and without predators present have confirmed that juvenile cod, especially young-of-the-year juveniles, survive better in more structured habitats where they are less susceptible to predation (Lindholm et al. 1999, Borg et al. 1997, Gotceitas et al and other refs). Lindholm et al. (2001) used a dynamic model to link patterns in habitat-mediated survivorship of post-settlement juvenile cod with spatial variations in habitat complexity. Model results demonstrated that patterns in the relationship between juvenile cod survivorship and density as well as movement rate were similar regardless of the density-dependent nature of predation, that juvenile cod movement rates and post-settlement density were critical for predicting the effects of marine protected-area size on survivorship, and that habitat change caused by fishing had significant negative effects on juvenile cod survivorship.

In deeper water, Lough et al. (1989) used a submersible and trawl survey data to show that recently-settled cod and haddock were found primarily on a large pebble-gravel deposit in the northeastern edge of Georges Bank at depths of 70-100 meters. They hypothesized that the gravel habitat (inclusive of the epifaunal invertebrates that provided cover) favors their survival through predator avoidance and may be essential to the recruitment success of the Georges Bank gadid population. In a follow-up paper, Lough (2010) used 1986 and 1987 estimates of pelagic juvenile abundance to estimate settlement mortality rates of 3 to 8% per day. Because the juveniles were much more abundant in 1987 than in 1986, but recruitment at age 1 in both years was similar, he concluded that the mortality of demersal juveniles was much higher in 1987 and that the limited gravel on the northern edge of the bank area may represent a survival bottleneck.

Evidence that complex habitats enhance the survival of juvenile fish in other habitat types is provided by research done in sandy bottom habitats in the Mid-Atlantic Bight. Here, structure is provided by bedforms (sand waves) of varying heights and biogenic structure such as animal tubes, shell and shell aggregation, or pits created by various species (Steves and Cowen 2000, Sullivan et al. 2000). Similar habitat types exist on Georges Bank and in southern New England and in areas of sandy sediment in the Gulf of Maine (Auster et al. 1995, 1998, Langton et al. 1995). Diaz et al. (2003) found more fish associated with larger bedforms that had some biogenic structure. Proximity of complex and simple habitats was important in providing refuge from predators in more complex habitats during the day and foraging opportunities in simpler habitats at night. Such diel patterns of habitat use would be expected to enhance survival and growth. Scharf et al. (2006) exposed prey species of fish (winter flounder, scup, and black sea bass) to predation in habitats of varying complexity in the laboratory and showed that survival increased with greater habitat complexity (bare sand, shell, and sponge). Significant species/habitat interactions implied that the impact of reduced seafloor complexity may be more severe for some species than for others.

4.1.3 Seabed vulnerability

Although both seafloor and water column aspects of habitat are important in determining fish distributions, the focus of the vulnerability assessment is seabed features since fishing activities do not substantively alter the water column. Seabed vulnerability to fishing gear impacts was evaluated using the Swept Area Seabed Impact (SASI) approach. SASI was developed by the Council's Habitat Plan Development Team to assist them in evaluating adverse effects across FMPs, developing measures to minimize those effects, and analyzing the impacts of those measures. This section summarizes some of the conclusions of the SASI analysis, specifically the spatial distribution of vulnerability by area and across gear types. Appendix D details the SASI approach. The approach was approved by the SSC and a peer-review panel convened specifically to assess the validity of using the SASI approach for these purposes.

The SASI approach consists of a vulnerability assessment and a spatial model. The vulnerability assessment reviewed the habitat impacts literature relevant to Northeast US fishing gears and seabed types, and created a framework for organizing and generating susceptibility and recovery values for seabed features based on a scale of relative differences for use in the SASI model. Next, a seafloor substrate map was created. Two data sources were used to develop the substrate map: a video survey conduted by the University of Massachusetts Dartmouth School for Marine Science and Technology, and the usSEABED database compiled by the United States Geological Survey, which consists mainly of grab samples and focuses on mud, sand, and granule-pebble grain sizes only. The substrate classification follows Wentworth (1922) (Table 9). In order to map substrate across the entire domain, a Voronoi tessellation method was used. This method draws lines equidistant between sample points and creates nodes where multiple lines intersect, creating the Voronoi polygons. This results in polygons around each sampling point in which all the space in that polygon is closer to one substrate sampling point than to any other sampling point. All of that space is given the same substrate classification as the sampling point, and in this way the substrate of the whole domain was interpolated and mapped. Voronoi cells are smaller where data points are closely spaced and larger where data points are far apart. Seafloor energy was classified as either high or low energy based on model estimates of flow rate at the seabed or according to depth in locations where flow estimates were unavailable (less than 0.194 $N{\cdot}m^{-2}$ flow or deeper than 60 meters was low energy). The substrate grids are shown in Map 4

(GOM), Map 12 (GB), and Map 16 (MAB). The energy assessment is more fully described in section 7.2 of Appendix D.

Table 9 – Substrate model classes (mud-boulder) and corresponding grain size range

Mud	< 0.0039-0.0625 mm
Sand	0.0625-2 mm
Granule-pebble	2-64 mm
Cobble	64 – 256 mm
Boulder	> 256 mm

Various seabed features such as sand waves or sponges were inferred to occur in particular substrate-energy types. Then the seabed features were given susceptibility and recovery scores according to the nature of the fishing gear impact (i.e. the type of gear). The initial effect of the gear (susceptibility) and the recovery duration were scored on a scale of zero to three (**Error! Reference source not found.**). The scores were based on interpretations from the literature review, which provided information specific to the susceptibility of benthic habitat features likely to be impacted by each gear type and the time required for those habitats to return to their pre-impact functional value.

An example is provided in Table 11, and all susceptibility and recovery scores can be found in Appendix D.

Table 10 – Susceptibility and recovery values used in the SASI vulnerability assessment and model

Relative S or R value	***Quantitative definition of susceptibility***	***Quantitative definition of recovery***
0	0 – 10%	< 1 year
1	>10%-25%	1 – 2 years
2	25 - 50%	2 – 5 years
3	> 50%	> 5 years

Table 11 – Sample of trawl gear vulnerability matrices. The Susceptibility (S) and Recovery (R) values are coded as described in Table 9. The literature column indicates those studies identified during the literature review as corresponding to that combination of gear, feature, energy, and substrate. The studies referenced here were intended to be inclusive, so any particular study may or may not have directly informed the S or R score. Any literature used to estimate scores is referenced in Table 31 (Trawl S), Table 39 (Geo R), and Table 40 (Bio R) of the SASI document.

Gear: Trawl					
Substrate: Mud					
Feature name and class – G (Geological) or B (Biological)	**Gear effects**	**Literature high**	**Literature low**	**S**	**R**
Biogenic burrows (G)	filling, crushing	334, 408, 409	97, 101, 313, 333, 336, 407	2	0
Biogenic depressions (G)	filling	236, 408, 409	101, 247, 336	2	0
Sediments, surface/subsurface (G)	re-suspension of fine sediments, compression, geochemical, mixing	88, 92, 211, 236, 330, 334, 406, 408, 409, 599	88, 97, 211, 247, 277, 283, 313, 320, 333, 335, 336, 338, 372, 407, 414	2	0

Gear: Trawl					
Amphipods, tube-dwelling (B) – see note	crushing	34, 113, 119, 211, 228, 292, 334, 408, 409, 599, 658	89, 80, 97, 113, 149, 320, 575	1	0
Anemones, cerianthid burrowing (B)	breaking, crushing, dislodging, displacing	none	None	2	2
Corals, sea pens (B)	breaking, crushing, dislodging, displacing	none	101, 164	2 (low energy only)	2 (low energy only)

Figure 1 shows how the underlying substrate Voronoi polygons relate to the SASI grid. A 10km x 10km resolution was selected for the SASI grid because it is roughly commensurate with the spatial scale over which mobile-gear fishing events occur. This structured grid is the resolution of the adverse effects and vulnerability outputs shown in the lower portion of the figure. The estimated vulnerability of these geological and biologal structures to different types of fishing gears, combined with the underlying habitat distribution, generates the vulnerability maps. Thus, the substrate distribution, specifically the area of each 100 km^2 grid dominated by a given substrate type, directly influences the features inferred and therefore the vulnerability results.

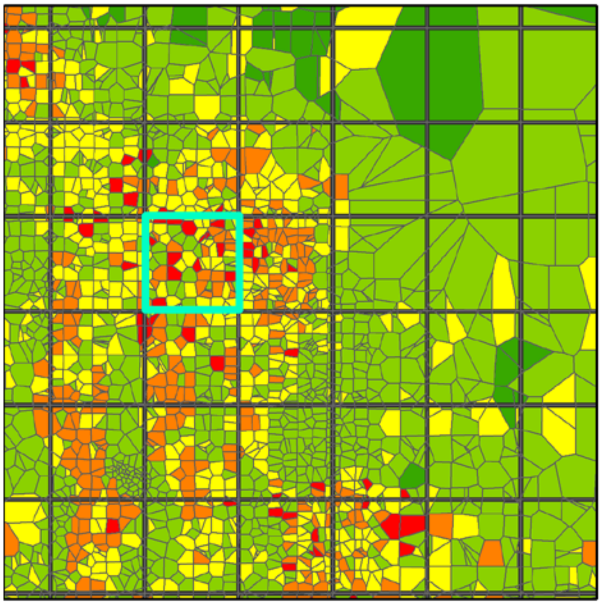
Due to the high degree of influence of the substrate model on the vulnerability results, an understanding of the spatial variation in the supporting data is useful when interpreting the modeling outputs. In locations where all substrate sizes (especially larger grain sizes such as boulders and cobbles) were sampled, and where substrate samples were taken close together, the map that serves as the foundation for the model is considered to be a relatively accurate representation of the true conditions of the seabed. These are considered to be areas with high data quality. In locations where gear only capable of sampling finer grain sizes was used (such as those areas where only grab samples were available), and/or where substrate samples were widely spaced, the map is a less accurate representation of the true seabed conditions. These are considered to be areas with low data quality. The substrate and resulting vulnerability results for areas with low data quality should be considered more cautiously. In order to provide a visual representation of data quality, a metric was created based on sampling ability of the gear and spacing between data points, as follows (Map 17):

- Low (1): Voronoi cell size greater than 100 km^2 AND only small grain sizes sampled
- Moderate (2): Voronoi cell size between 10-100 km^2 AND only small grain sizes sampled
- High moderate (3): Voronoi cell size between 1-10 km^2 AND only small grain sizes sampled
- Very high moderate (4): Voronoi cell size less than 1 km^2 AND only small grain sizes sampled
- High (5): Voronoi cell size 10-100 km^2 AND all grain sizes sampled
- Very high (6): Voronoi cell size 1-10 km^2 AND all grain sizes sampled
- Ultra high (7): Voronoi cell size less than 1 km^2 AND all grain sizes sampled

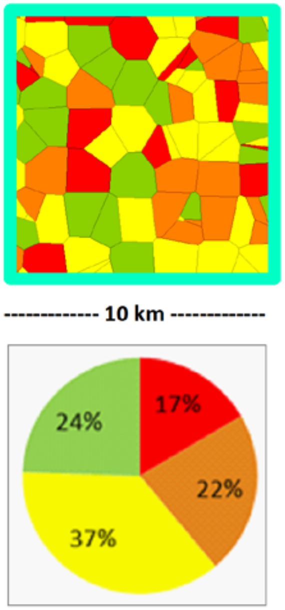
In general, Georges Bank, much of the Mid-Atlantic Bight, and the tops of shallower features in the Gulf of Maine area considered to be high data quality. Coastal areas have moderate data quality; generally the samples are closely spaced such that the grid is highly resolved spatially, but not all grain sizes were sampled in the data so cobble and boulder-dominated habitats are not well mapped. Deep water areas of the Gulf of Maine and areas off the edge of the shelf are generally low data quality.

The model itself then combined area swept fishing effort data with the vulnerability assessment. The model output is a gear-specific, contact- and vulnerability-adjusted area swept value in square kilometers. There are two main model outputs described in the next two sections: potential adverse effect, which is the underlying vulnerability of the seafloor, and realized adverse effect, which is where adverse effects as a result of actual fishing activity are accumulating. Both of these are assessed by gear type. Each section describes the basic methods used to produce these outputs and discusses the results. Additional information about vulnerability by management area and alternative is presented in the environmental impacts of spatial management alternatives section of this EIS, which is in Volume 3.

Figure 1 – Using the SASI model to estimate vulnerability of seabed habitats to otter trawl gear.



The 10x10 km grid overlays the unstructured sediment and energy grid, and the underlying sediment and charcteristics are carried forward based on the area covered by each substrate/energy type.



☐ Structured grid

Unstructured Grid

Substrate

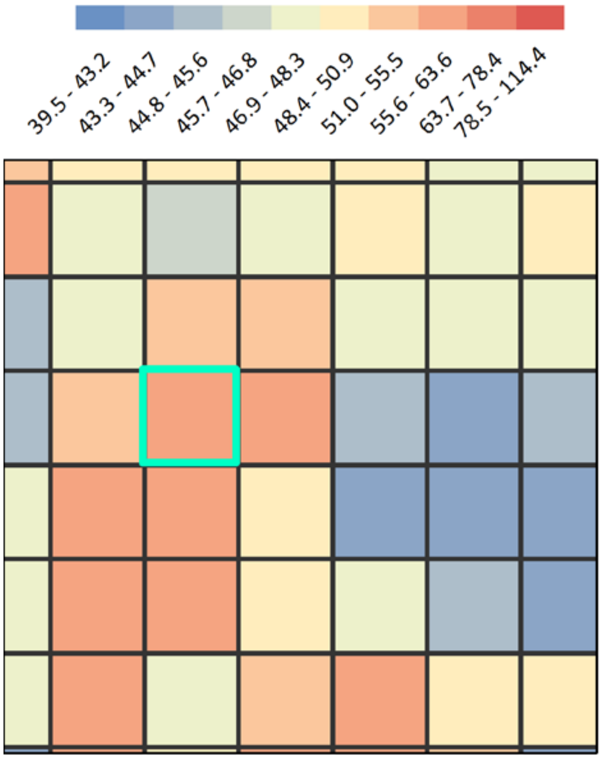
🟩 Mud-Silt

🟩 Sand

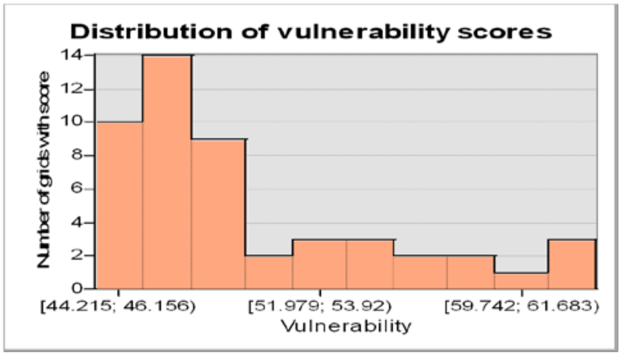
🟨 Granule-Pebble

🟧 Cobble

🟥 Boulder

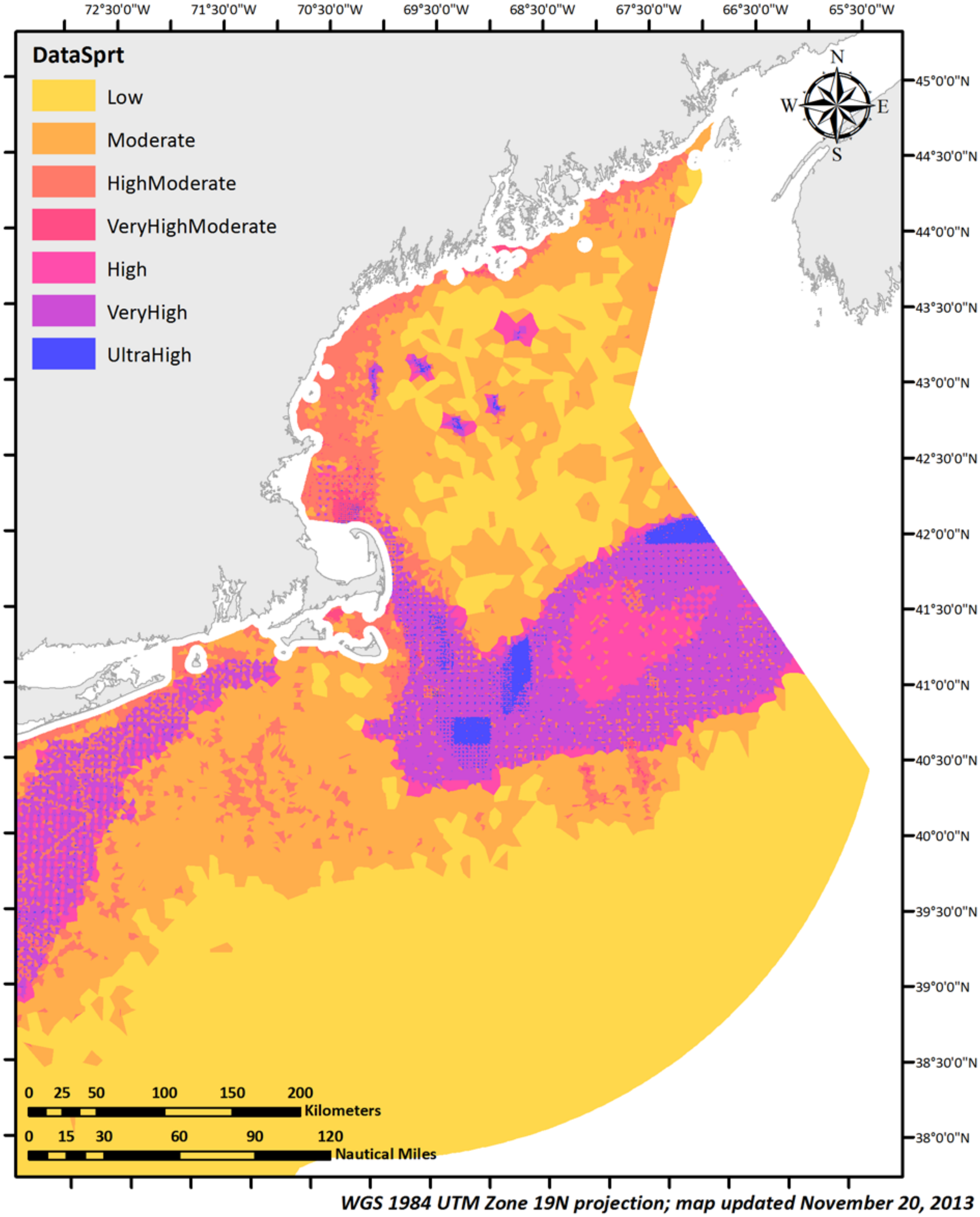


100 km2 of area swept is added to each structured grid cell each year. This value is reduced initially to account for gear contact with the seabed and the vulnerability of structural habitat features associated with each sediment type, and is further reduced over time as recovery occurs. Because the maximum recovery time allowed by the model is ten years, the area swept value comes to equilibrium in year 11.



The vulnerability score for the highlighted cell is 58.9, and it was identifed as a high vulnerability cluster in the spatial analysis. The distribution of vulnerability scores for the portion of the grid at left are shown in the histrogram above.

Map 17 – SASI substrate grid data support values



WGS 1984 UTM Zone 19N projection; map updated November 20, 2013

4.1.3.1 SASI vulnerability estimates

The underlying vulnerability of the seafloor was assessed using simulation runs of the SASI model. Because the model relies on area swept of each gear type to examine where adverse effects accumulate over time, a uniform area swept fishing effort layer of 100 km^2 area swept per cell, per year was used to produce six sets of vulnerability outputs, one for each gear type (Map 18 - Map 23, methods detailed in Section 8.3.1 of SASI Appendix). **These simulation runs reflect the underlying vulnerability of the seabed in various locations to each gear type.**

The range of the vulnerability estimates varies by gear type; fixed gears, i.e. longlines, gillnets, and traps, have vulnerability scores that are about one third that of scallop dredges and otter trawls (Figure 2). Hydraulic dredges have higher vulnerability scores than otter trawls and scallop dredges, and much higher vulnerability scores than the fixed gears (Figure 2). Vulnerability scores across all gear types except hydraulic dredges have a narrow, skewed distribution, with a single mode and outliers on the upper end (Figure 2). The hydraulic dredge scores are distributed somewhat differently; they have a bimodal distribution (Figure 2), with lower scores in higher energy areas, and higher scores in lower energy areas (Map 20). The hydraulic dredge model is fairly different from the others because the assumption was made that hydraulic dredges can only operate on sand and granule-pebble substrates, so the model ignores other substrate types when they occurred in a particular grid cell. **Overall, the conclusion of the modeling work was that fixed gears have impacts that are of much lower magnitude compared to mobile gear impacts. Further, the scores assigned in the vulnerability assessment point to gear effects from fixed gears that are relatively limited in their magnitude and relatively short in duration**.

A cluster analysis (local indicators of spatial association, LISA) was run on these vulnerability estimates to identify contiguous areas with similar vulnerability scores (Section 9 of SASI Appendix). The cluster analysis tests how probable it is that the spatial distribution of the vulnerability scores is random and it used a probability threshold of less than or equal to 0.05. Therefore, it is unlikely that the vulnerability scores are randomly distributed; it is likely that they are spatially clustered. The clusters of high vulnerability are shown on the figures below (Map 18 - Map 23). Area boundaries drawn around clusters are more likely to encompass more vulnerable seafloor than area boundaries drawn at random. In addition to the varying magnitude of impact by gear type, the different gears also differentially impact the various seafloor features. The model reflects estimated contact of the gear with the seabed, the susceptibility of the seabed features to the gear type, and the recovery rates of the features.

For **otter trawl gear** (Map 18), areas with high potential vulnerability scores include the area between Cape Cod and the deeper waters of the Great South Channel, a small area in central Georges Bank, the northeastern flank of Georges Bank, areas along the coast in the Gulf of Maine, and various offshore banks and ledges in the Gulf of Maine, including Jeffreys Bank, Stellwagen Bank, Platts Bank, Jeffreys Bank, Fippennies Ledge, and Cashes Ledge. An additional high vulnerability area was mapped off the Rhode Island coast. These areas were highlighted by the cluster analysis, with the exception of Fippennies and Cashes Ledges, which are relatively small features.

These model results relate closely to the vulnerability assessment, which identified cobble- and boulder-dominated habitats as being more vulnerable to fishing impacts (Appendix D, Grabowski et al 2013 in press). Although vulnerable seabed habitat types have been positively identified in the Gulf of Maine, due to higher data quality on Georges Bank as compared to the Gulf of Maine, the spatial distribution of vulnerability is expected to be more accurate on Georges Bank. Two types of areas in the Gulf of Maine are problematic in terms of the vulnerability estimates. First, vulnerability in the vicinity of Stellwagen Bank is probably underestimated. Substrate type in this area is sampled as relatively high rate, but mostly with gear not capable of detecting cobble or boulder. A multibeam backscatter-based sediment map of this area (Map 5) indicates a higher amount of gravel habitat as compared to the SASI grid, which is shown on Map 4. The distribution of vulnerability in the vicinity of Platts Bank and Jeffreys Bank is not very accurately mapped because of the underlying substrate grid. There are many closely spaced substrate samples on the shallow portions of these features, where the sampling gear used (video) was capable of sampling cobble and boulder, but the surrounding areas are mapped at very low resolution with gear incapable of sampling these larger grain sizes. The result is that the substrate grid has some very large cobble and boulder grid cell sizes along the edges of the features, which makes the vulnerable areas and average scores larger and higher. This is not to say that these offshore features do not contain seabed types vulnerable to impact, only that they are not mapped very accurately. Generally, the PDT determined that large substrate grain sizes are probably relatively rare in deep mud habitats, although there are exceptions to this (e.g., rocky ‘bumps’ found scattered throughout Jordan Basin).

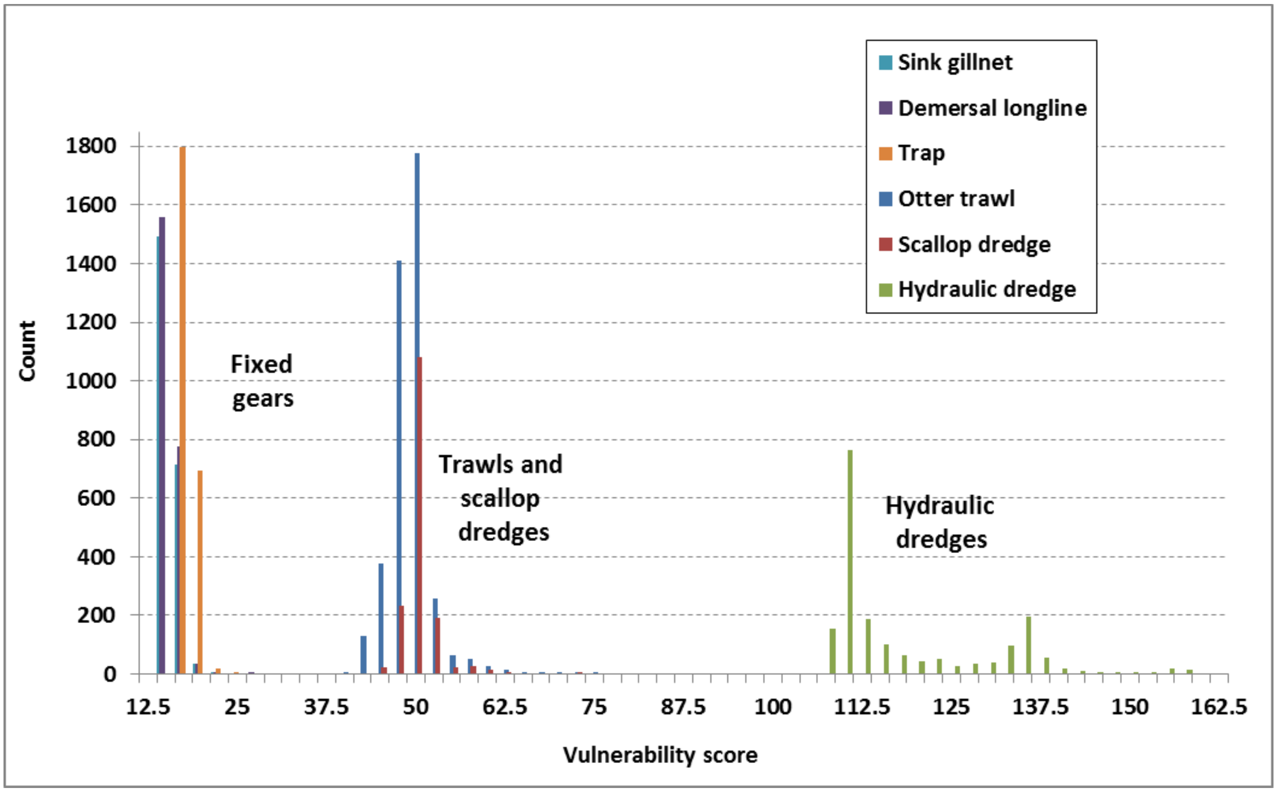
For **scallop dredge gear** (Map 19), the results are very similar to the trawl gear results. However, the domain of the scallop dredge gear map is limited to areas shallower than 83 m, based on the distribution of scallop dredge effort relative to depth in the at-sea fishing observer data. Thus, many of the vulnerable Gulf of Maine areas are not really relevant with regards to the scallop fishery, with the exception of Platts Bank.

The **hydraulic clam dredge gear** model (results on Map 20) assumes the gear can only operate over sand or granule-pebble substrates. Thus, this map is really a depiction of sand and granule-pebble vulnerability to the gear by area. On Georges Bank, there are somewhat higher vulnerability estimates overlapping areas with more granule-pebble vs. sand, i.e. on the northeast part of the bank and in the area west of the Great South Channel, but in general the highest vulnerability scores are in low energy areas along the coast in the Gulf of Maine, and towards the edge of the shelf. The domain of the map extends to a maximum depth of 138 meters.

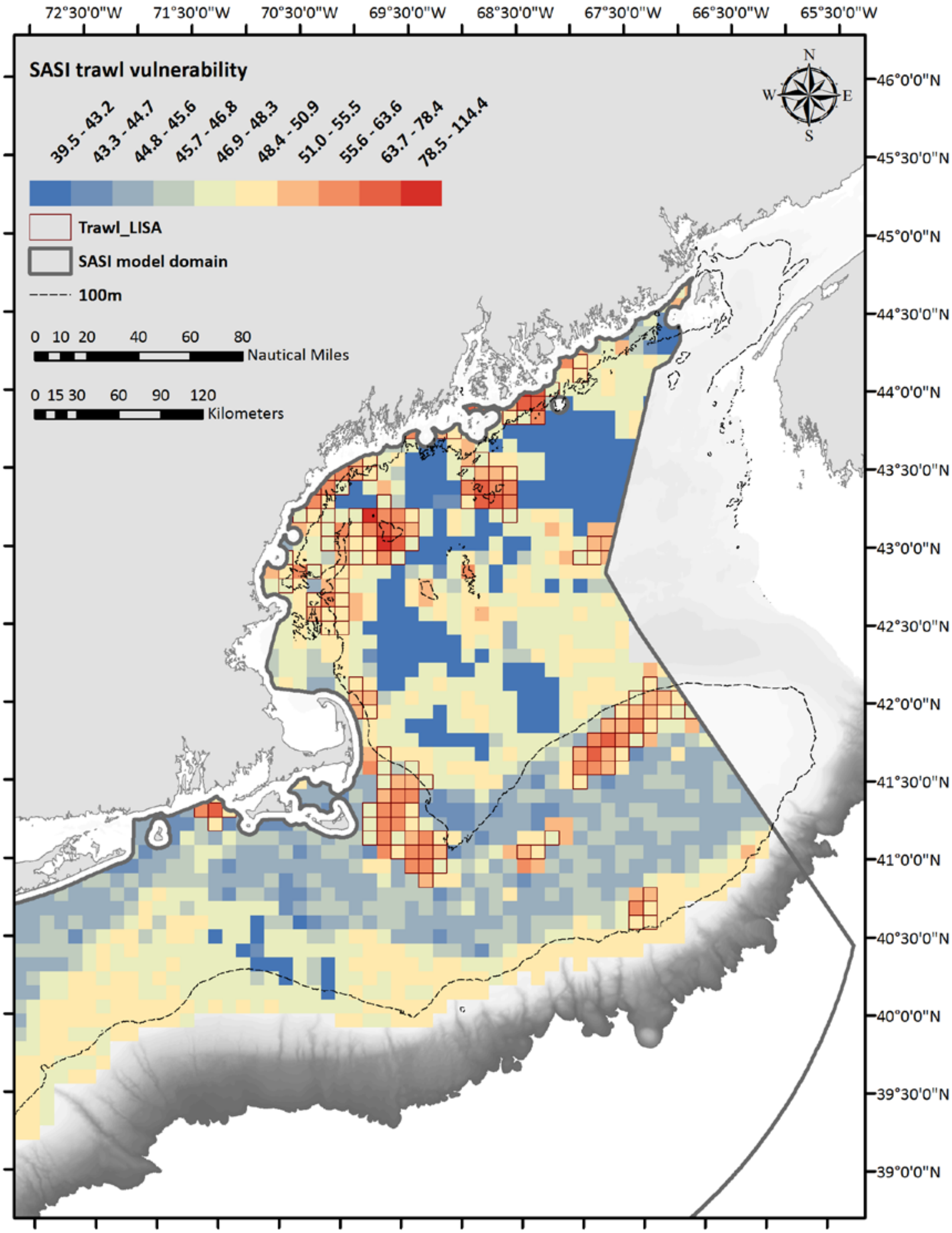
The same areas of Georges Bank and the Gulf of Maine identified as vulnerable to trawl gear are generally identified as vulnerable to the **demersal longline gear** (Map 21), **sink gillnet gear** (Map 22), and **trap gear** (Map 23). Low energy mud areas in the Gulf of Maine and in Southern New England were also estimated to be relatively more vulnerable to the impacts of trap gear. Although the longline/gillnet and trap vulnerability assessment results were very similar (compare **Error! Reference source not found.** and **Error! Reference source not found.**), biogenic depressions and surface/subsurface sediments were estimated to be more vulnerable to trap gear, which accounts for the differences between the longline or gillnet vs. trap vulnerability maps.

The trawl vulnerability estimates and associated cluster analyses were used to identify general locations of more vulnerable seafloor. This SASI analysis combined with other information underpinned the design of some of the habitat management areas (HMAs) in this amendment. The trawl vulnerability assessment and map were the primary SASI outputs used to design HMAs because (1) mobile gear impacts are of greater magnitude than fixed gear impacts, (2) the trawl vulnerability maps and scallop dredge vulnerability maps are based on very similar vulnerability assessment results, so the trawl map was used as a proxy because it extends into deeper waters, (3) the hydraulic dredge maps were viewed as a more specialized output, and that fishery is spatially concentrated, as compared to the trawl and scallop dredge fisheries, and (4) the greatest overall magnitude of realized adverse effects throughout the region come from trawl gears (realized adverse effects are explained in the next section).

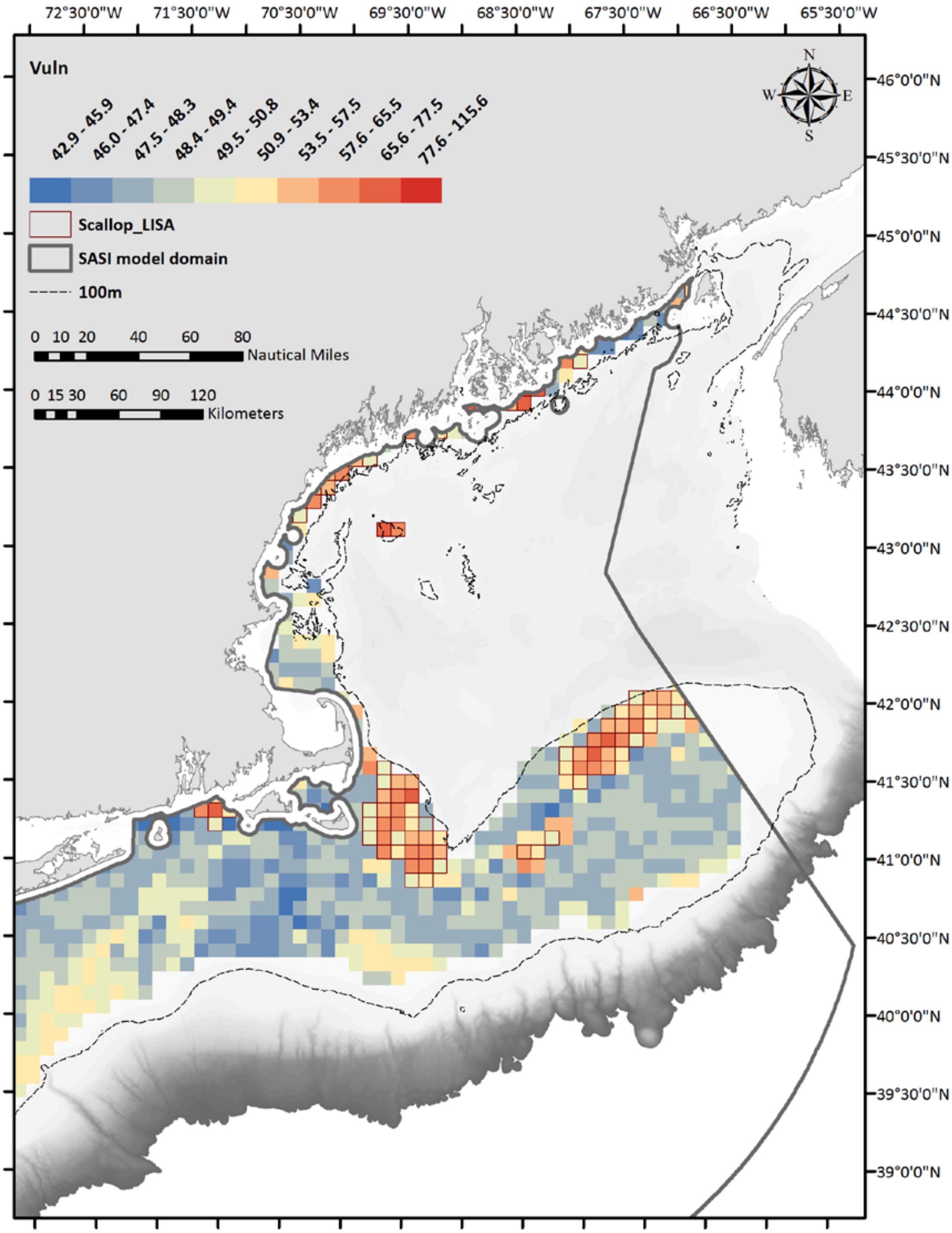
Figure 2 – Distribution of vulnerability scores by gear type



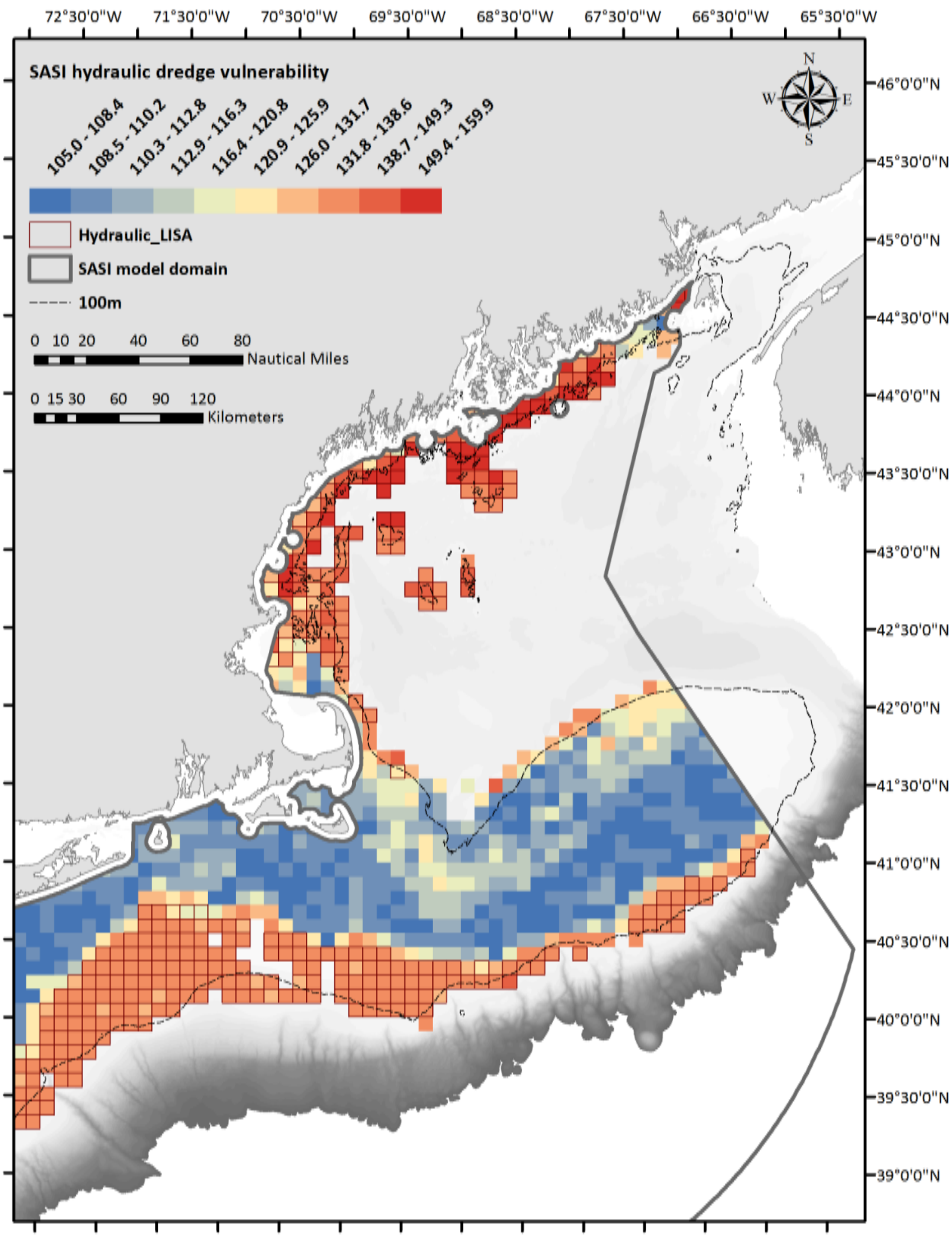
Map 18 – SASI model estimate of seabed habitat vulnerability to adverse effects from demersal otter trawl gears (blue=low vulnerability, red=high vulnerability). Clusters of high vulnerability grids are outlined in red.



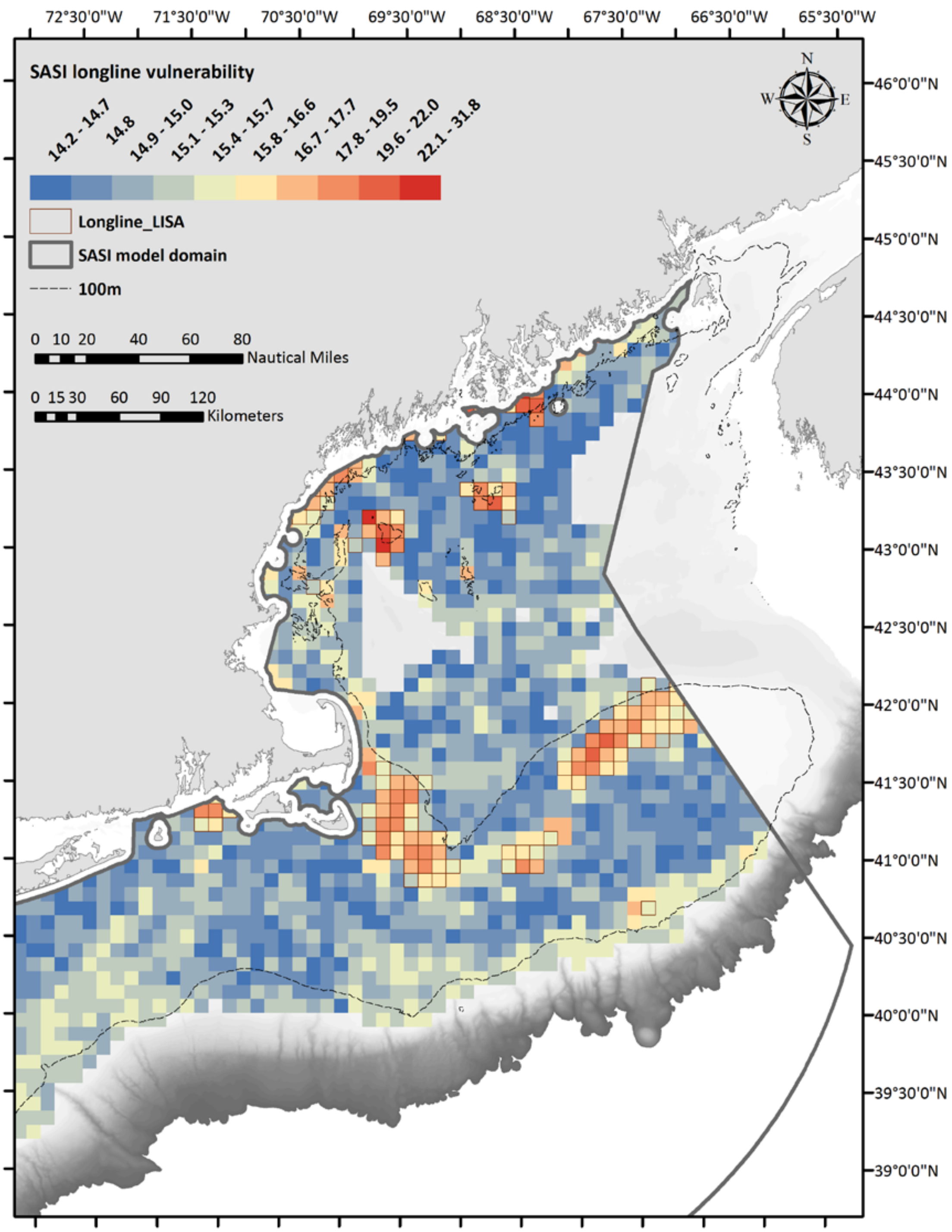
Map 19 – SASI model estimate of seabed habitat vulnerability to adverse effects from scallop dredge gears (blue=low vulnerability, red=high vulnerability). Clusters of high vulnerability grids are outlined in red.



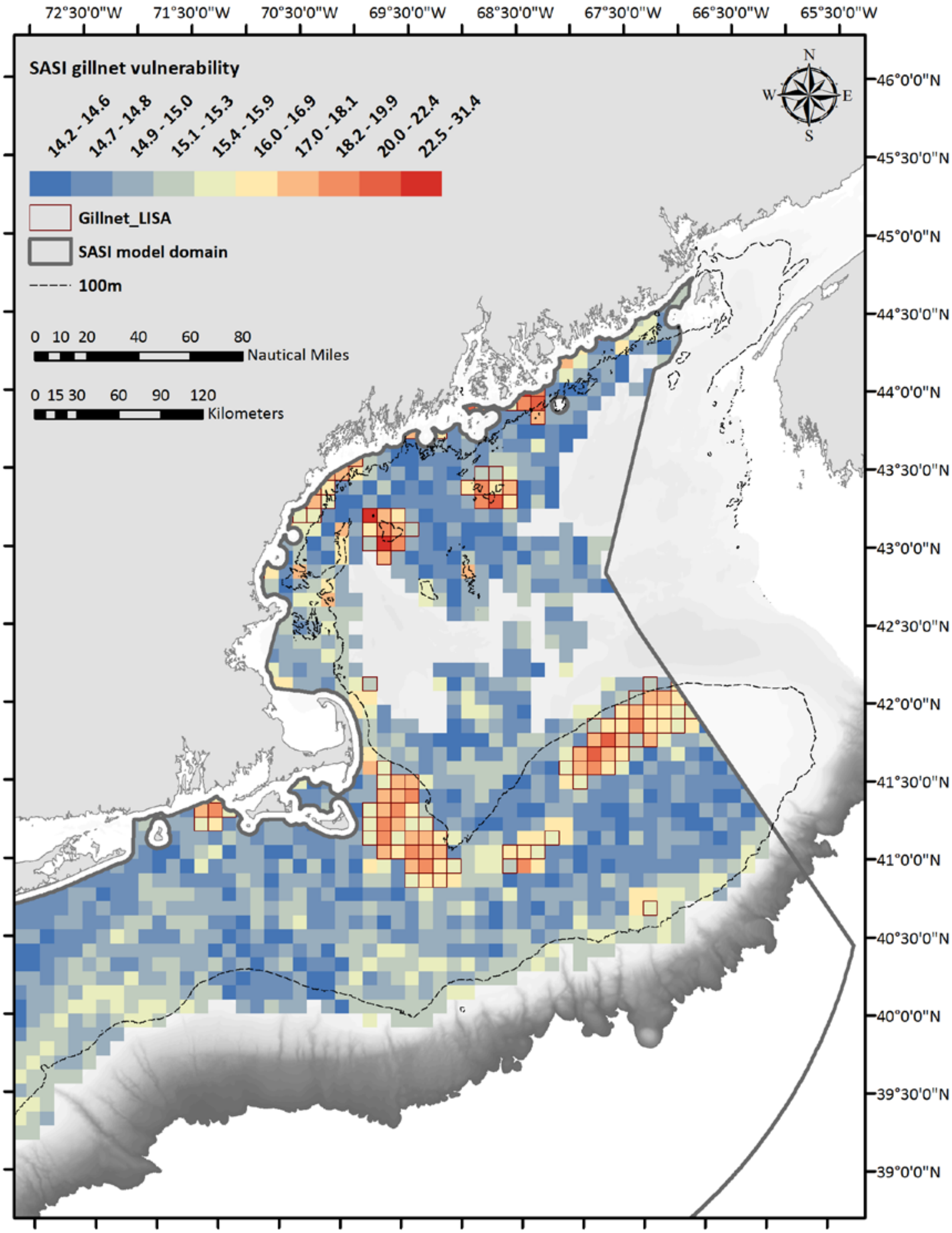
Map 20 – SASI model estimate of seabed habitat vulnerability to adverse effects from hydraulic clam dredge gears (blue=low vulnerability, red=high vulnerability). Clusters of high vulnerability grids are outlined in red.



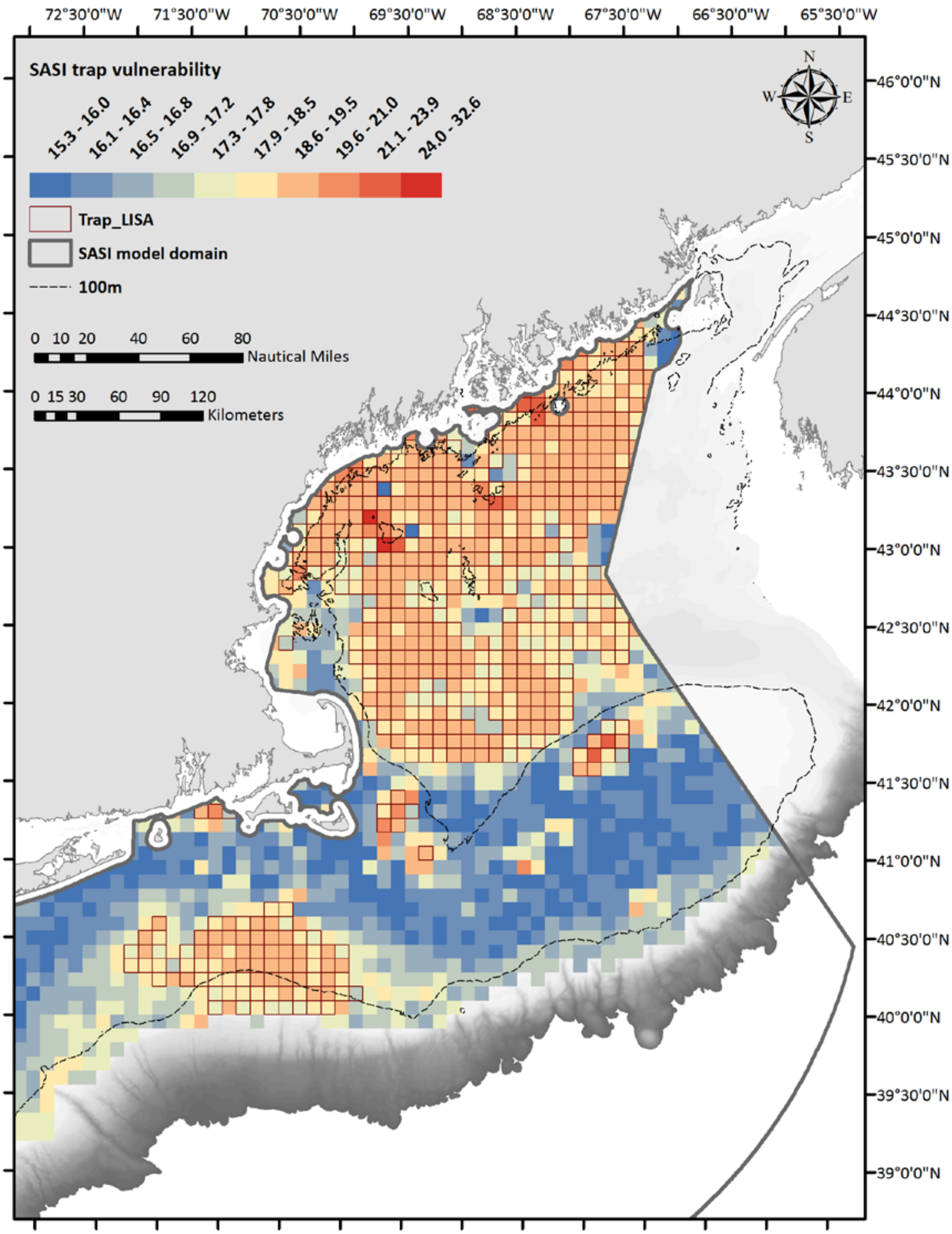
Map 21 – SASI model estimate of seabed habitat vulnerability to adverse effects from demersal longline gears (blue=low vulnerability, red=high vulnerability). Clusters of high vulnerability grids are outlined in red.



Map 22 – SASI model estimate of seabed habitat vulnerability to adverse effects from sink gillnet gear (blue=low vulnerability, red=high vulnerability). Clusters of high vulnerability grids are outlined in red.



Map 23 – SASI model estimate of seabed habitat vulnerability to adverse effects from trap gear (blue=low vulnerability, red=high vulnerability). Clusters of high vulnerability grids are outlined in red.



4.1.3.2 SASI realized area swept and adverse effects

Another way to understand and evaluate adverse effects is to consider how the magnitude and distribution of fishing effort interacts with the vulnerability of the underlying seabed. The SASI model can also be used to compare the realized magnitude of fishing impacts to the seabed across space, time, and gear type. To develop these realized adverse effects estimates, fishing effort was converted to area swept and gridded at 10km x 10km resolution, in annual time steps. The model is then run using these annual effort layers and the vulnerability information appropriate to each gear type. The result is a series of maps and figures that show how the distribution and magnitude of adverse effects have changed over time for the New England region.

The realized effort runs disaggregate fishing gear type to a finer degree as compared to the simulation runs, as listed in Table 12. Trawl gears were disaggregated in the realized effort model because the various sub-types were expected to have different seabed contact indices, as well as a relationship to specific locations and fisheries. Scallop dredge effort was diaggregated by permit type. The area swept models and data sources used are described in section 6.0 of the SASI appendix. The model itself and the realized model runs are described in section 8.0 and 8.3.2 of the SASI appendix.

Table 12 – Gears evaluated using the SASI approach. Left column shows the basic gear type evaluated in the vulnerability assessment and modeled in the simulation runs; right column indicates when the gear type was disagreggated further for realized adverse effects modeling.

Simulation runs; evaluated in vulnerability assessment	**Realized runs**
Otter trawl	Generic otter trawl, squid trawl, shrimp trawl, raised footrope trawl.
Scallop dredge	Limited access, limited access general category
Hydraulic clam dredge	Same
Demersal longline	Same
Sink gillnet	Same
Trap	Same

Map 24-Map 33 depict the spatial distribution of realized adverse effects by bottom-tending gear type for three years, 2000, 2005, and 2010, which is the last year for which these estimates were developed. The data bins shown in the legend are the same for each panel within a single map, but vary between gear types across the various maps. However, dark blue always represents the lowest adverse effect values per grid, and red always represents the highest adverse effect values per grid. Note that although the map legends indicate that the lower bound of the lowest interval on all maps in zero, these lower values only approach zero, and no zero grids are plotted. This is evidenced by the different ‘footprints’ on the different maps for different gear types, although the SASI model domain is the same for all gears. The model domain does not extend into state waters (3 nm or less from shore) so any adverse effects/effort in state waters is not shown. Because the realized adverse effects model is run continuously over time, the adverse effects estimates on the maps are the result of past impacts where the habitat has not yet fully recovered, and new, annual impacts. Thus, each annual panel should be viewed as a snapshot of the conditions present during that year.

The magnitude of adverse effects resulting from the **generic otter trawl gear** category have declined substantially over time, as evidenced by the cooler colors shown in the 2005 and 2010 panels as compared to the 2000 panel in Map 24. However, areas of concentrated adverse effects have remained stable over time, including the southwestern Gulf of Maine, the northeast flank of Georges Bank from Cape Cod to the EEZ boundary, and the Southeast Part of Georges Bank. Effects are also concentrated along the coast in Southern New England, and along the shelf break in Southern New England.

Adverse effects from the **shrimp trawl gear** category accumulate in the inshore Gulf of Maine, particularly along the northeastern Massachussetts, New Hampshire, and southern Maine coasts (Map 25). The cooler colors from 2000-2010 indicate a gradual decrease adverse effects over time.

Adverse effects from the **squid trawl gear** category occur along the southern flank of Georges Bank and throughout southern New England and the Mid-Atlantic Bight (Map 26). There appears to be a decrease in the overall and typical per unit area values over time from 2000-2010.

Adverse effects from the **raised footrope trawl gear** category are very localized to the inshore Gulf of Maine and off the eastern side of Cape Cod (Map 27). There are no clear spatial patterns evident, and the grids with higher values likely reflect the location of concentrations of effort over time.

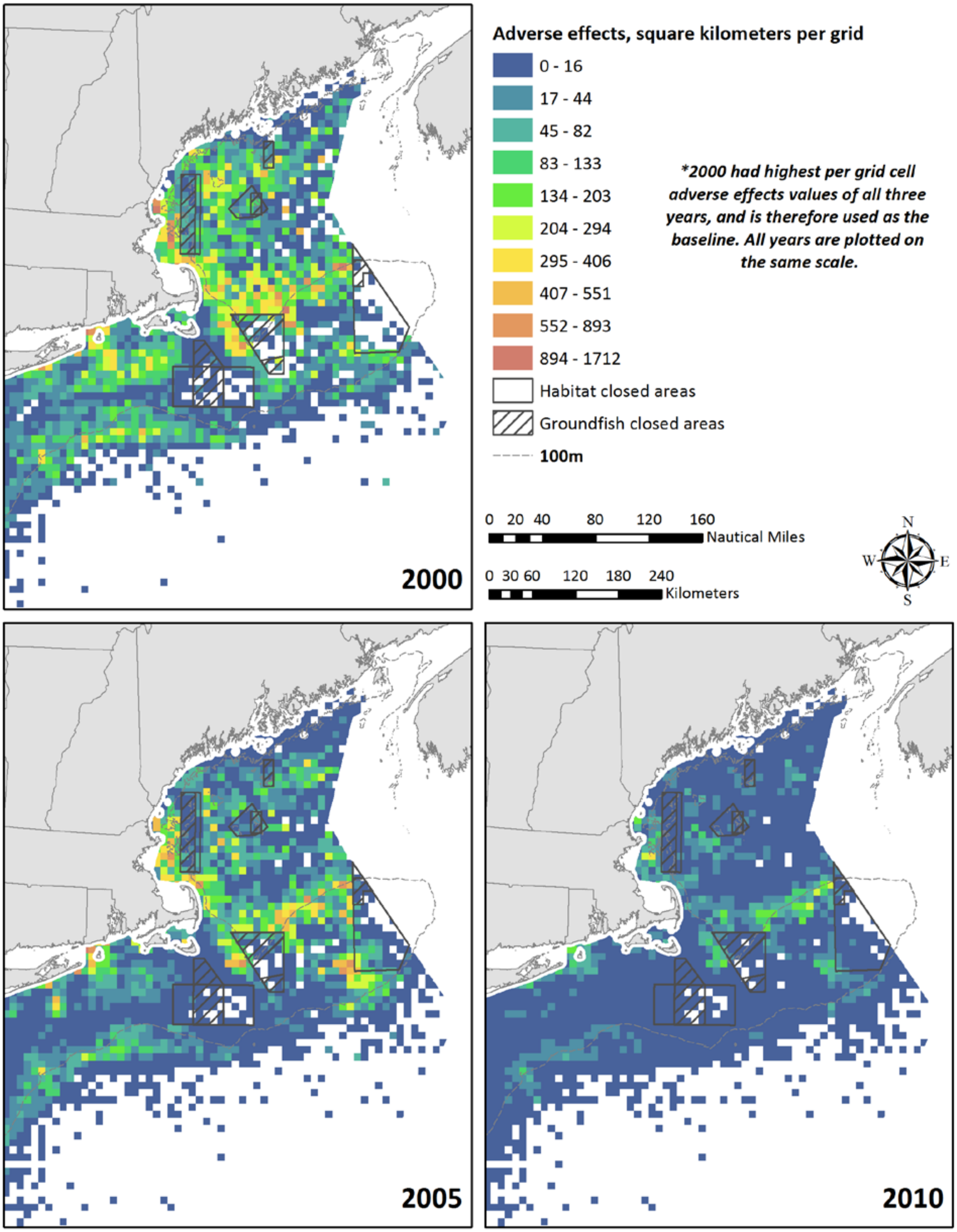
Adverse effects from the **limited access scallop dredge gear** category occur around the edges of Georges Bank, in the southwestern Gulf of Maine, and throughout the Mid-Atlantic Bight (Map 28). Annual maps (not shown here) show more clearly the shifting adverse over time that accrue due to the highly concentrated access fisheries that occur throughout the region. Certain areas consistently show adverse effects accumulation on Georges Bank, including the area west of the Great South Channel, the area west of the northern part of Closed Area II, and the Southeast Part of the bank. There are relatively low but consistent levels of adverse effects along the coast of Maine (mid-coast to eastern Maine). Adverse effects from the limited access general category scallop dredge gear type have a much more inshore distribution (Map 29). Adverse effects in this fishery appear to have peaked in the mid-2000s, and have declined recently. This is consistent with the overall levels of effort in this fishery over time. Concentrations of adverse effects occur in the southwester Gulf of Maine, west of the Great South Channel/east of Cape Cod, and more recently, in off the Southern New England coast.

Adverse effects from the **clam dredge** fishery are distributed throughout Southern New England and the Mid-Atlantic Bight, with concentrations that likely correspond to annual shifts in fishing effort (Map 30). There is also a small area with high adverse effects values per grid in eastern Maine, close to the coast. It should be noted that the vulnerability assessment for this gear was completed with hydraulic clam dredges in mind, while the eastern Maine fishery uses a different gear type (see section 4.3.1.8).

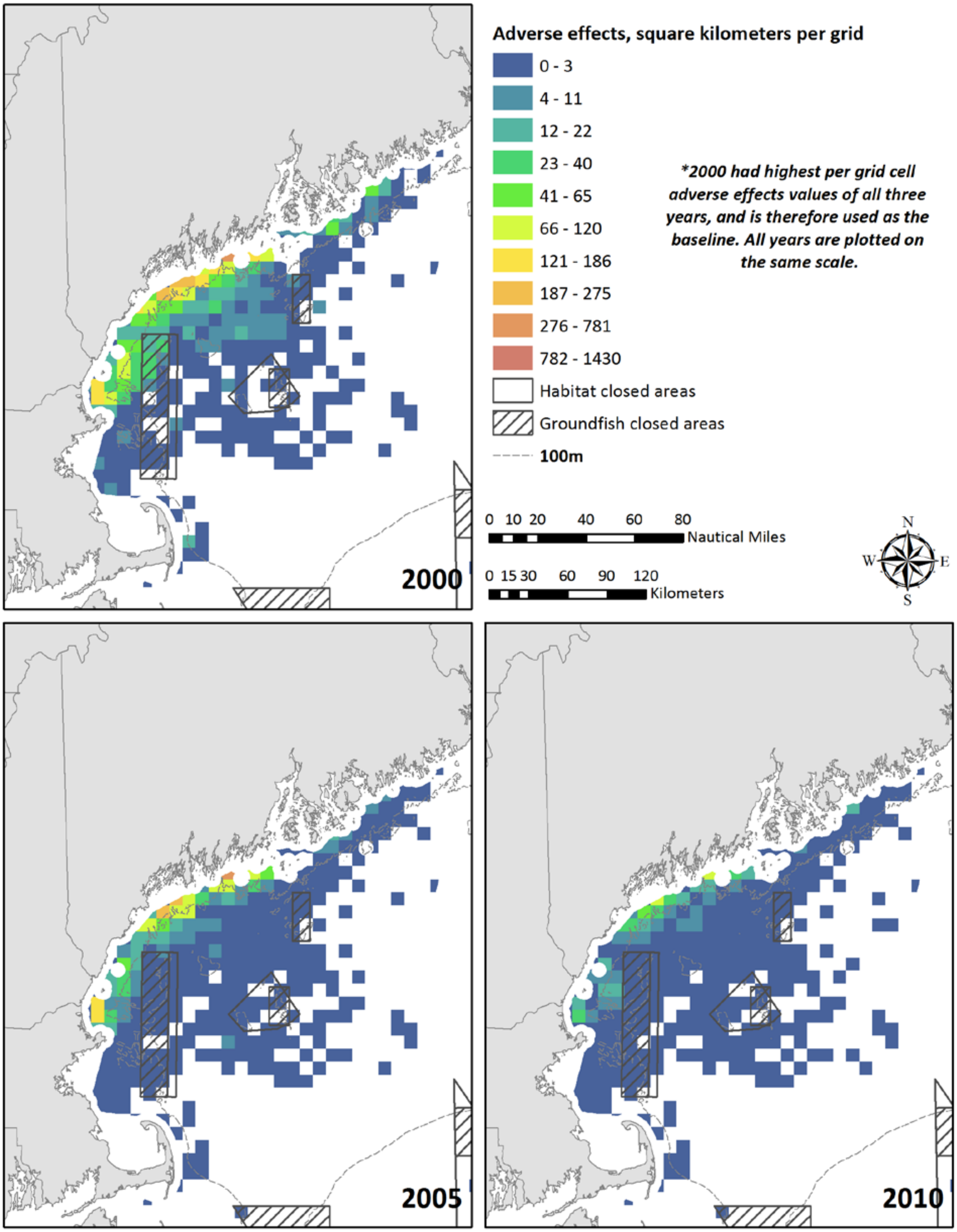
The spatial distribution of adverse effects for the **demersal longline gear type** is concentrated inshore, and in muddy areas off the shelf in Southern New England (Map 31). Adverse effects are relatively high in the southwestern Gulf of Maine, and between Cape Cod and the Great South Channel. Similar to the generic otter trawl gear type, the overall magnitude of adverse effects from this gear type have declined over time. **Sink gillnet** adverse effects show a similar pattern, although there are greater adverse effects offshore in the Gulf of Maine and near the coast in Southern New England as well (Map 32). **Trap gear** adverse effects probably reflect concentrations of effort in the lobster fishery, and occur mainly along the coasts of Maine, New Hampshire, Masschusetts, and Rhode Island (Map 33). Adverse effects were lower in 2010 as compared to 2000 and 2005.

The goal of the amendment is to avoid and minimize to the extent practicable the adverse effects of fishing on the seabed. The realized runs illustrate a reduction in accumulated adverse effects over time. This is due to a reduction in area swept as a result of reduced fishing pressure. It could be argued that existing management actions are reducing area swept and minimizing adverse effect. Due to the potential for fishing pressure to move into areas with high potential vulnerability, it was determined that identifying vulnerable seafloor and designing methods to reduce impacts to those areas was of primary importance. Although adverse impact has been reduced over time, this reduction may be rapidly reversed if the more vulnerable seafloor is not identified and protected from the gear types that could impact it.

Map 24 – Spatial distribution of realized adverse effects from generic otter trawl gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.

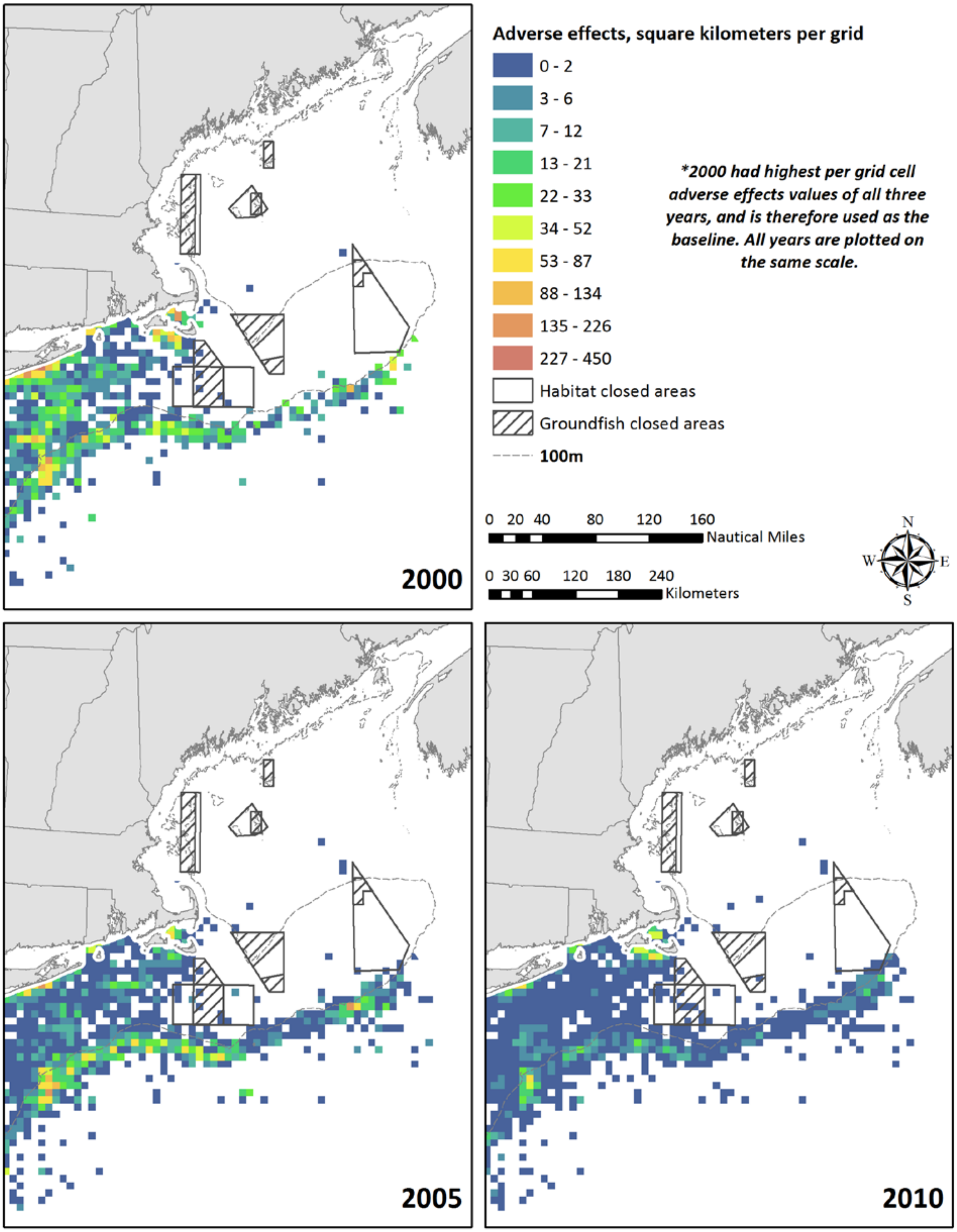


Map 25 – Spatial distribution of realized adverse effects from shrimp trawl gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.



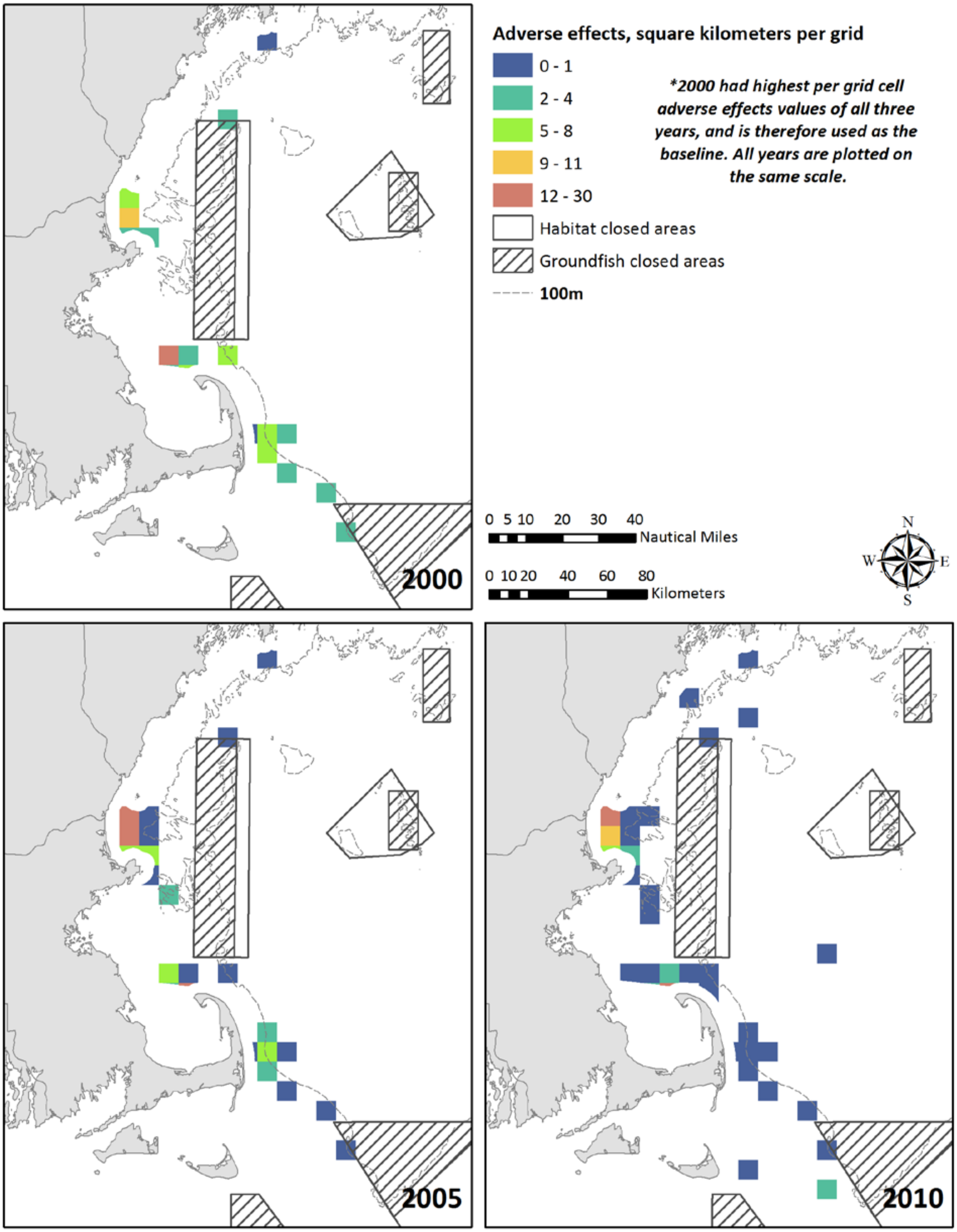
**2000 had highest per grid cell adverse effects values of all three years, and is therefore used as the baseline. All years are plotted on the same scale.*

Map 26 – Spatial distribution of realized adverse effects from squid trawl gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.

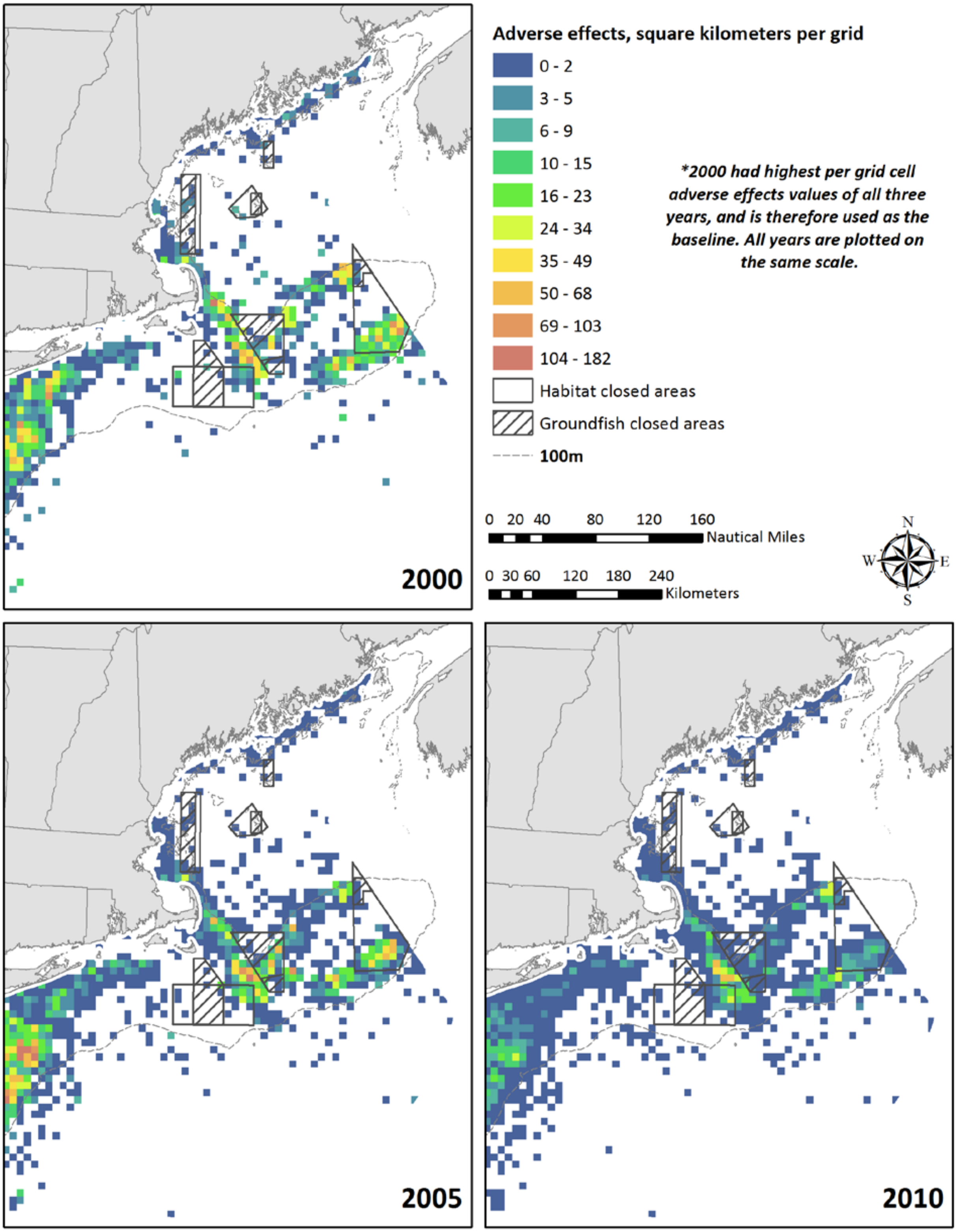


**2000 had highest per grid cell adverse effects values of all three years, and is therefore used as the baseline. All years are plotted on the same scale.*

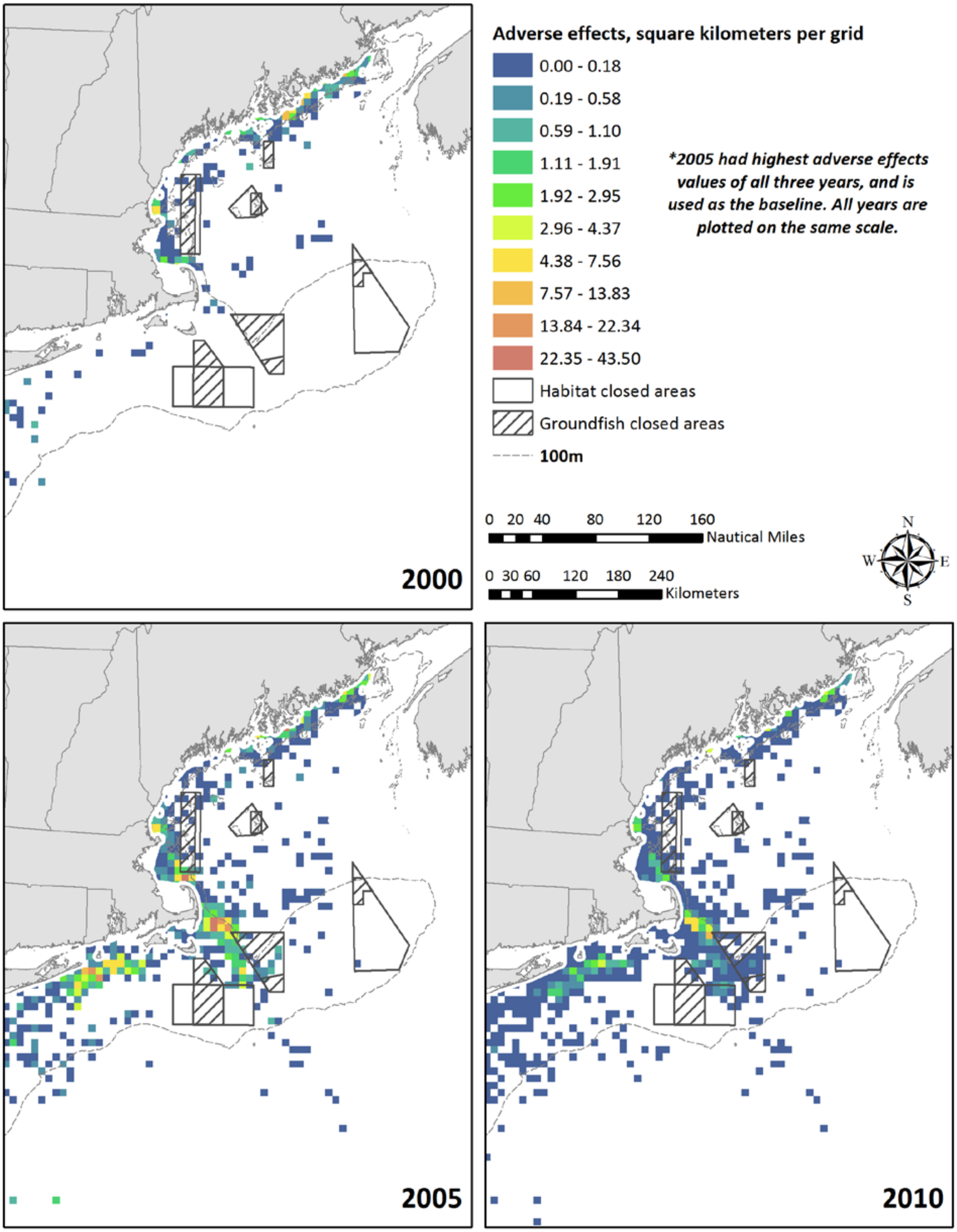
Map 27 – Spatial distribution of realized adverse effects from raised footrope trawl gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.



Map 28 – Spatial distribution of realized adverse effects from limited access scallop dredge gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.

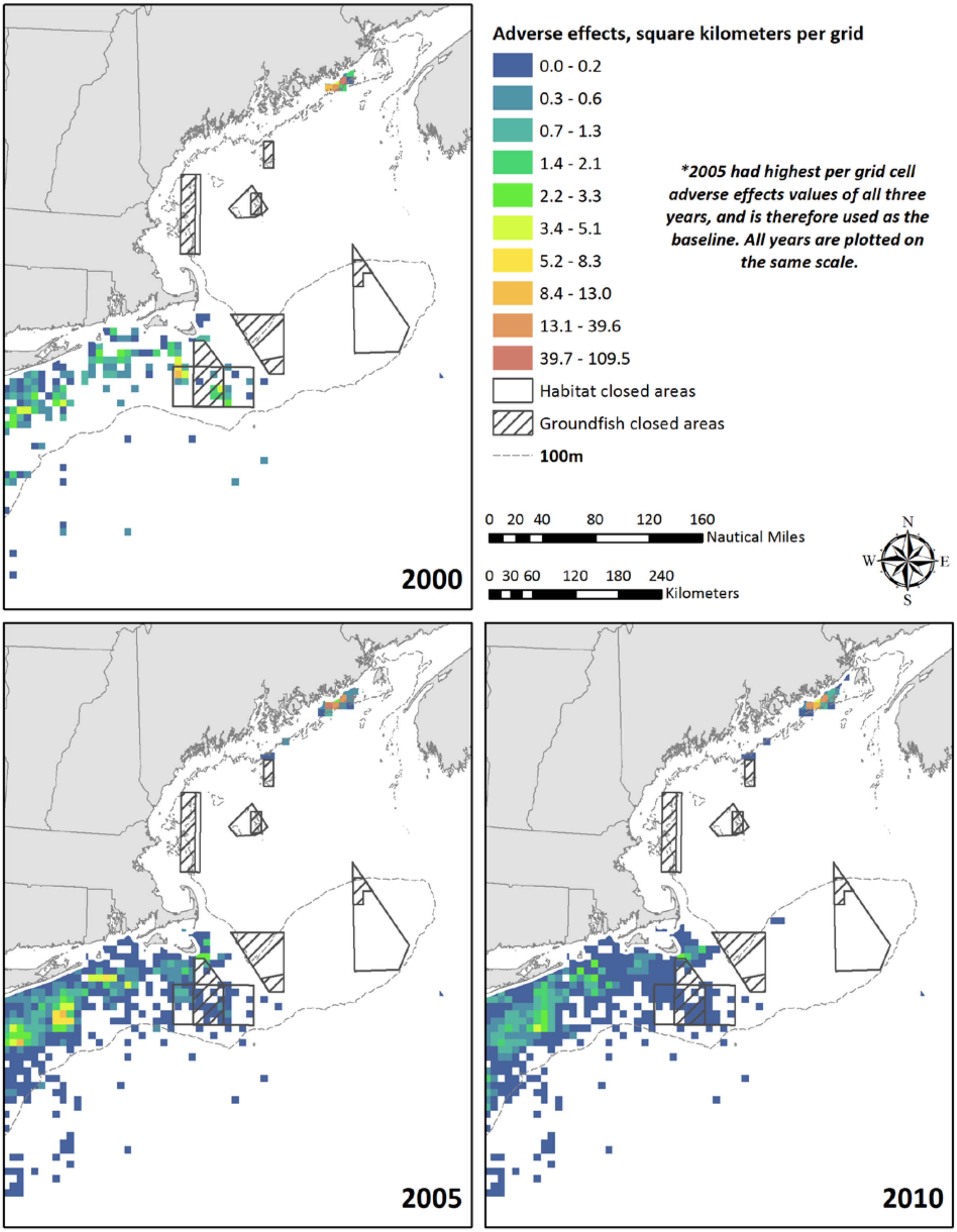


Map 29 – Spatial distribution of realized adverse effects from general category scallop dredge gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.

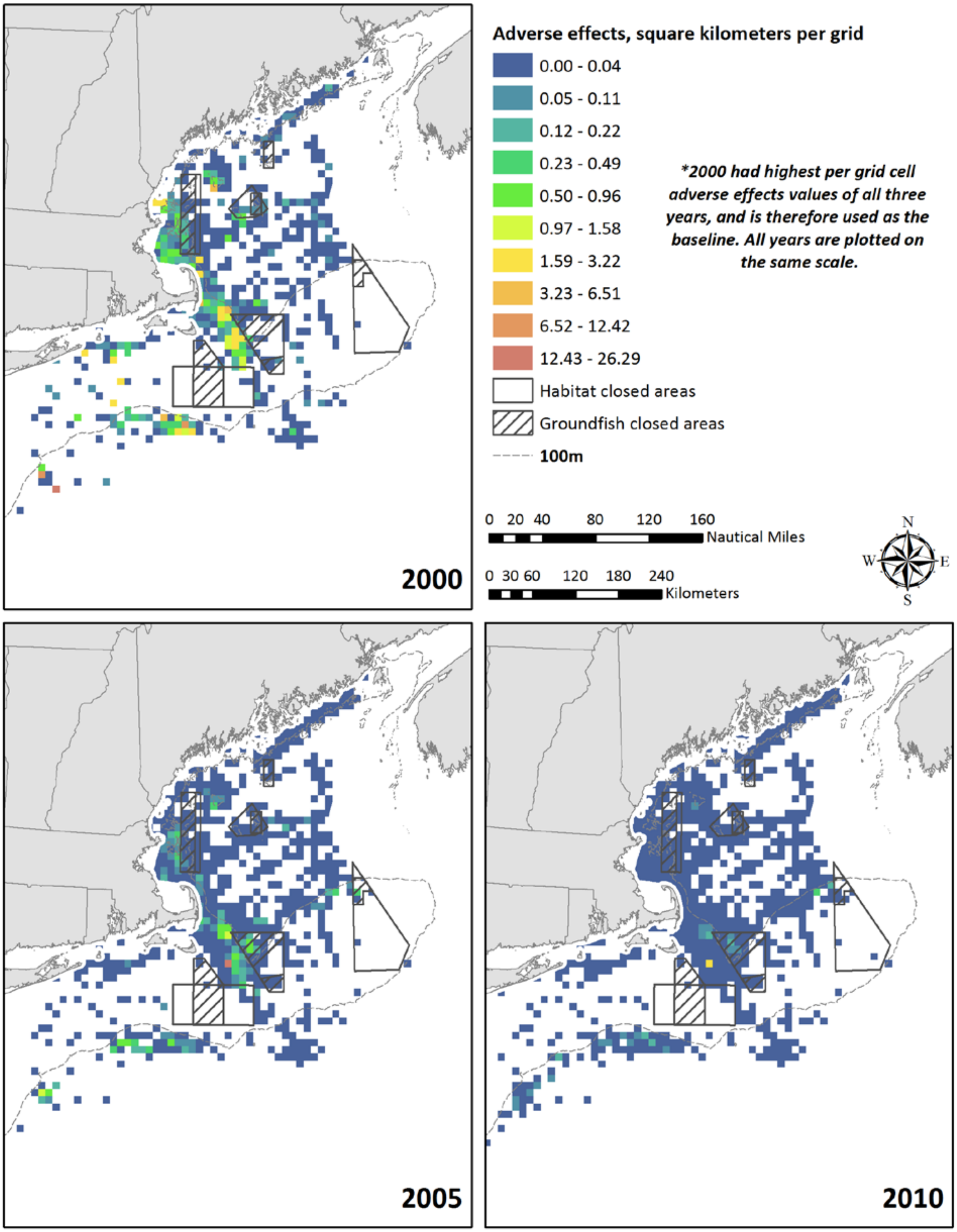


**2005 had highest adverse effects values of all three years, and is used as the baseline. All years are plotted on the same scale.*

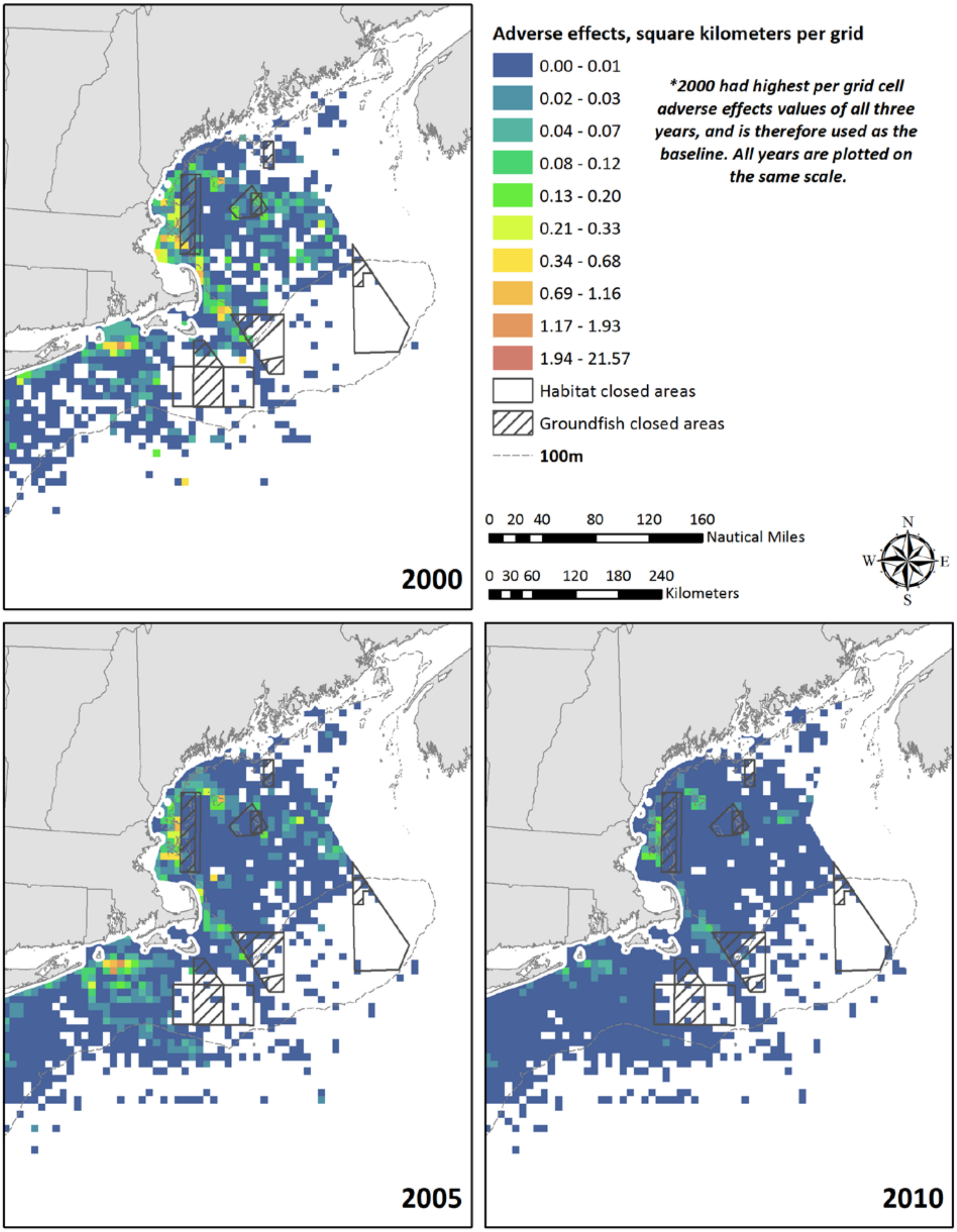
Map 30 – Spatial distribution of realized adverse effects from clam dredge gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.



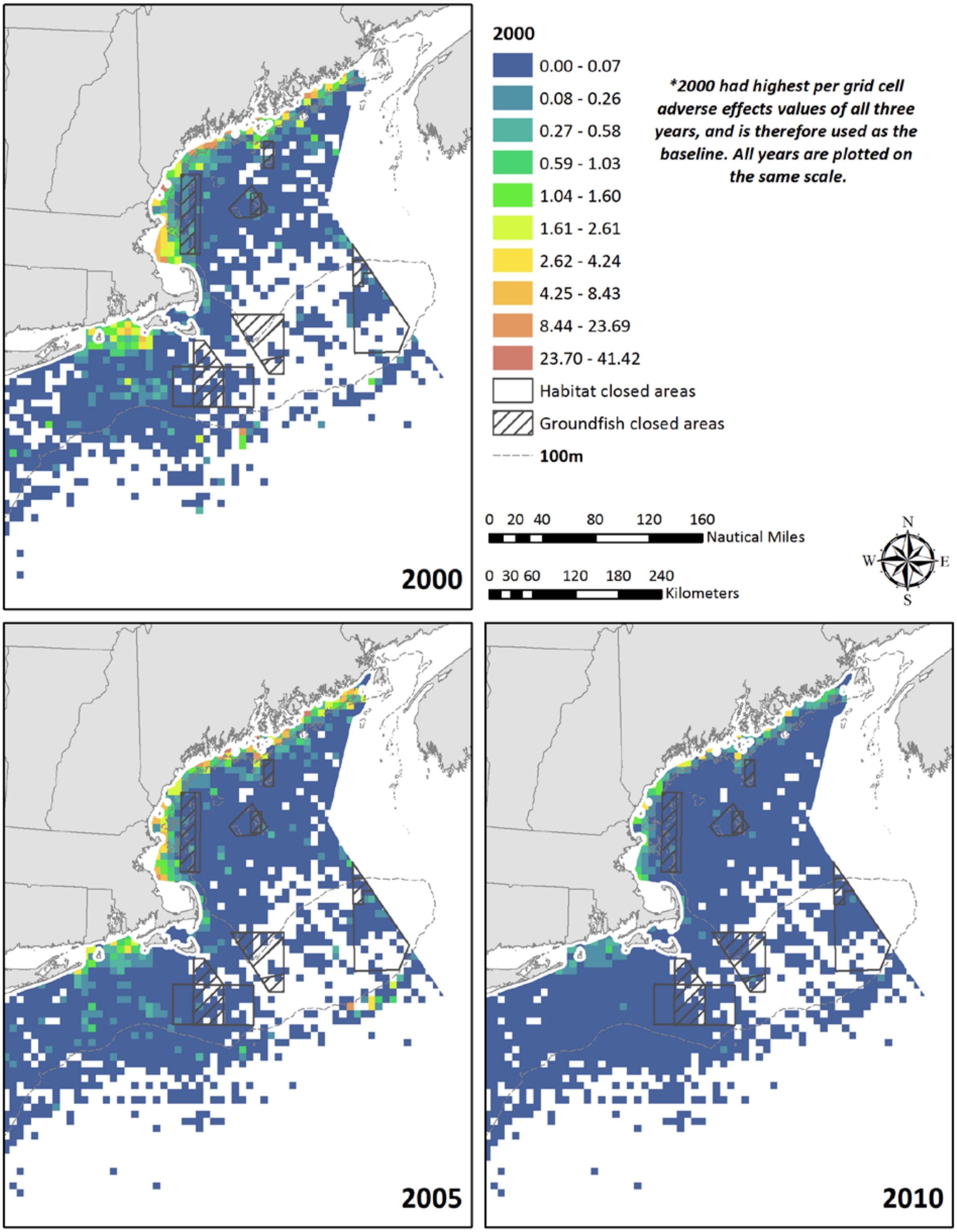
Map 31 – Spatial distribution of realized adverse effects from demersal longline gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.



Map 32 – Spatial distribution of realized adverse effects from sink gillnet gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.



Map 33 – Spatial distribution of realized adverse effects from trap gear type at three timesteps: 2000, 2005, and 2010. All panels use the same color scale.



4.1.4 Species diversity

This section summarizes species diversity within existing areas and other areas under consideration. These values are then compared to determine which areas have the highest and lowest diversity. Species diversity is a measure of both species richness (the number of species in a sample) and species evenness (the relationship between the level of abundance of each species in a sample). An example is shown below to illustrate these concepts. Here, each 'sample' is a survey tow. All other factors being equal, management of an area with higher diversity could have positive benefits for more species than management of an area with lower diversity.

<u>Sample #1 – 100 fish total, has lower species diversity and higher evenness:</u>

- 23 cod
- 27 haddock
- 24 pollock
- 26 redfish

<u>Sample #2 – 100 fish total, has higher species diversity and lower evenness:</u>

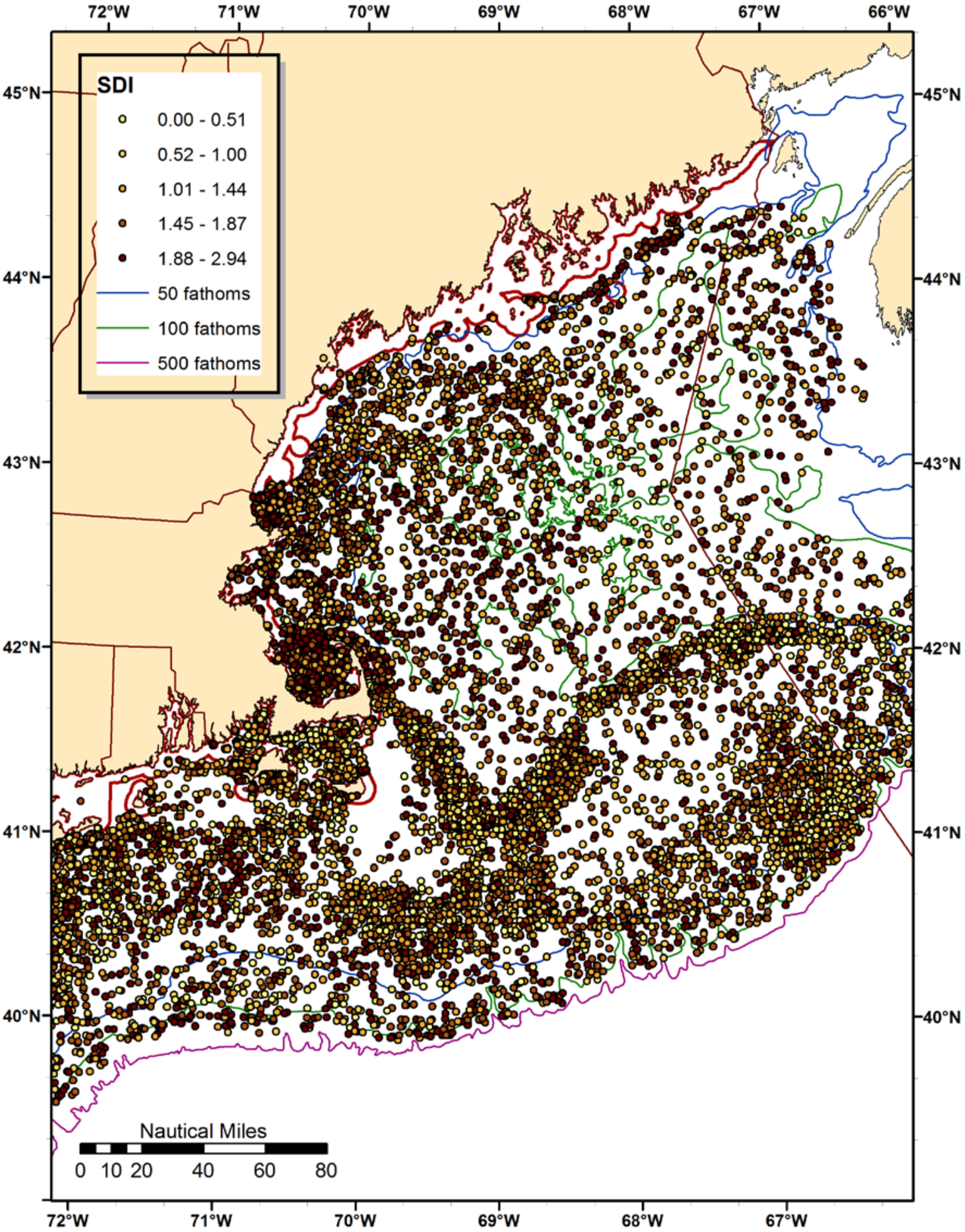
- 2 cod
- 40 haddock
- 12 pollock
- 14 redfish
- 4 silver hake
- 5 red hake
- 4 winter flounder
- 19 yellowtail flounder

There are many indices used by ecologists to quantify species diversity and each has useful attributes (Magurran 2004). Here, two widely used species diversity measures were evaluated. The **Shannon Diversity Index (SDI)** is the most suitable for comparing areas to identify those with highest overall diversity. The calculation of SDI minimizes the effect of abundant species and therefore is sensitive to the number of rare species in a sample. Conversely, the **Simpson Index** is more sensitive to changes in the abundant species in a sample, and may be more appropriate for focusing on managed species. However, a higher Simpson Index value represents a lower diversity due to the way it is calculated. Thus, in this analysis, the Simpson Index is subtracted from 1 to represent an "Inverted" Simpson Index (ISI). Inverted index values were calculated for two groups of species, large mesh groundfish and all regulated species.

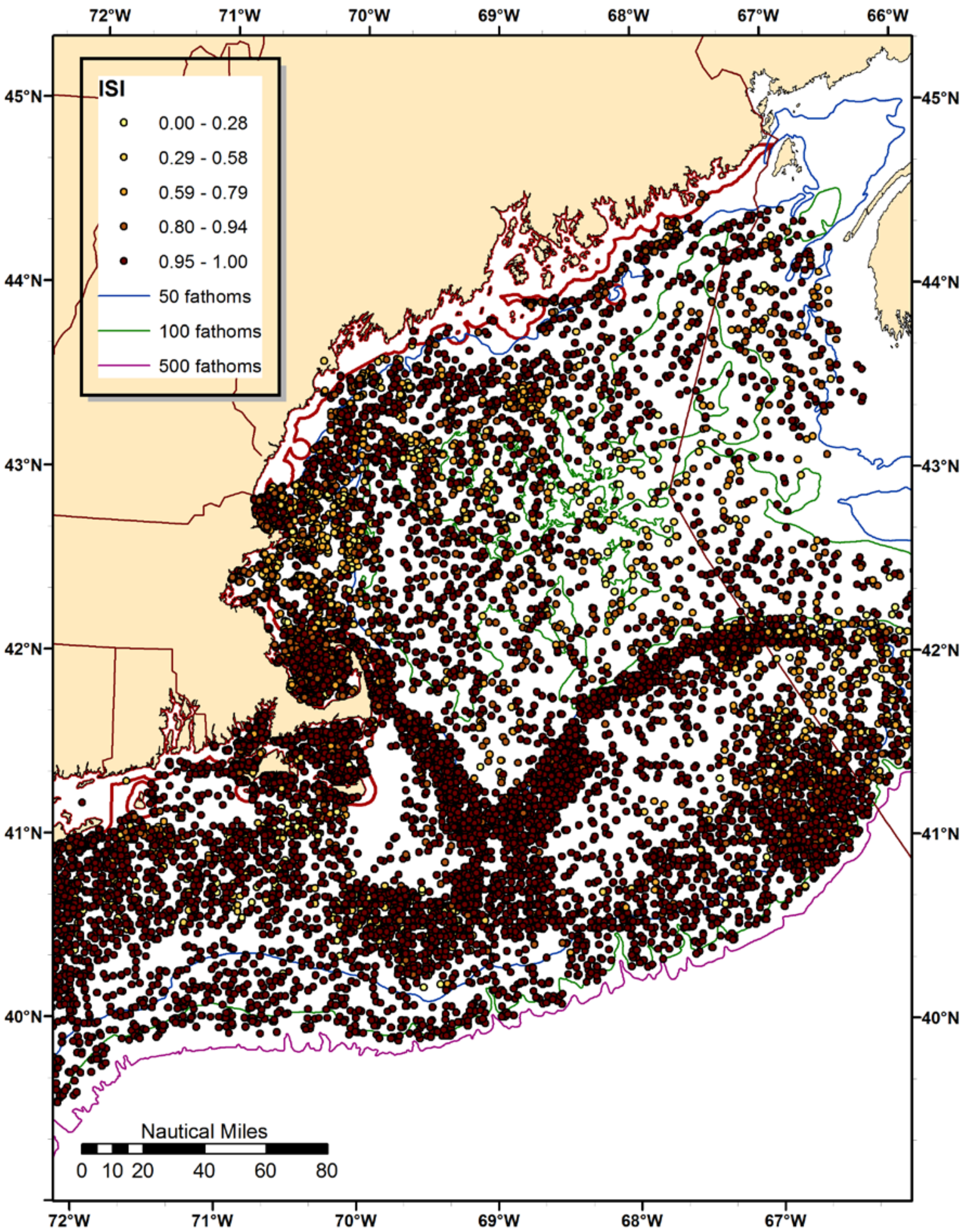
The average Shannon and Simpson diversity indices were calculated for each area using all random and non-random tows from the spring, fall, summer and winter survey data from 2002-2012. The survey data from the NMFS fall/winter/spring trawl survey, the MADMF spring/fall trawl survey, and industry-based surveys for cod, yellowtail flounder and monkfish are used. Each tow is of equal length and the location is randomized.

The species included in large mesh groundfish are: Atlantic cod, haddock, yellowtail flounder, winter flounder, redfish, American plaice, witch flounder, windowpane flounder, white hake, pollock, Atlantic halibut, and Atlantic wolffish. Regulated species include all large mesh groundfish as well as: silver hake, offshore hake, red hake, spiny dogfish, barndoor skate, winter skate, clearnose skate, rosette skate, little skate, smooth skate, thorny skate, herring, sea scallop, monkfish, summer flounder, black sea bass, Atlantic mackerel, butterfish, tautog, American lobster, northern shrimp, northern shortfin squid and longfin squid. The values for each diversity index are plotted in Map 34, Map 35, and Map 36.

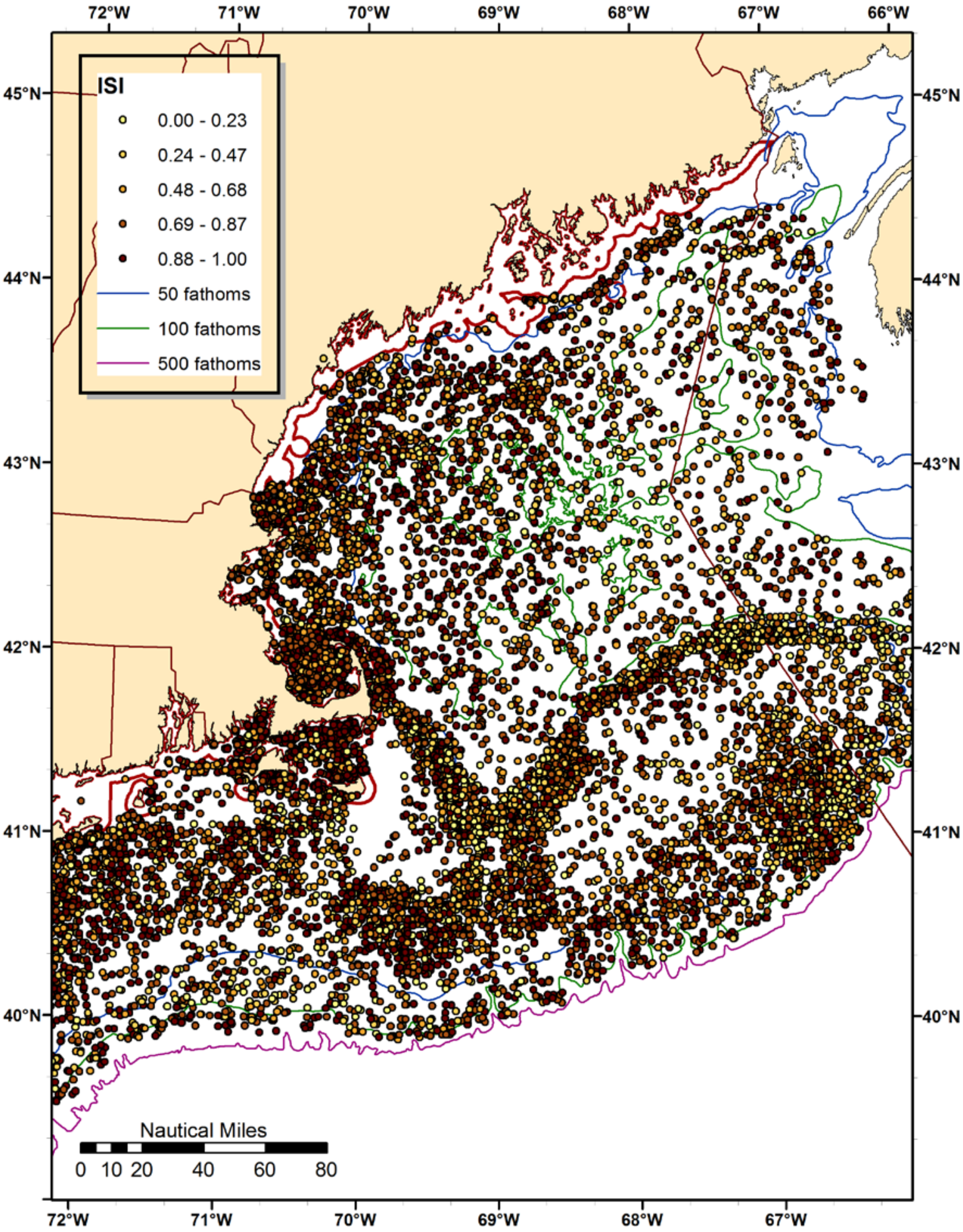
Map 34 – Shannon Diversity Index SDI for all species caught by survey tow from 2002-2012, from NMFS spring/fall/winter trawl data, MADMF spring/fall trawl data and industry-based surveys for cod, yellowtail flounder and monkfish.



Map 35 – Inverted Simpson Index (ISI) for large mesh groundfish by survey tow from 2002-2012, from NMFS spring/fall/winter trawl data, MADMF spring/fall trawl data and industry-based surveys for cod, yellowtail flounder and monkfish.



Map 36 – Inverted Simpson Index (ISI) for regulated species by survey tow from 2002-2012, from NMFS spring/fall/winter trawl data, MADMF spring/fall trawl data and industry-based surveys for cod, yellowtail flounder and monkfish.



Habitat Management Areas

Seasonal species diversity indices of tows within each habitat management area allow comparison of this metric across the possible alternative areas (Table 13). Areas with the highest diversity values (75th percentile) for each diversity index were highlighted with a specific color (groundfish = red, regulated = yellow, all species = green) to indicate which areas are most diverse with respect to groundfish, regulated species and all species. In some cases, ranking varied seasonally. For example, if groundfish diversity in the Cashes Ledge groundfish closure is highlighted in the spring and not in the summer, then the spring diversity ranked in the 75th percentile while the summer diversity did not.

For the areas in **Gulf of Maine**, in the spring, groundfish diversity ranges from 0.372 in Platts Bank 1 to 0.965 in the Machias area. The Machias area is the only area to rank in the 75th percentile for groundfish diversity. Regulated species diversity is lower in the spring than in other seasons, ranging from 0.372 in Platts Bank 1 to 0.745 in the inshore roller gear restricted area. All species diversity ranges from 0.812 in Platts Bank 2 to 1.660 in the small Eastern Maine area. The Jeffreys Bank EFH closure (1.584) and the large Eastern Maine area (1.576) were the other areas with the highest all species diversity.

In the summer, diversity for all species appears to be much higher than other seasons. Most of the areas sampled in the summer rank within the 75th percentile for groundfish and regulated species diversity. Groundfish diversity ranges from 0.854 in the Cashes Ledge groundfish closure to 0.999 in the Toothaker Ridge and the large Eastern Maine areas. The areas with highest groundfish diversity in the summer included the Jeffreys Bank EFH closure (0.998) and the small Bigelow Bight area (0.995). Regulated species diversity ranges from 0.702 in the alternate roller gear restricted area to 0.929 in the large Eastern Maine area. The areas with the highest regulated species diversity include the WGOM groundfish closure (0.926) and the Jeffreys Bank EFH closure (0.923). All species diversity ranges from 1.346 in the WGOM EFH closure to 1.675 in the alternate roller gear restricted area. The Cashes Ledge EFH closure (1.647) and the WGOM groundfish closure (1.595) were also among the areas with highest all species diversity.

Diversity for all species groups in the fall is higher than spring or winter diversity. Groundfish diversity ranges from 0.342 in Platts Bank 1 to 0.999 in the small Eastern Maine area. A value so close to 1.00 indicates there is almost a 100% chance that any two sampled individuals in that area will be of different species. The large Eastern Maine area (0.995), Toothaker Ridge (0.984) and the Cashes Ledge EFH closure (0.976) also has high groundfish diversity. Regulated species diversity ranges from 0.341 in Platts Bank 1 to 0.918 in the Cashes Ledge EFH closure. No other area rank within the 75th percentile for regulated species diversity. All species diversity ranges from 0.685 in Platts Bank 1 to 1.649 in the small Eastern Maine area. The WGOM groundfish closure (1.642), Cashes Ledge EFH (1.615), the inshore roller gear restricted area (1.582) and the Western Gulf of Maine EFH area (1.573) also has high all species diversity.

Diversity in the winter is lower than in the summer and fall. Only the large Eastern Maine rank in the 75th percentile for groundfish (0.995) and regulated species diversity (0.913). All species diversity ranges from 0.432 in the Cashes Ledge groundfish closure to 2.174 in the large Eastern Maine area. The large Bigelow Bight area (1.952) and the small Eastern Maine area (1.763) were also among the areas with highest all species diversity.

For the areas in **Georges Bank and Southern New England**, diversity appears to be lowest in the spring within Georges Bank and Southern New England areas. Groundfish diversity ranges from 0.801 in the west Nantucket Shoals area to 0.996 in the Great South Channel gear modification area. The Great South Channel area is the only area in the spring to rank in the 75th percentile for groundfish diversity. The only area in the spring to rank in the 75th percentile of regulated species diversity is the small Georges Shoal gear modification area (0.781). The lowest regulated species diversity is in the Great South Channel gear modification area (0.502). None of the areas sampled in the spring rank in the 75th percentile for all species diversity. All species diversity ranges from 0.960 in the CAII EFH closure area to 1.393 to the CAI EFH South area.

With a total of 7 areas in the 75th percentile, it appears the highest overall groundfish diversity in the analysis is within Georges Bank/Southern New England areas in the summer. Values range from 0.986 in the small Georges Shoal gear modification area to 0.999 in the CAI groundfish closure, CAII EFH closure and the Great South Channel gear modification area. In addition to the previous areas, the highest groundfish diversity is in the east Great South Channel area and the Nantucket Lightship groundfish closure. The highest regulated species diversity ranges from 0.772 in the Nantucket Lightship EFH closure to 0.857 in the small Georges Shoal gear modification area. The other areas with high regulated species diversity are the Great South Channel area and the CAI EFH South area. All species diversity ranges from 0.659 in the CAII EFH closure to 1.476 in the CAI EFH South closure. The small Georges Shoal gear modification area (1.466) also has high all species diversity.

Fall groundfish diversity is very high in Georges Bank/Southern New England. However, the number of tows within some areas is much lower in the fall than in other seasons. This could result in some misrepresentative diversity values. Groundfish diversity ranges from 0.743 in the Nantucket Lightship EFH closure to 1.000 in the Cox Ledge 1 and west Nantucket Shoals areas. The other areas with high groundfish diversity are the CAI EFH South area and Cox Ledge 2. Regulated species diversity ranges from 0.061 in Cox Ledge 1 to 0.944 in Cox Ledge 2. This is the widest range of diversity values in the analysis. The Nantucket Shoals west area (0.991) and the small Georges Shoal gear modification area (0.773) also have the highest fall regulated species diversity values. All species diversity appears to be highest in the fall in Georges Bank/Southern New England. All species diversity ranges from 0.182 in Cox Ledge 1 to 2.348 in Cox Ledge 1. The other areas with high all species diversity are the small Georges Shoal gear modification area (1.838), the Great South Channel gear modification area (1.768), the CAII EFH closure (1.707), CAI EFH North (1.592), CAI groundfish closure (1.573) and the Great South Channel east area (1.570). The number of tows in Georges Bank/Southern New England areas in the winter is also very low, resulting in potential misleading diversity values.

Winter groundfish diversity ranges from 0.804 in the CAII groundfish closure to 1.000 in CAI EFH South and the large Georges Shoal gear modification area. Regulated species diversity is very high in the winter, evidenced by the high number of areas ranked in the 75th percentile. Regulated species diversity ranges from 0.321 in CAI EFH South to 0.882 in the Great South

Channel east area. The other areas with high regulated species diversity are the Great South Channel area (0.820), the CAI groundfish closure (0.802), the large Georges Shoal gear modification area (0.782), and CAI EFH North (0.776). All species diversity ranges from 0.830 in CAI EFH South to 1.858 in CAI EFH North. The other areas with high all species diversity are the CAI groundfish closure (1.803) and Cox Ledge 1 (1.655).

Table 13 – Average diversity indices by no action and proposed habitat management areas. The 75th percentile for diversity of each species group is highlighted.

	SPRING				SUMMER				FALL				WINTER			
Row Labels	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI
⊟ Gulf of Maine																
⊟ **EFH closure**																
Cashes Ledge EFH	8	0.558	0.462	1.112	5	0.982	0.888	1.647	3	0.976	0.918	1.615	3	0.201	0.201	0.444
Jeffreys Bank EFH	21	0.801	0.729	1.584	17	0.998	0.923	1.405	21	0.810	0.587	1.281	13	0.687	0.674	1.474
Western Gulf of Maine EFH	109	0.651	0.558	1.234	43	0.913	0.877	1.346	49	0.847	0.715	1.573	44	0.577	0.543	1.143
⊟ **Groundfish closure**																
Cashes Ledge GF	12	0.628	0.517	1.158	21	0.854	0.772	1.511	9	0.729	0.619	1.479	5	0.196	0.195	0.432
Western Gulf of Maine GF	11	0.847	0.646	1.567	21	0.972	0.926	1.595	14	0.870	0.756	1.642	2	0.644	0.616	1.571
⊟ **Habitat Management Area**																
Alternate Roller Gear Restricted Area	55	0.701	0.677	1.279	1	0.975	0.702	1.675	38	0.750	0.617	1.324	30	0.594	0.567	1.133
Bigelow Bight, large	48	0.769	0.636	1.435	11	0.987	0.897	1.484	19	0.904	0.628	1.402	16	0.867	0.765	1.763
Bigelow Bight, small	37	0.766	0.677	1.474	18	0.995	0.917	1.484	18	0.760	0.587	1.302	12	0.673	0.658	1.475
Eastern Maine, large	23	0.929	0.676	1.576	9	0.999	0.929	1.462	10	0.995	0.757	1.510	2	0.995	0.913	2.174
Eastern Maine, small	20	0.881	0.710	1.660					6	0.999	0.839	1.649	2	0.881	0.820	1.952
Inshore Roller Gear Restricted Area	547	0.801	0.746	1.565	83	0.964	0.896	1.514	331	0.844	0.685	1.582	94	0.608	0.566	1.181
Jeffreys Bank EFH, modified	11	0.655	0.631	1.421	3	0.901	0.882	1.401	5	0.618	0.518	1.100	12	0.850	0.675	1.469
Machias	1	0.965	0.701	1.424												
Platts Bank 1	3	0.497	0.496	1.067					1	0.342	0.341	0.685	1	0.368	0.368	0.733
Platts Bank 2	2	0.372	0.372	0.812					2	0.551	0.523	1.197				
Toothaker Ridge	5	0.871	0.664	1.563	16	0.999	0.914	1.549	4	0.984	0.855	1.483				
⊟ Georges Bank/Southern New England																
⊟ **EFH closure**																
Closed Area I EFH N	65	0.969	0.555	1.156	84	0.993	0.498	0.908	20	0.854	0.727	1.592	3	0.932	0.776	1.858
Closed Area I EFH S	15	0.994	0.739	1.393	19	0.992	0.795	1.476	7	0.999	0.537	1.223	1	1.000	0.321	0.830
Closed Area II EFH	14	0.839	0.541	0.960	25	0.999	0.381	0.659	6	0.980	0.711	1.707				
Nantucket Lightship EFH	114	0.821	0.709	1.075	78	0.993	0.772	1.158	106	0.743	0.594	1.079	15	0.982	0.530	1.149
⊟ **Groundfish closure**																
Closed Area I GF	75	0.983	0.610	1.234	123	0.999	0.543	1.023	16	0.985	0.659	1.573	1	0.994	0.802	1.803
Closed Area II GF	173	0.869	0.658	1.240	276	0.989	0.628	1.112	80	0.876	0.611	1.417	6	0.803	0.500	1.068
Nantucket Lightship GF	147	0.868	0.658	1.166	120	0.997	0.510	0.937	130	0.817	0.596	1.152	22	0.987	0.630	1.308
⊟ **Habitat Management Area**																
Cox Ledge 1	2	0.983	0.754	1.389					2	1.000	0.061	0.182	2	0.982	0.695	1.655
Cox Ledge 2									1	0.998	0.944	2.348				
Great South Channel	38	0.968	0.769	1.334	19	0.993	0.805	1.248	30	0.984	0.664	1.466	1	0.824	0.820	1.223
Great South Channel Gear Modification Area	60	0.996	0.502	1.050	94	0.999	0.543	0.920	14	0.974	0.750	1.768				
Great South Channel, east	66	0.994	0.672	1.195	72	0.998	0.482	0.846	12	0.986	0.656	1.570	3	0.890	0.882	1.189
Nantucket Shoals, west	5	0.801	0.654	1.434					1	1.000	0.991	0.710				

Spawning Areas

Seasonal species diversity indices of tows within each spawning management area allow comparison of this metric across the possible alternative areas (

Table 14). For this analysis, the areas with the highest diversity values (75th percentile) for each index were highlighted with a specific color. Groundfish diversity is highlighted in red, regulated diversity in yellow and all species in green. Only the winter and spring tows within the areas were analyzed to overlap with the spawning closure seasons.

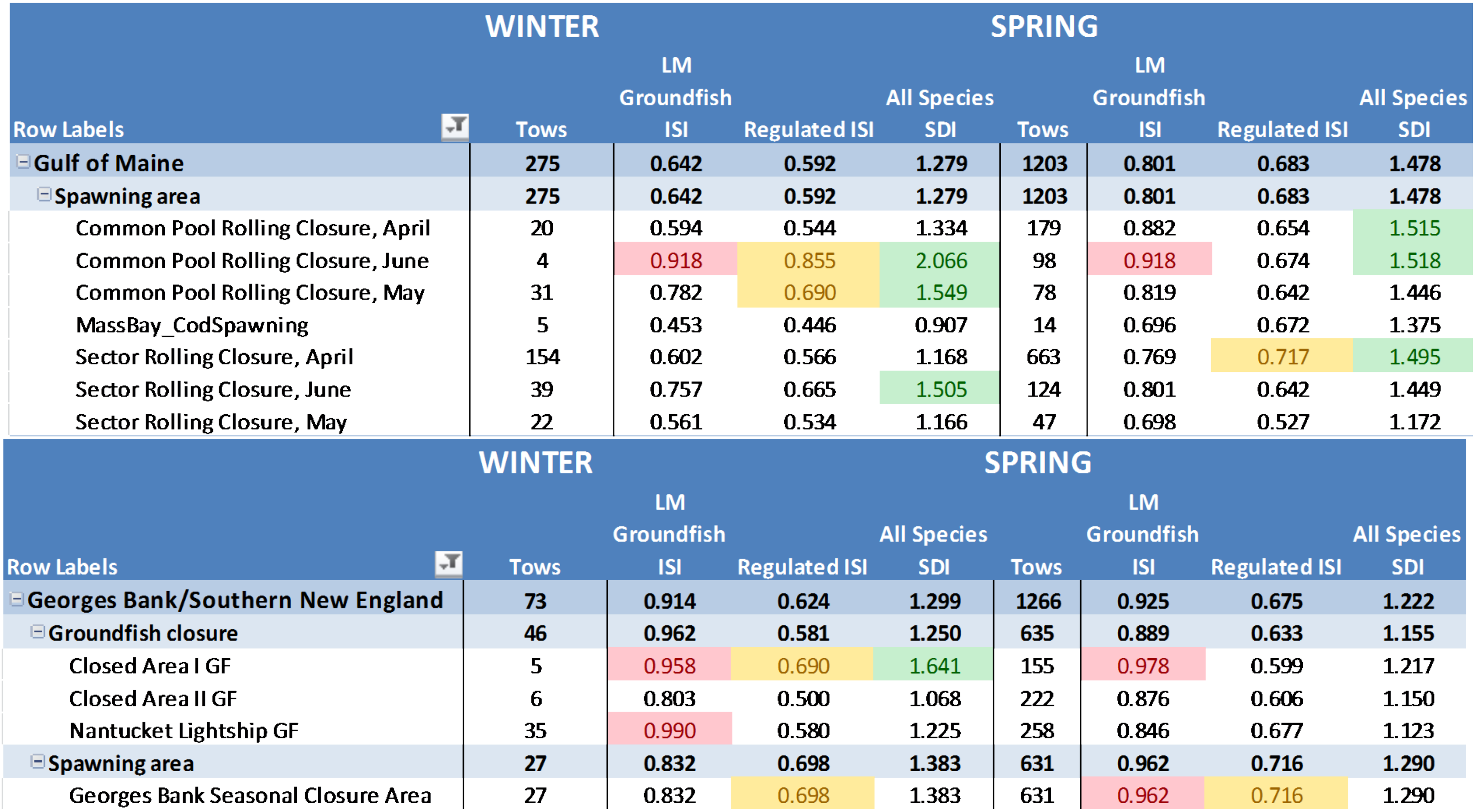
For areas in the **Gulf of Maine**, winter groundfish diversity ranges from 0.453 in the Massachusetts Bay cod spawning area to 0.918 in the June common pool rolling closure. Winter groundfish diversity in the June rolling closure is much higher than in other areas. Regulated species diversity in the winter ranges from 0.446 in the Massachusetts Bay cod spawning area to 0.855 in the June common pool rolling closure. Regulated species diversity is also high within the May common pool rolling closure (0.690). All species diversity ranges from 0.907 in the Massachusetts Bay cod spawning area to 2.066 in the June common pool rolling closure. The May common pool rolling closure (1.549) and the June sector rolling closure (1.505) also has high all species diversity.

Spring groundfish diversity ranges from 0.696 in the Massachusetts Bay cod spawning area to 0.918 in the June common pool rolling closure. Regulated species diversity ranges from 0.642 in the May common pool rolling closure and June sector rolling closure to 0.717 in the April sector rolling closure. All species diversity ranges from 1.172 in the May sector rolling closure to 1.518 in the June common pool rolling closure. The April common pool rolling closure (1.515) and the April sector rolling closure (1.495) also has high all species diversity.

For areas in **Georges Bank/Southern New England**, winter groundfish diversity ranges from 0.832 in the Georges Bank seasonal closure area to 0.990 in the Nantucket Lightship groundfish closure. Winter groundfish diversity is also high in the CAI groundfish closure (0.958). Regulated species diversity ranges from 0.500 in the CAII groundfish closure to 0.698 in the Georges Bank seasonal closure area. Regulated species diversity is also high within the CAI groundfish closure (0.690). All species diversity ranges from 1.068 in the CAII groundfish closure 1.641 in the CAI groundfish closure.

Spring groundfish diversity ranges from 0.846 in the Nantucket Lightship groundfish closure to 0.978 in the CAI groundfish closure. Regulated species diversity ranges from 0.599 in the CAI groundfish closure to 0.716 in the Georges Bank seasonal closure area. All species diversity ranges from 1.123 in the Nantucket Lightship groundfish closure to 1.290 in the Georges Bank seasonal closure area.

Table 14 - Average diversity indices by no action and proposed spawning areas. The 75th percentile for diversity of each species group is highlighted.



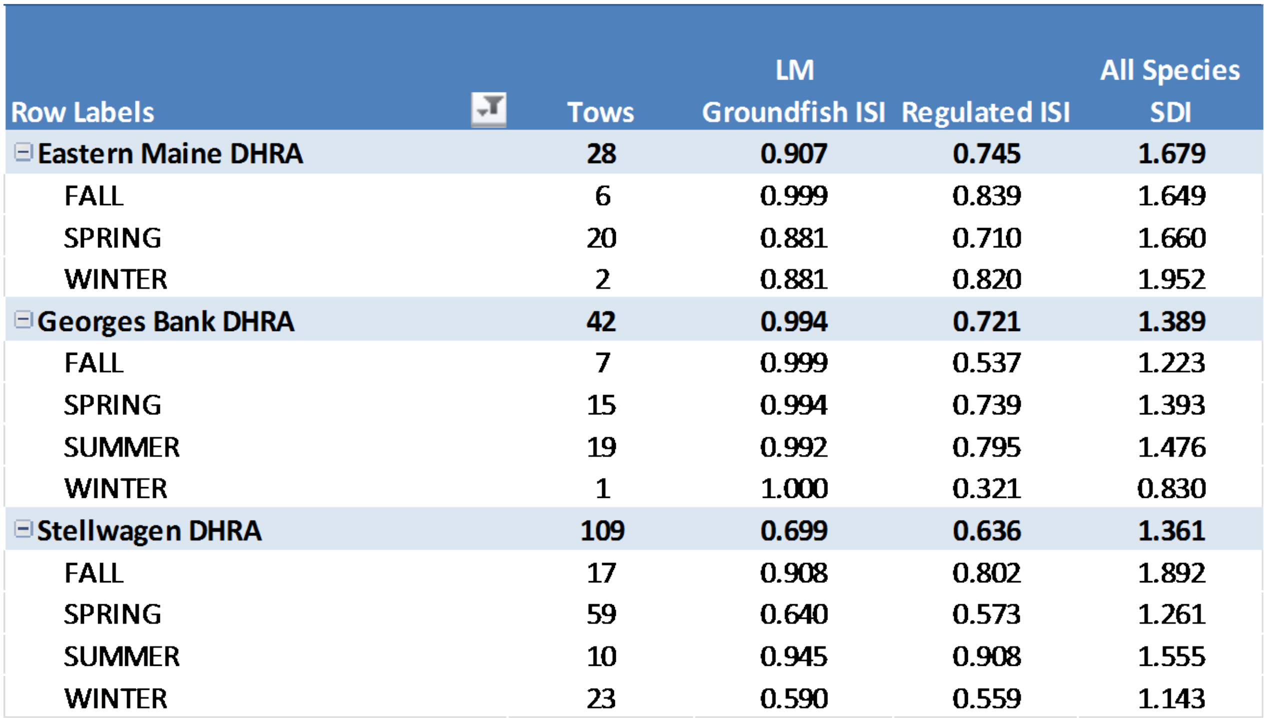
	WINTER				SPRING			
Row Labels	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI
⊟Gulf of Maine	275	0.642	0.592	1.279	1203	0.801	0.683	1.478
⊟Spawning area	275	0.642	0.592	1.279	1203	0.801	0.683	1.478
Common Pool Rolling Closure, April	20	0.594	0.544	1.334	179	0.882	0.654	1.515
Common Pool Rolling Closure, June	4	0.918	0.855	2.066	98	0.918	0.674	1.518
Common Pool Rolling Closure, May	31	0.782	0.690	1.549	78	0.819	0.642	1.446
MassBay_CodSpawning	5	0.453	0.446	0.907	14	0.696	0.672	1.375
Sector Rolling Closure, April	154	0.602	0.566	1.168	663	0.769	0.717	1.495
Sector Rolling Closure, June	39	0.757	0.665	1.505	124	0.801	0.642	1.449
Sector Rolling Closure, May	22	0.561	0.534	1.166	47	0.698	0.527	1.172

	WINTER				SPRING			
Row Labels	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI
⊟Georges Bank/Southern New England	73	0.914	0.624	1.299	1266	0.925	0.675	1.222
⊟Groundfish closure	46	0.962	0.581	1.250	635	0.889	0.633	1.155
Closed Area I GF	5	0.958	0.690	1.641	155	0.978	0.599	1.217
Closed Area II GF	6	0.803	0.500	1.068	222	0.876	0.606	1.150
Nantucket Lightship GF	35	0.990	0.580	1.225	258	0.846	0.677	1.123
⊟Spawning area	27	0.832	0.698	1.383	631	0.962	0.716	1.290
Georges Bank Seasonal Closure Area	27	0.832	0.698	1.383	631	0.962	0.716	1.290

DHRAs

Seasonal species diversity indices of tows within each dedicated habitat research area were averaged to allow comparison of this metric across the three possible alternative areas (Table 15). Groundfish diversity ranges from 0.699 in the Stellwagen DHRA to 0.994 in the Georges Bank DHRA, the highest groundfish diversity value in this analysis. The range of regulated species diversity is much narrower, ranging from 0.636 in the Stellwagen DHRA to 0.745 in the Eastern Maine DHRA. All species diversity ranges from 1.361 in the Stellwagen DHRA to 1.679 in the Eastern Maine DHRA. The lack of summer data in the Eastern Maine DHRA and the low amount of fall and winter tows in the Eastern Maine and Georges Bank DHRA may have impacted the average diversity values.

Table 15 – Average diversity indices by DHRA and season.



Row Labels	Tows	LM Groundfish ISI	Regulated ISI	All Species SDI
⊟ **Eastern Maine DHRA**	**28**	**0.907**	**0.745**	**1.679**
FALL	6	0.999	0.839	1.649
SPRING	20	0.881	0.710	1.660
WINTER	2	0.881	0.820	1.952
⊟ **Georges Bank DHRA**	**42**	**0.994**	**0.721**	**1.389**
FALL	7	0.999	0.537	1.223
SPRING	15	0.994	0.739	1.393
SUMMER	19	0.992	0.795	1.476
WINTER	1	1.000	0.321	0.830
⊟ **Stellwagen DHRA**	**109**	**0.699**	**0.636**	**1.361**
FALL	17	0.908	0.802	1.892
SPRING	59	0.640	0.573	1.261
SUMMER	10	0.945	0.908	1.555
WINTER	23	0.590	0.559	1.143

4.2 Managed species

The managed species valued ecosystem component includes the following fishery resources:

- Northeast multispecies
- Monkfish
- Skates
- Atlantic sea scallop
- Atlantic herring
- Deep-sea red crab

- Surfclam and ocean quahog
- Northern shrimp
- American lobster
- Atlantic bluefish
- Atlantic mackerel, squid, and butterfish
- Spiny dogfish
- Summer flounder, scup, and black sea bass
- Golden tilefish

4.2.1 Biology, status, and overall distribution

This section describes the distribution, life history, spawning behavior, habitat associations, and stock status of various managed species. Species are grouped by fishery management plan, with individual species sections listed in alphabetical order by common name. The EFH designations themselves (Volume 2) and the accompanying supplementary Appendix B contain additional information about the distribution and habitat preferences of species managed by the New England Council. Although technically a managed species, imformation about Atlantic salmon is located in the protected resources section, because the fishery management plan prohibits possession of Atlantic salmon and there is no commercial fishery for the stock.

Maps were prepared to show the distribution of each species throughout the New England region. Total biomass per tow for the spring and fall trawl surveys from 2002-summer 2013 was plotted over stock boundaries described in SAW (http://www.nefsc.noaa.gov/nefsc/saw/), TRAC (http://www2.mar.dfo-mpo.gc.ca/science/TRAC/rd.html), and Status of the Stock (http://www.nefsc.noaa.gov/sos/) documents. For species that had data to analyze age 0/1 and large spawner hotspots, abundance and biomass per tow data were also plotted, respectively.

4.2.1.1 Northeast multispecies (groundfish)

4.2.1.1.1 Acadian redfish

The Acadian redfish (*Sebastes faciatus*) is a long-lived rockfish species found in moderate to deep waters in the Gulf of Maine as well as in moderate depths (EFH to 600 m) along the continental slope off the Northeast US. Adults are found throughout the deep basins in the Gulf of Maine, but juvenile redfish are restricted to somewhat shallower depths. A similar species, *S. mentella,* co-occurs with *S. faciatus* along the continental slope and is not distinguished in survey catches.

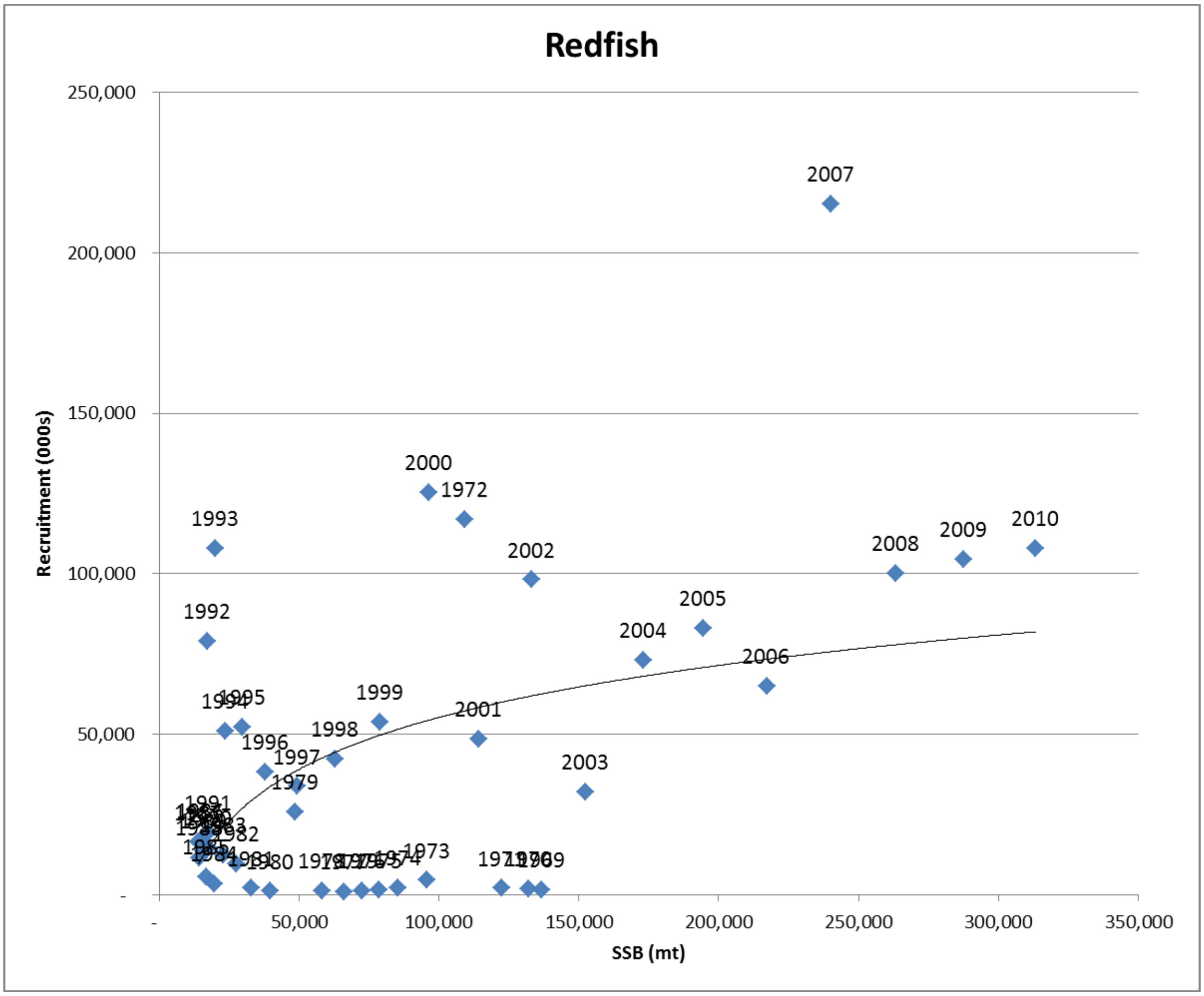
Redfish are found primarily on mud habitats, often associated with living and non-living structures. Habitat association studies in the deep mud habitats near Stellwagen Bank found that juvenile redfish were one of the most numerous species observed on deep (50-100 m) boulder reefs (Auster and Lindholm 2005). The redfish appear to use these reefs for cover and for access to increased current flows above the reef, where drifting zooplankton prey can be consumed at higher rates. Early juveniles were found primarily on the reefs themselves, while late juveniles were found on both the reefs and among dense aggregations of cerianthid anemones (Auster et al. 2003). These life stages, ages up to 5-7 years, were considered year-round residents with small home ranges (Auster et al. 2003). Redfish have also been observed in association with hard bottom habitat and corals on ‘bump’ habitats in Western Jordan Basin (Auster 2005).

Crustaceans are the most important prey item for both juveniles and adults. Juveniles and adults also consume larvaceans, which are free-swimming, filter feeding, soft-bodied invertebrates. Adults will eat silver hake, and to a much lesser extent, other fish. The proportion of fish in the diet increases with increasing redfish size.

Redfish have internal fertilization and bear live young. The larvae are released throughout the adult range from April through August, with peak activity in late May/early June. MARMAP surveys (1977-1987) found larvae between March and October. In spring, abundance was greatest at slope stations off the southern flank of Georges Bank, but by late summer the larvae were more common in the Gulf of Maine.

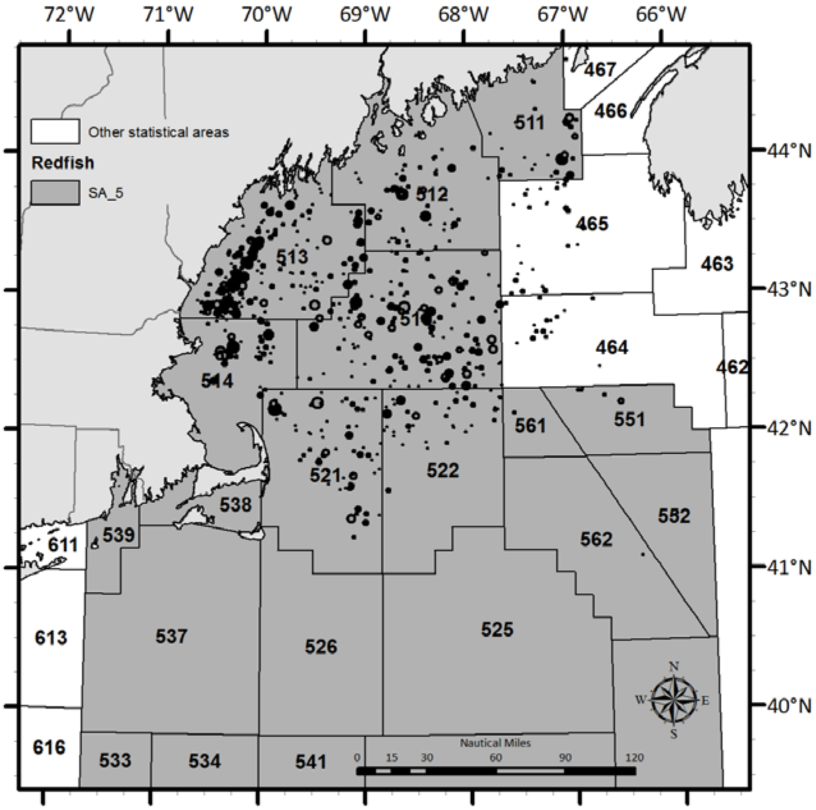
Redfish are managed within the Northeast Multispecies FMP as a large mesh species. Biomass of the single stock (Map 37) currently exceeds the target, and appears to have increased between 2007 (2008 GARM) and 2010 (2012 assessment update). Recruitment appears to have increased between 2008 and 2010. Fishing mortality rates have remained low. Recently, there has been interest in increasing the harvest of redfish in the Gulf of Maine. Because of their relatively small size, redfish are not retained in large numbers using legal-sized mesh. An experimental, small mesh trawl fishery was conducted during 2011, and currently a there is a small mesh exemption that can be used to target redfish, provided that there is 100% observer coverage and various other requirements are met (78 Federal Register 14226).

Figure 3 – Recruitment and spawning stock biomass estimates for Redfish (NMFS stock assessments)

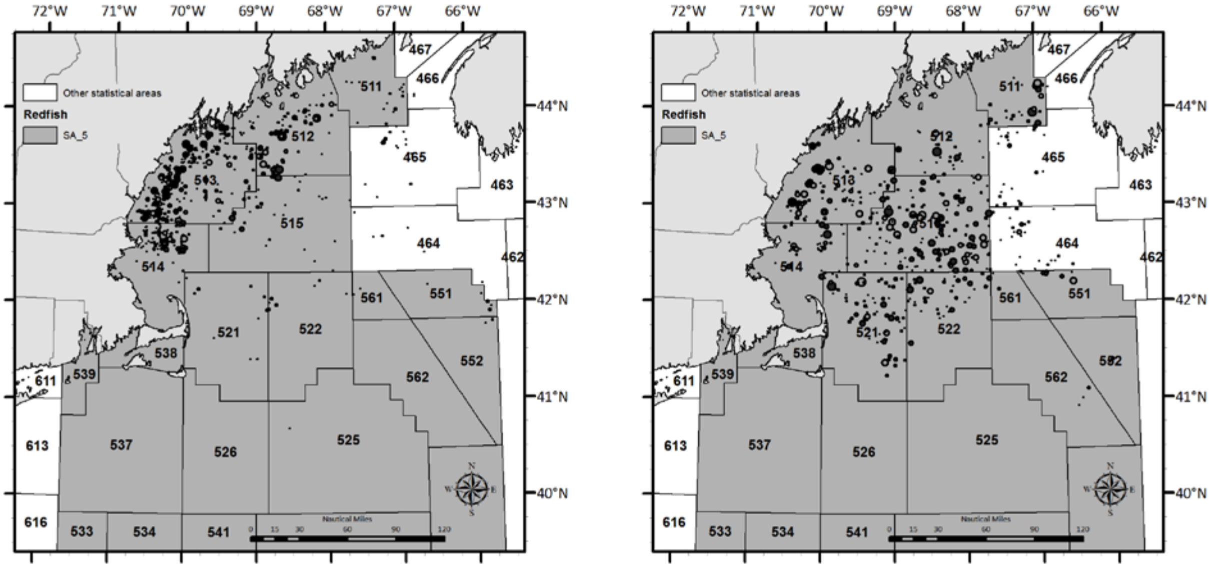


Map 37 – Acadian redfish stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

Total biomass (kg/tow)



Juvenile abundance < 15cm (#/tow) **Spawner biomass > 30cm (kg/tow)**



4.2.1.1.2 American plaice

American plaice (*Hippoglossoides platessoides*) are a benthic flatfish found mainly in the Gulf of Maine and to a lesser extent along the northern edge of Georges Bank. Juveniles in particular are more abundant in shallower, inshore waters; the adults occur both in coastal regions and in deeper waters (Methratta and Link 2007, Johnson 2004). Plaice travel from relatively cool, deep water in the fall to relatively cool, shallow water in the spring (Methratta and Link 2006). They spawn between March and mid-June in the Gulf of Maine, with peak activity during April and May (Bigelow and Schroeder 1953, Colton et al 1979, Smith et al 1975).

Some distributional metrics have shifted over time. Between 1968 and 2007, plaice have experienced significant range expansion, decrease in maximum latitude, and increase in mean depth, however there are no significant trends in poleward movement, minimum latitude, or mean temperature (Nye et al 2009).

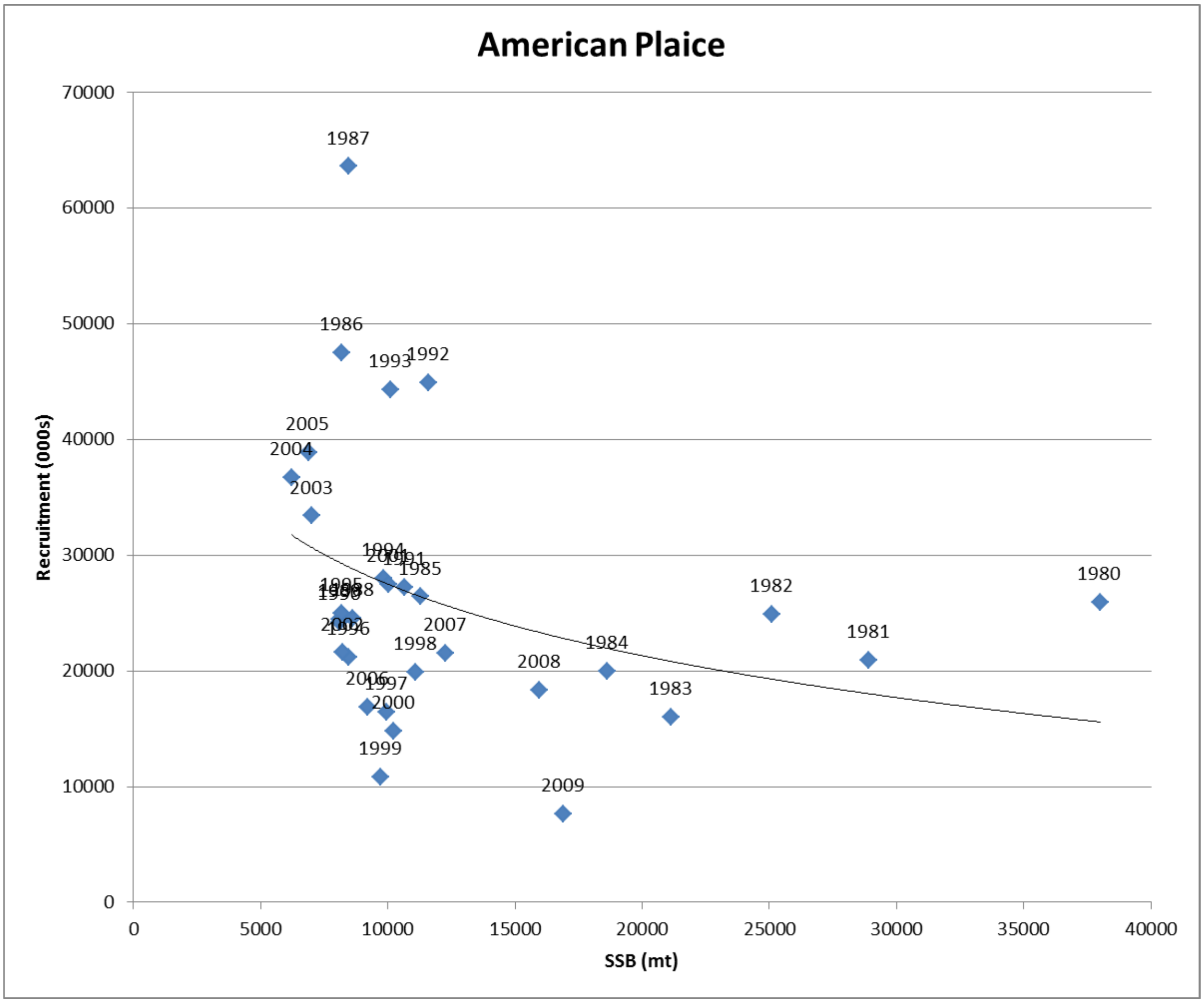
They are associated with mud, sand, and fine gravel substrates, although gravel associations have been documented based on work conducted off Newfoundland and in the North Sea, not in our portion of the North Atlantic (Sparholt 1990, Langton and Bowman 1981, Scott and Scott 1988, Bowering and Brodie 1991, Morgan 2000, Scott 1982, Keats 1991). Plaice do not use benthic structures for shelter.

In the southern part of its range in the Gulf of Maine, the spawning season extends from March through the middle of June, with peak spawning activity in April and May (Bigelow and Schroeder 1953; Colton et al. 1979; Smith et al. 1975). Nursery areas are found in coastal waters of the Gulf of Maine (Bigelow and Schroeder 1953).

Plaice feed on a variety of benthic prey including echinoderms such as sand dollars, polychaete worms, crustaceans, and bivalves.

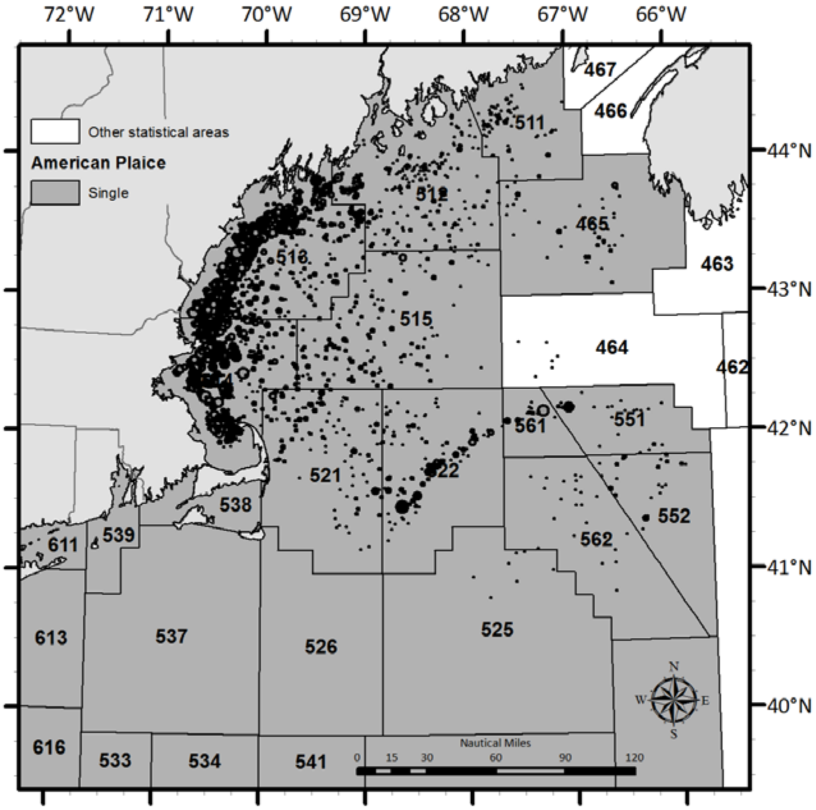
The species is managed as a single stock (Map 38). GARM III (2008) and the 2012 assessment updated indicated that the stock is not overfished and overfishing is not occurring. Biomass increased between 2008 and 2012. Recruitment appears to be at an all-time low in 2009.

Figure 4 - Recruitment and spawning stock biomass estimates for American plaice (NMFS stock assessments)

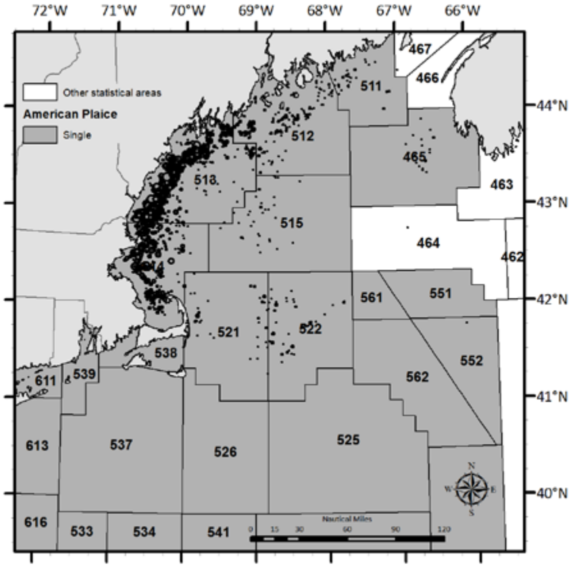


Map 38 – American plaice stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

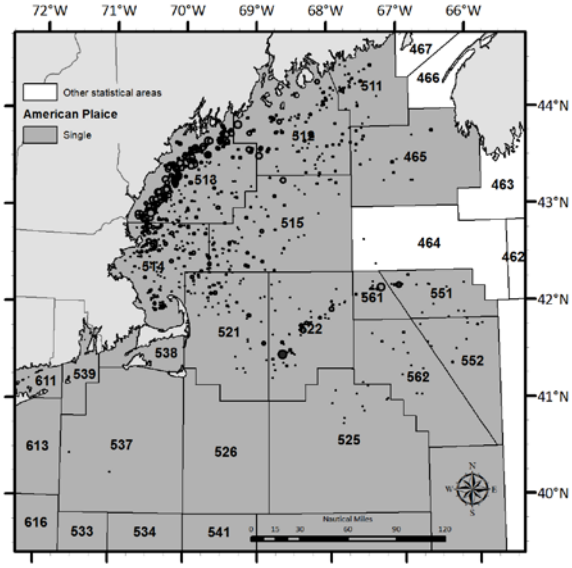
Total biomass (kg/tow)



Juvenile abundance < 20cm (#/tow)



Spawner biomass > 40cm (kg/tow)



4.2.1.1.3 Atlantic cod

In U.S. waters, adults and juveniles are widespread in the shallower areas of the Gulf of Maine, including inshore waters as well as on shallow offshore banks and ledges. They are particularly concentrated in the southwestern GOM. Howe et al. 2002 analyzed 22 years of semi-annual inshore research-trawl survey and calculated the mean catch per tow, mean length and frequency of occurrence for age 0 and 1 cod to conclude that age 0 cod preferred depths <90’ while age 1 cod stayed within 61-180’ (Howe et al. 2002). In the fall, age 0 cod were widely distributed from 31-180’ and age 1 cod preferred 121-180’ (Howe et al. 2002). As a general conclusion, smaller and younger cod occupied shallower depths and would move deeper in the water column as they would grow and age.

Howe et al. compiled this data to determine which coastal embayments served as a settlement area for juvenile cod. Age 0 densities were highest in Ipswich Bay and on the shore of Mass. Bay and Cape Cod Bay in the spring and highest north of Cape Ann, on the shore of Mass. Bay and in all of Cape Cod Bay in the autumn. Age 1 densities were highest in Ipswich Bay, Mass. Bay and northern Cape Cod Bay in the spring and highest north of Cape Ann and in central Mass. Bay in the autumn.

Cod are widely distributed on Georges Bank, with the highest concentrations on the northern edge and in the Great South Channel. Adults are found somewhat further south than juvenile cod, to at least NJ in spring. A recent analysis of 1968-2005 NMFS survey data from the NE region shows that juvenile cod (<35 cm) were more likely to be caught in depths of 30-120 m, whereas adults were more likely to be caught between 30 and 160 m. Analysis of trawl survey data from the NW Atlantic shows that, as they age, cod inhabit increasingly deeper waters (Tremblay and Sinclair 1985; Wigley and Serchuk 1992; Anderson and Gregory 2000; Dalley and Anderson 2000).

Over time, the range of Georges Bank cod has contracted and their center of distribution has moved north. Gulf of Maine cod have not experienced significant range contraction, but the stock has moved south (Nye et al. 2009).

Lough (2010) concluded that the northeastern gravel area on Georges Bank may provide a “survival bottleneck” depending on the distribution and abundance of juvenile cod settlement in relation to that of their predators. Juveniles were widespread across Georges Bank in June and in mid-July they were found on all bottom types from sand to gravel on eastern Georges Bank (Lough 2010). By late July/early August they had they were found to be most abundant on the northeastern edge gravel deposit where the complex relief levels provided abundant prey and refuge from predators (Lough 2010). The distribution patterns of pelagic and recently settled juvenile cod were examined from nine surveys on Georges Bank in the summer from 1984-1989 to relate the survival of juveniles to the sedimentary environment (Lough 2010).

Analyzing the vertical distribution patterns of juvenile haddock and cod on Georges Bank, Lough and Potter 1994 found that pelagic juveniles moved deeper as they grew. By mid-July most juveniles (~40 mm in length) were associated with deeper waters (Lough and Potter 1994).

The juveniles would remain demersal during the day and migrate 3-5m upwards at night. Cod would typically be situated at shallower depths than haddock at smaller sizes (Lough and Potter 1994). These distribution patterns were summarized from eight research cruises that took place on Georges Bank during the spring and summer from 1981-1986.

Cod exhibit seasonal migrations. Methratta and Link (2006) analyzed 1968-2002 spring and fall NEFSC trawl survey data in relation to depth and bottom temperatures and described cod as a species that remains in cool water, migrating from deeper water in the fall to shallower water in the spring. A similar pattern has been observed in the Maine/New Hampshire inshore trawl survey. Specifically, data from 2000-2007 showed that juveniles (<35 cm) were more likely to be caught between 10 and 50 m in the spring and at two different depth intervals (20-30 and 50-90 m) in the fall, while adults were more likely to be caught between 80 and 110 m in the spring and 80-140 m in the fall, with a very abrupt increase in catch rates at 80 m during both seasons.

Cod are demersal gadids, usually found within two meters or so of the bottom (Klein-MacPhee 2002). Larger fish generally stay closer to the bottom unless feeding in the water column. They are associated with a variety of bottom types, but prefer coarser substrates. Analysis of trawl survey data (all sizes) from the NMFS survey stratum that includes the Stellwagen Bank National Marine Sanctuary (SW Gulf of Maine) showed a significant positive relationship with bottom reflectance, i.e., higher catches on harder bottom (Auster et al. 2001). Acoustic tagging studies and underwater observations in this same area have revealed that cod are associated with gravel and deep (50-100 m) boulder reef habitats (Lindholm and Auster 2003, Auster and Lindholm 2005, Lindholm et al. 2007). Some adults remained on the reef while others departed the area rapidly following release. Video surveys and hook-and-line sampling suggested that cod are most abundant in complex habitats such as rocky ledge and cobble habitats. Analysis of 1998-2002 spring and fall NEFSC trawl survey data (kg/tow, all sizes) in relation to sediment type showed that cod catch rates were higher in coarse sand, fine rock, and coarse rock substrates (ten minute squares with mean grain sizes of 0.25-8 mm) and that cod consistently distinguished fine rock (2-8 mm) from all finer-grained substrates (Methratta and Link 2006b).

Juvenile settlement studies have mainly been conducted in the laboratory and in nearshore locations, even though young-of-the-year cod are known to also utilize deeper, offshore habitats. Inshore studies generally confirm a preference among young-of-the-year juveniles for structured bottom habitats that provide shelter from predators (see, for example, Gotceitas and Brown 1993; Gotceitas et al, 1995; Borg et al. 1997; Gregory et al. 1997, Linehan et al. 2001; Lazzari and Stone 2006).

Age 0-1 cod preferred gravel substrates when the threat of predation was not present, but older cod (age 2+) would move into more coarse substrates (Gregory et al. 1997, Gotceitas and Brown 1993). Based on an analysis of the distribution of juvenile cod relative to available habitat in Newfoundland waters, Gregory et al. concluded that 80% of age 2-4 juvenile cod were associated with coarse substrate areas and high bathymetric relief. In contrast, 59% of age-1 cod were associated with areas with a gravel substrate and low relief (Gregory et al. 1997). Gregory et al. considered numerous factors in their classification of habitat: depth, substrate type, bathymetric relief and the presence or absence of macroalgae (Gregory et al. 1997). Neither of the age groups appeared to show a preference for the presence or absence of macroalgae. Most of the juvenile cod in both age groups were found at depths greater than 60 meters. Deep-sea submersibles were used to analyze the seabed in Placentia Bay, Newfoundland where juvenile cod ages 1-4 were settled. Gregory et al. analyzed a total of 40 hours of videotape and audiotape as well as written records from 13 day dives and 2 night dives performed in April 1995 (Gregory et al. 1997).

Gotceitas and Brown (1993) analyzed the effect of predation as a factor influencing the distribution of juvenile cod amongst substrate types, concluding that juvenile cod will move from sand/gravel-pebble substrates to cobble substrates in the presence of a predator. The tested cod were collected from an inshore area at Bellevue, Newfoundland and split into two age groups. The first group was juvenile cod age 0+ and the second group was larger cod age 3+, which were introduced as the predators (Gotceitas and Brown 1993). The juvenile cod were housed in separate tanks in a laboratory where the temperature was maintained between 5-10°C. In separate tanks with water maintained between 5-10°C, the juvenile cod were given the choice between pairs of three different substrates: sand, gravel-pebble and cobble (Gotceitas and Brown 1993). Before the age 3+ cod were introduced into the tanks, juveniles settled into either the sand/gravel-pebble substrates and in the presence of a predator, juveniles hid in the substrates where cobble was present (Gotceitas and Brown, 1993). Two and a half hours after the age 3+ cod were removed, the larger juvenile cod showed a preference to the finer-grained substrates whereas the smaller juvenile cod continued to associate with the cobble (Gotceitas and Brown, 1993).

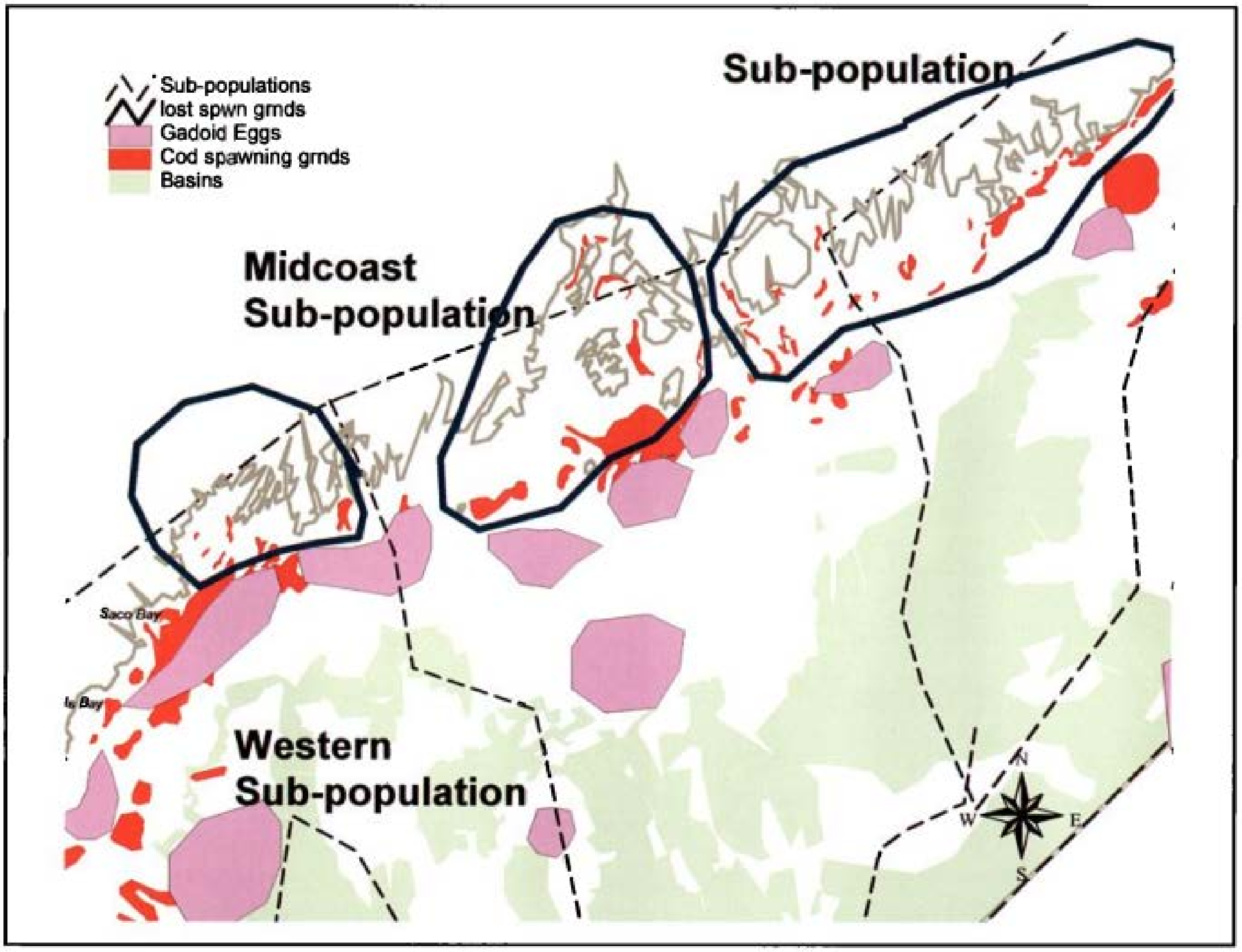
Offshore habitat association studies on Georges Bank indicate that there is a narrow window when cod are closely associated with gravel substrates. Submersible studies on eastern Georges Bank (Lough et al. 1989, Valentine and Lough 1991) showed that recently-settled cod and haddock are widely dispersed over the bank and are present on a range of sediment types from sand to gravelly sand to gravel pavement. However, by late July and August, these fish occur predominantly on the gravel pavement habitat on the northeastern part of the bank and are absent from sandy areas. It is not clear if this represents low survival on sand, or migration to gravel habitats. During late summer, as they continue to grow, they are carried to the east and southeast in the residual bottom current, and by fall they are more widely dispersed and are no longer confined to gravel pavements.

Studies in the SWGOM have found very young juvenile cod along the margins of boulder reefs (Lindholm and Auster 2003, Auster and Lindholm 2005, Lindholm et al. 2007). These juveniles would hide amongst the cover provided by rocky substrate and epifauna when disturbed. Grabowski et al. (in press) analyzed trawl survey data from mid-coast Maine and reported that larger juveniles (10-25 cm) were far more abundant on gravel than on mud or sand bottom. Examination of tows conducted at similar depths demonstrated that juvenile cod densities on gravel were more abundant than those on either sand (20-35 m) or mud (35-50 m).

In the Gulf of Maine, Cape Cod Bay, Ipswich Bay, and Massachusetts Bay were most often cited in the literature as cod spawning areas. Saco Bay and Jeffries Ledge were identified as cod spawning locations less frequently in the reviewed literature. There were no conclusions within the literature that directly disputed the evidence that cod spawning is occurring in those areas. However, after conducting a region-wide tag and recapture study on Atlantic cod, Tallack concludes that spawning in the Gulf of Maine is occurring year-round and throughout the entire region rather than within specific areas and times (Tallack 2008).

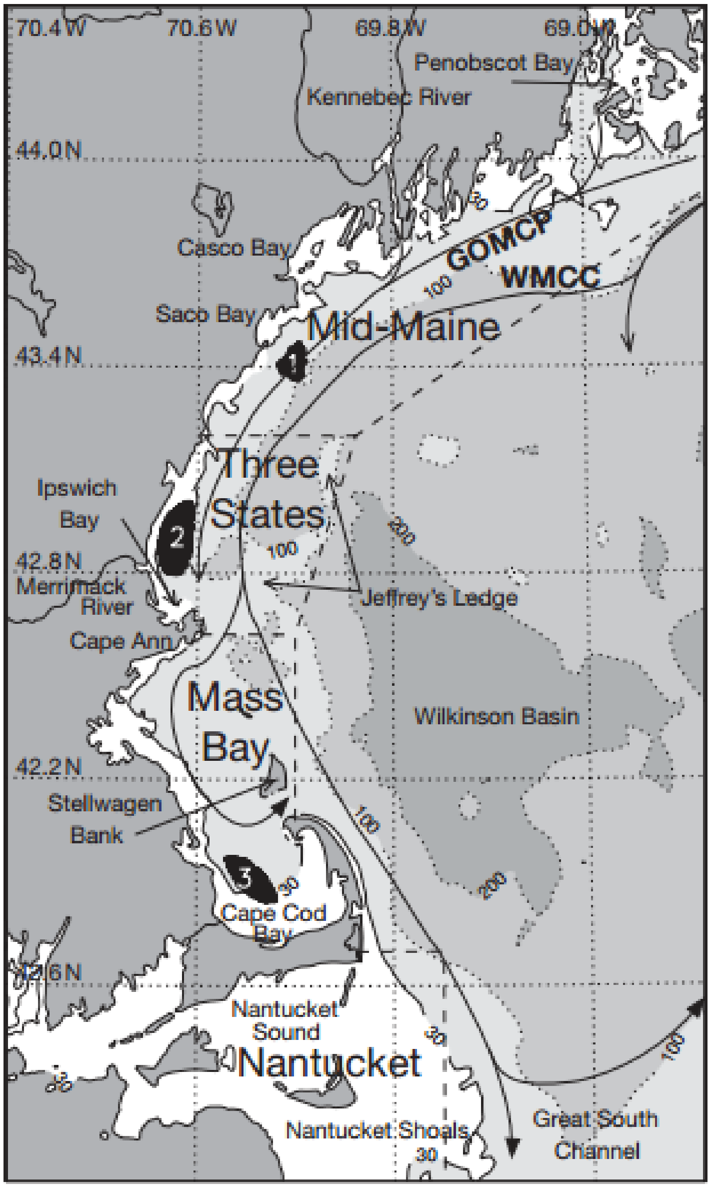
Ames analyzed cod larval and egg data from the 1920s and corroborated that data with surveys of retired fishermen to identify numerous cod spawning locations mostly within the inshore Gulf of Maine. This was one of the most comprehensive analyses on cod spawning locations in New England waters. Ames concluded that these data were consistent with current cod populations and with the existence of localized spawning components (Ames 2004). The work done by Ames provided a basis for several of the other papers in this review and was often cited in other literature. The spawning grounds identified by Ames are displayed in Figure 5.

Figure 5 – Cod spawning areas. Circled areas indicate former spawning grounds that are no longer active. Ames, 2004.



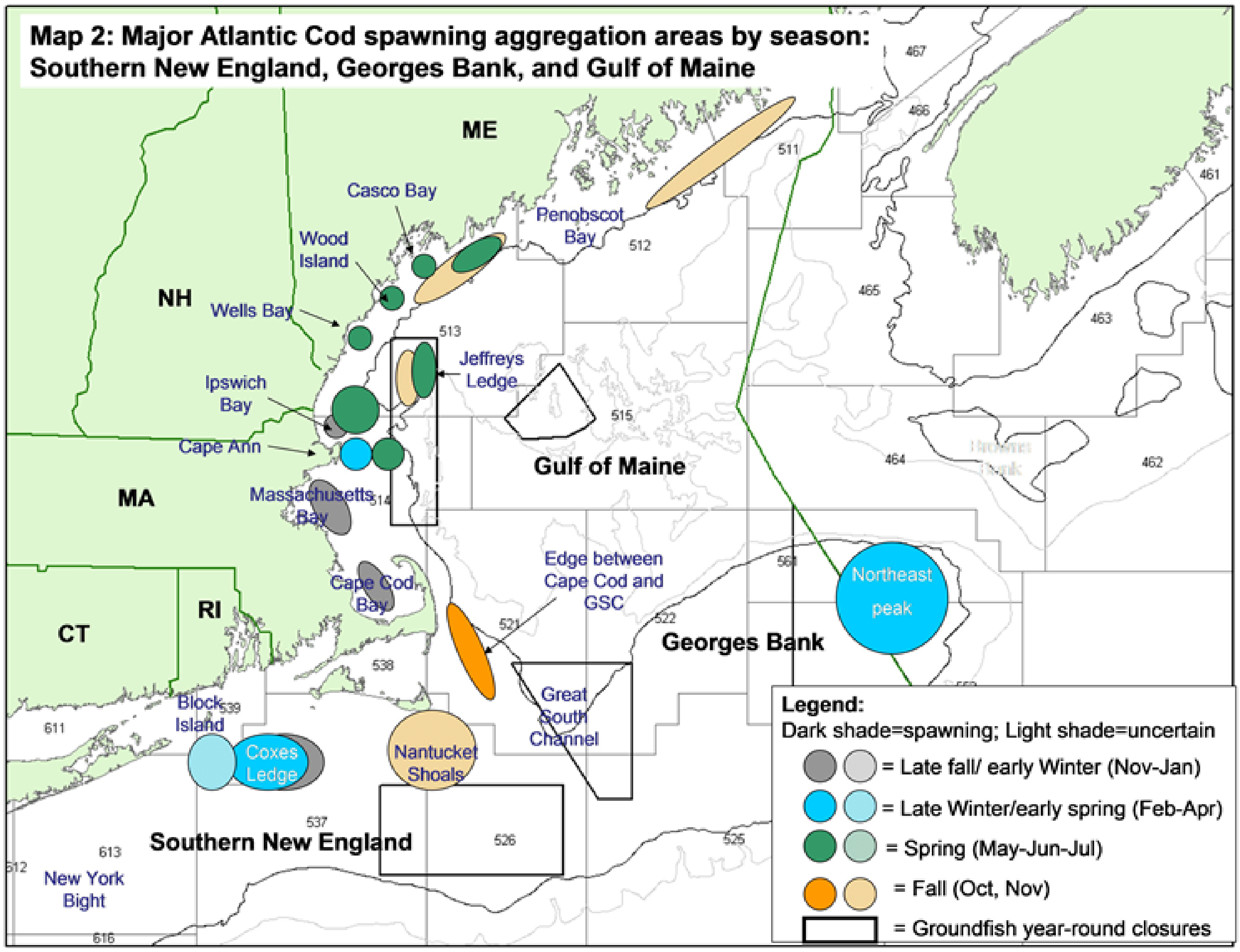
Huret et al. also identified a larger range of cod spawning areas at different times of the year within Ipswich Bay, Cape Cod Bay and Saco Bay. Huret et al. identified cod spawning periods from May to July and December to January in Ipswich Bay, December to January in Cape Cod Bay and July and October for Saco Bay (See Figure 6). Huret et al. assessed transport success of larvae from major spawning grounds to nursery areas with particle tracking using the unstructured grid model FVCOM (finite volume coastal ocean model)(Huret et al. 2007). Spawning grounds were identified in order to determine the starting point of these larvae paths.

Figure 6 – Locations of 3 identified cod spawning grounds. 1 - Saco Bay. 2 - Ipswich Bay. 3 - Cape Cod Bay. Source: Huret et al. 2007.



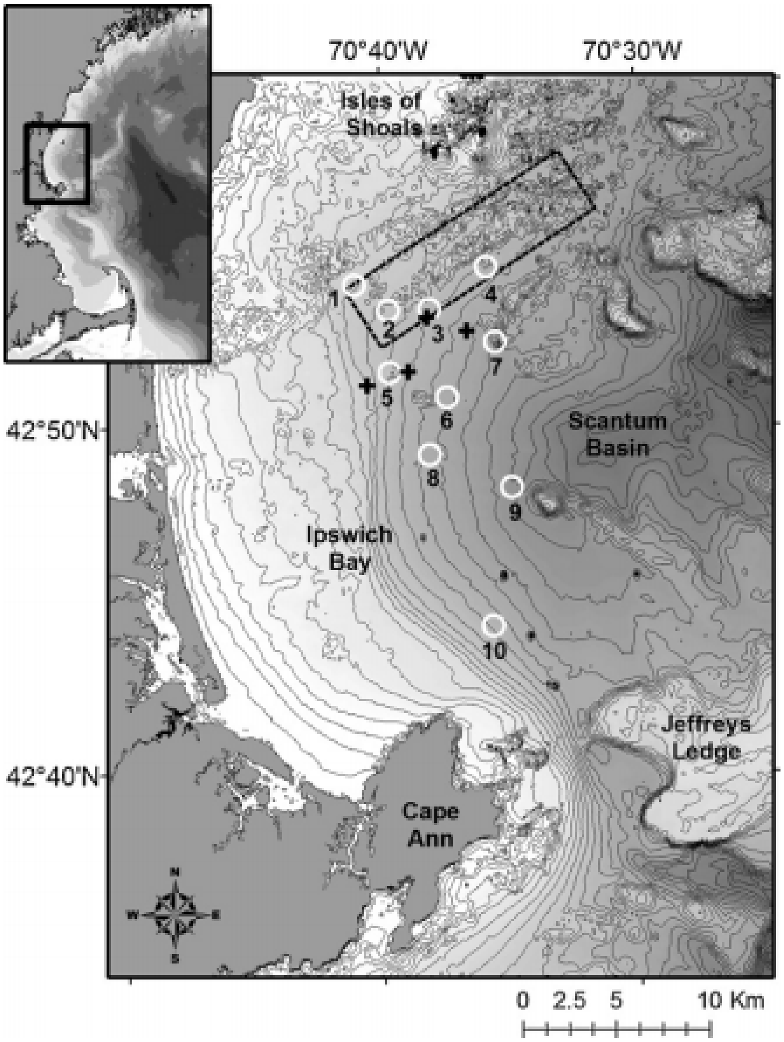
Deese reviewed observations of Atlantic Cod spawning aggregations off the northeastern United States, synthesizing data from sources such as research surveys and fishermen's observations. Deese identifies cod spawning aggregations in locations both in the Gulf of Maine and Georges Bank. In the inshore Gulf of Maine specifically, Deese indicates there is fall and winter spawning in Cape Cod Bay, Massachusetts Bay and Ipswich Bay. Aggregations of cod that may be spawning occur along the western Maine coast and on Jeffries Ledge (Deese 2005). Fall spawning also occurs in the inshore areas of Cape Cod down to Nantucket Shoals and winter spawning is observed in the Coxes ledge area (Deese 2005). Outside of fall and winter, major aggregations of spawning cod are observed off Cape Ann from March-April and in Ipswich Bay from May-June (Deese 2005). A summary of these spawning areas by season are displayed in Figure 7.

Figure 7 – Summary of cod spawning areas. Source: Deese 2005.



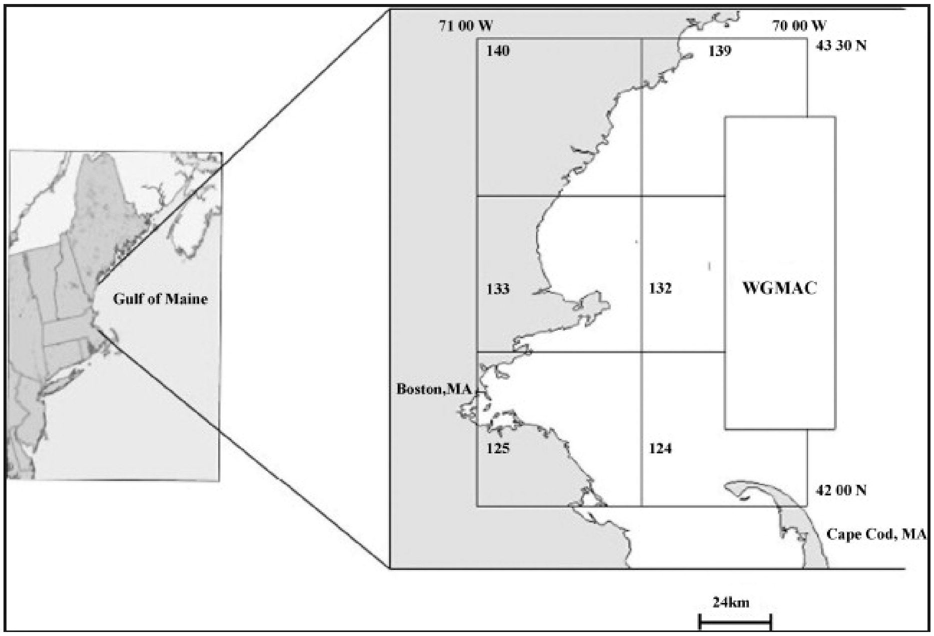
Colton et al. summarized that cod spawned on Browns Bank from March-April (peaking in March), in what may be the most comprehensive layout of spawning locations and times for cod and other species in this review. While the modern relevance of the analysis may be questionable due to the year in which it and the cited papers were published, it does nonetheless provide a simple and informative look at spawning in New England waters. The spawning summaries are based primarily on published data collected by the National Marine Fisheries Service, icthyoplankton surveys of the Gulf of Maine performed in the 1950s and 1960s, and published data from earlier literature ranging from 1929 to 1953 (Colton et al. 1979). Siceloff and Howell identified the “Whaleback” feature (see Figure 8) as a location where spawning cod would aggregate, at depths > 40m after conducting a cod tagging study that examined spawning cods’ movement within Ipswich Bay (Siceloff and Howell 2012). The tagged spawning cod aggregated in small, concentrated groups around specific humps and ridges (Siceloff and Howell 2012). The spawning areas were <60 km² in size with a mean size of 41 km² (Siceloff and Howell 2012). The analysis performed by Siceloff and Howell was instrumental in establishing the whaleback closure in Framework 45.

Figure 8 – Bathymetic map of Ipswich Bay. Black dotted rectangle highlights the elevated bathymetric feature "Whaleback". Source: Siceloff and Howell 2012.



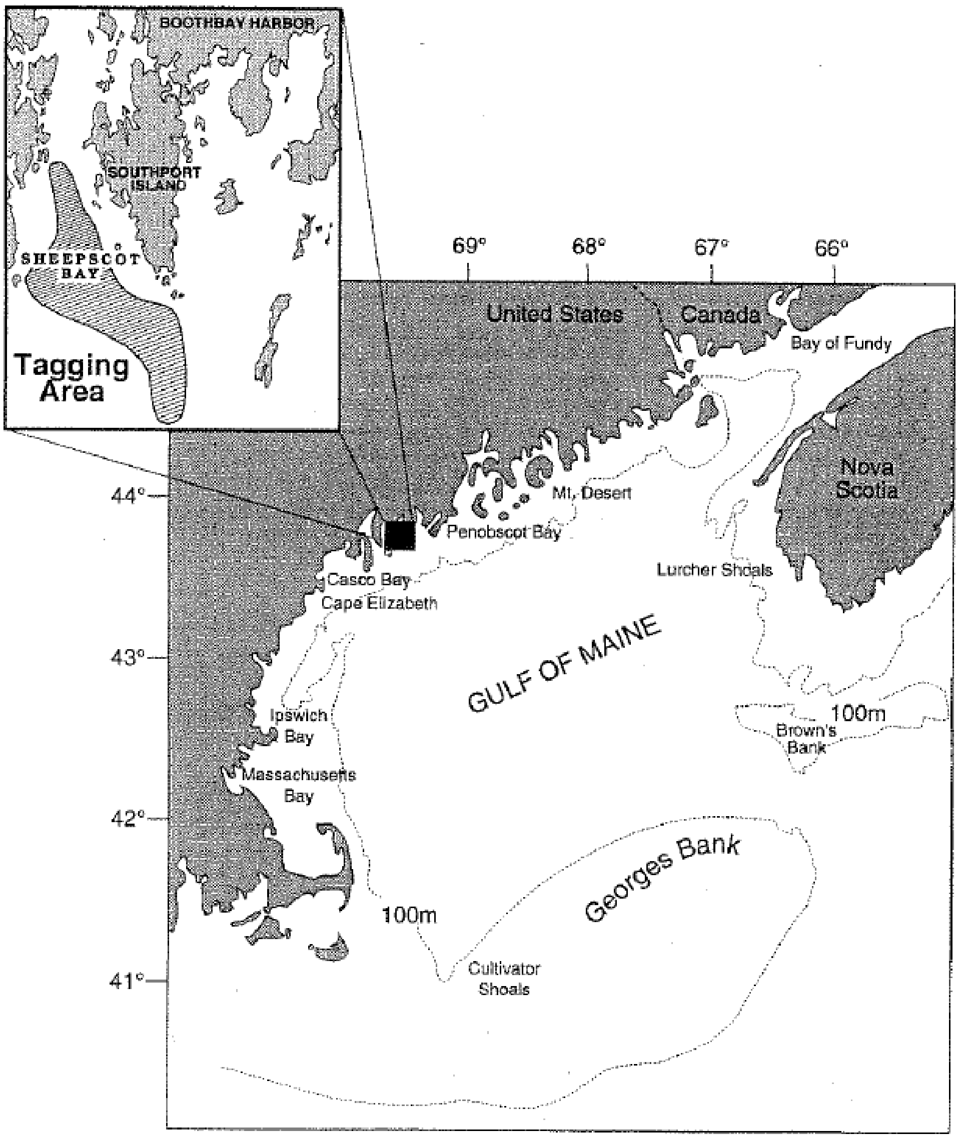
After analyzing the results of a mark and recapture study of cod in the western Gulf of Maine, Howell et al. concluded that there were two spawning groups in Area 133; a winter group that spawns from November to January and a spring group that spawns from April to July. A total of 27,772 cod were tagged and 1334 were recaptured with sufficiently detailed recapture location noted (Howell et al. 2008). Howell et al. observed that the general pattern was a concentration of large cod into Area 133, a small inshore area in both the spring and winter, with dispersion from that area in the ensuing months (Howell et al. 2008). The location of Area 133 is shown in Figure 9.

Figure 9 – Areas where cod were tagged in the western Gulf of Maine (Howell et al. 2008).



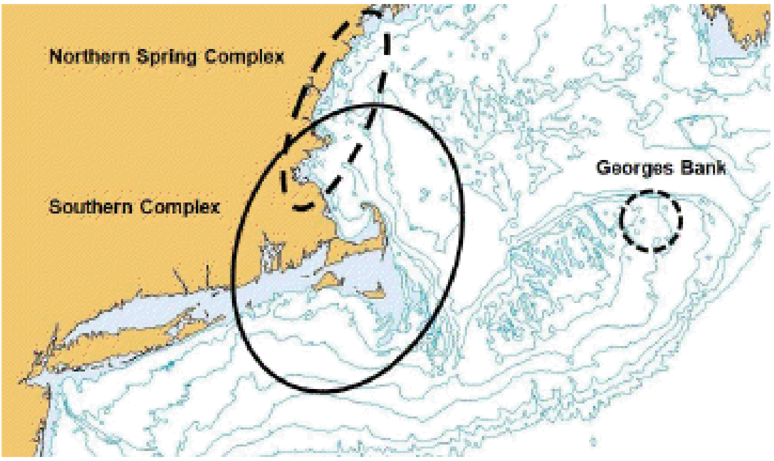
Perkins et al. 1997 conducted a cod tagging study within Sheepscot Bay and concluded there were seasonal cod spawning aggregations within Sheepscot Bay from May to July. 4,191 cod were tagged between 1978 and 1983 and over 7% of the tagged fish were recaptured within six years of their release (Perkins et al. 1997). The cod were tagged and released offshore within Sheepscot Bay and most of the recaptured cod were caught along the coast from Cape Elizabeth to the Bay of Fundy. Perkins et al. observed the emission of milt and eggs by mature Atlantic cod from late March to mid-July within the tagging area (see Figure 10).

Figure 10 – Map of the Gulf of Maine showing the location of Sheepscot Bay, where cod were tagged and released from 1978-1982. (Perkins et al. 1997)



Berlinsky 2009 and Morin 2000 identified two cod spawning complexes; a spring spawning complex in the northern Gulf of Maine and a spring/winter spawning complex in the western Gulf of Maine (see Figure 11). These areas are not quite as specific as in the previous analyses. Berlinsky's research was a partnership of commercial fisherman and scientists from UNH and NYU with the purpose of investigating stock definitions for Atlantic cod using 10 microsatellite and 6 SNP markers (Berlinsky 2009). Morin used a mark and recapture method.

Figure 11 – Proposed cod spawning complexes. (Berlinsky 2009)



Berlinsky concluded in 2009 that cod spawning on Georges Bank was concentrated within the northeast area, mostly in gravel substrates with complex relief levels. Lough and Potter reinforced that conclusion, having concluded that peak cod spawning on Georges Bank occurs in that same area, peaking in February and March. Lough and Potter placed more emphasis on bottom sediment type and its relation to cod spawning. The northeast peak, previously identified as the location where most cod spawning takes place, was cited as "dominated by gravel with portions of sand, common boulder areas and tightly packed pebbles (Lough and Potter 2010). The Colton et al. analysis also noted that cod spawning occurred on Nantucket Shoals from January-April (peaking in January). Literature on cod spawning in Georges Bank was scarcer than for the Gulf of Maine and the conclusions drawn from the available literature cited larger and less specific spawning areas. While not directly disputing the conclusions made by the available literature, Tallack's 2008 analysis indicates that spawning is very protracted and occuring throughout all of Southern New England, as well.

Overall, 90% of spawning occurs from mid-November to mid-May with a peak in late winter and early spring (60% between February 23 and April 6, MARMAP data, 1978-1987). On Georges Bank, spawning peaks in February and March (GLOBEC data, 1995-1999). Spawning periods are shifted later in the Gulf of Maine.

Copepods of various species are important prey for larvae and pelagic juveniles. After settlement, cod switch to benthic prey items. Juveniles consume mainly crustaceans, while adults eat mostly fish, and also crabs and squid. Herring and silver hake are common in the diet of adult cod.

The Atlantic cod is managed as two stocks in U.S. waters, Gulf of Maine and Georges Bank and further south (Map 39). The GOM stock was last assessed at the 53rd Stock Assessment Workshop. It is overfished and overfishing is occurring. Biomass estimates are reduced from the previous assessment, partly due to perception of 2005 year class, partly due to reduced weight at age estimates. Fishing mortality has been relatively flat since 2001, but high in terminal year of assessment (2010). Stock recruitment and spawning biomass were both low in 2010. *Add updated stock structure/assessment information.*

The GB assessment was last updated in 2012 (update, not benchmark). The stock was overfished with overfishing occurring. The assessment found a smaller biomass estimate, slightly higher recruitment and higher fishing mortality rate as compared to 2008 GARM estimates. *Transboundary information to be added.*

Figure 12 - Recruitment and spawning stock biomass estimates for Gulf of Maine cod (NMFS stock assessments)

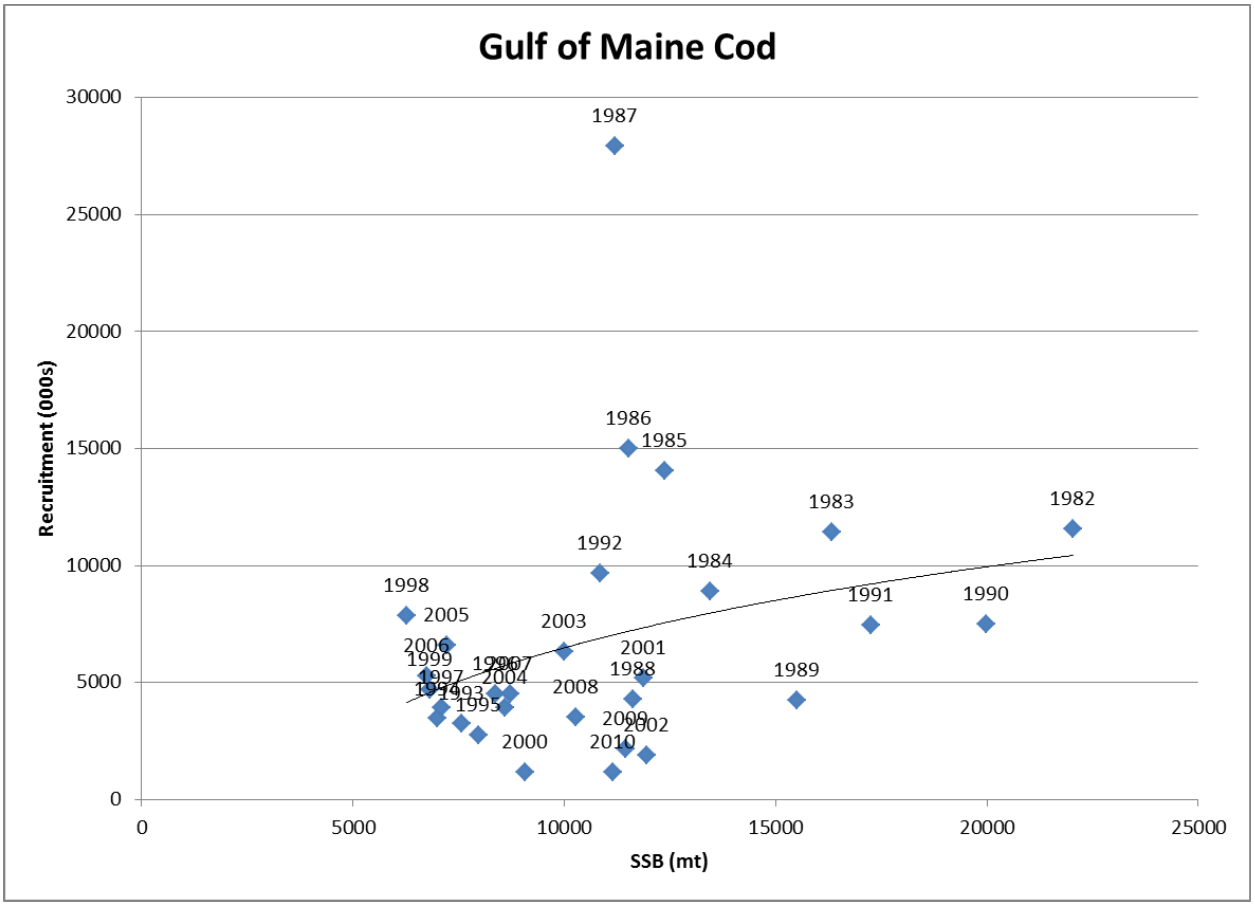
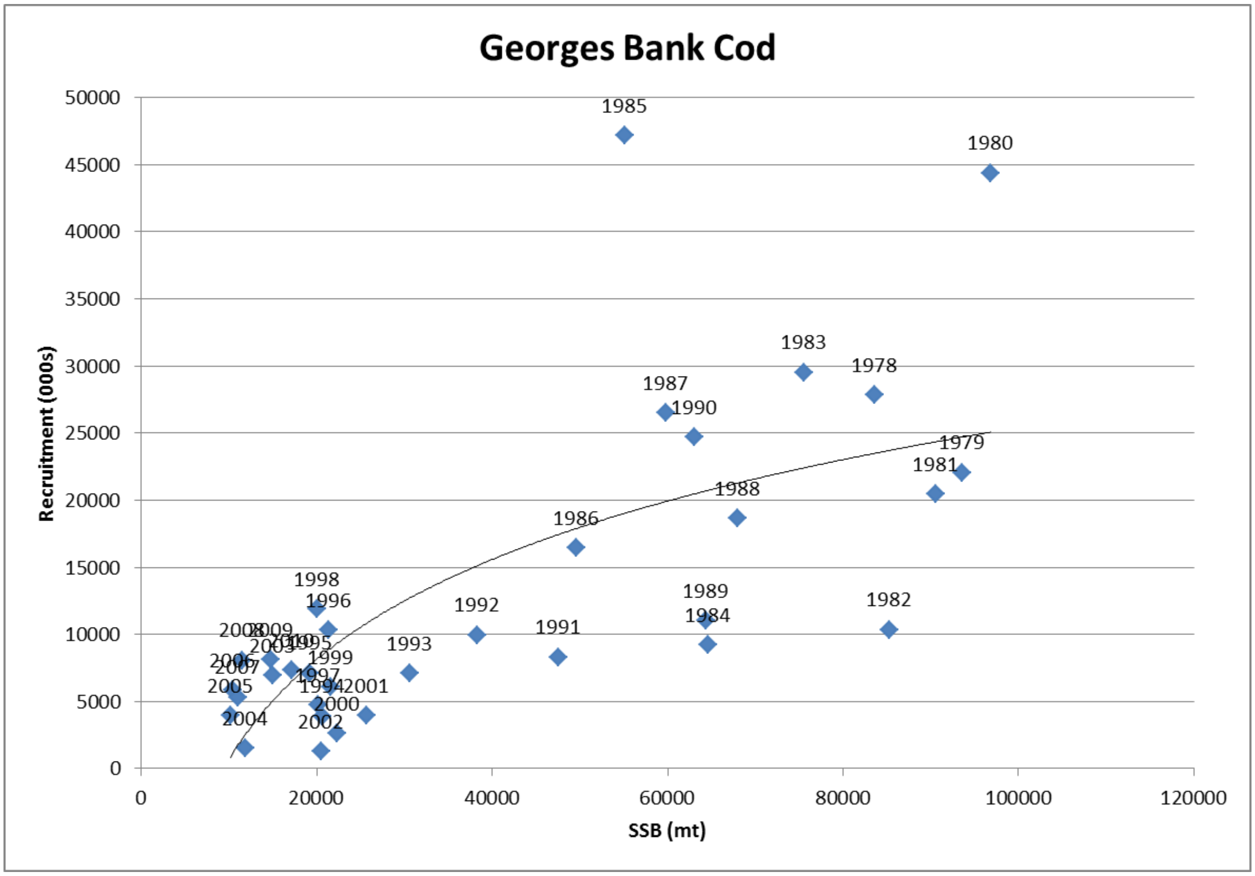
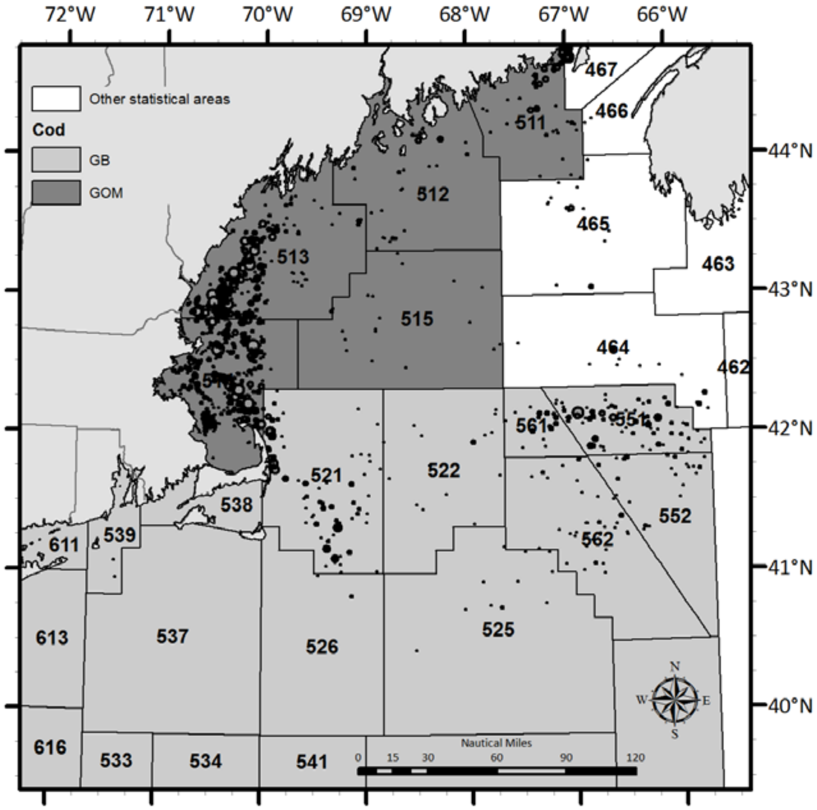


Figure 13 - Recruitment and spawning stock biomass estimates for Georges Bank cod (NMFS stock assessments)

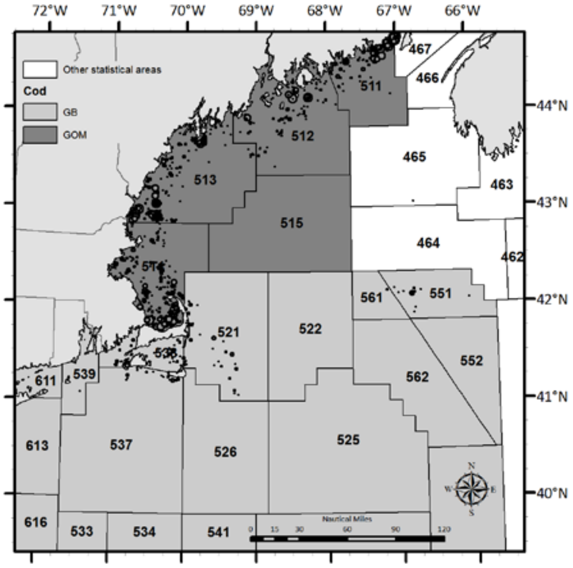


Map 39 – Atlantic cod stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile groundfish habitat and spawning areas.

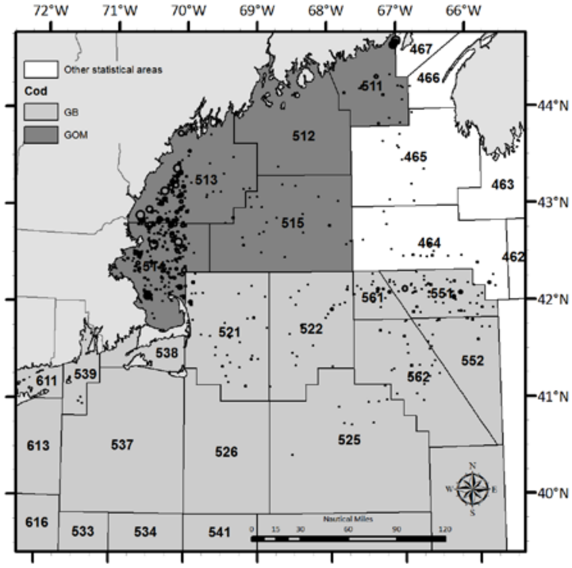
Total biomass (kg/tow)



Juvenile abundance < 35cm (#/tow)



Spawning biomass > 75cm (kg/tow)



4.2.1.1.4 Atlantic halibut

The Atlantic halibut (*Hippoglossus hippoglossus*) is a long-lived benthic flatfish found in moderate depths in the Gulf of Maine and on Georges Bank. The greatest concentrations in the NMFS fall and spring surveys are found along the eastern Maine coast and on the Scotian Shelf. They are the largest flatfish found in the region: length at maturity is 103 cm for females and 82 cm for males.

Some distributional metrics have shifted over time. Between 1968 and 2007, halibut have experienced a poleward shift in their distribution, and increase in minimum latitude, and an increase in mean depth, however there were no significant trends in area occupied, maximum latitude, or mean temperature (Nye et al 2009).

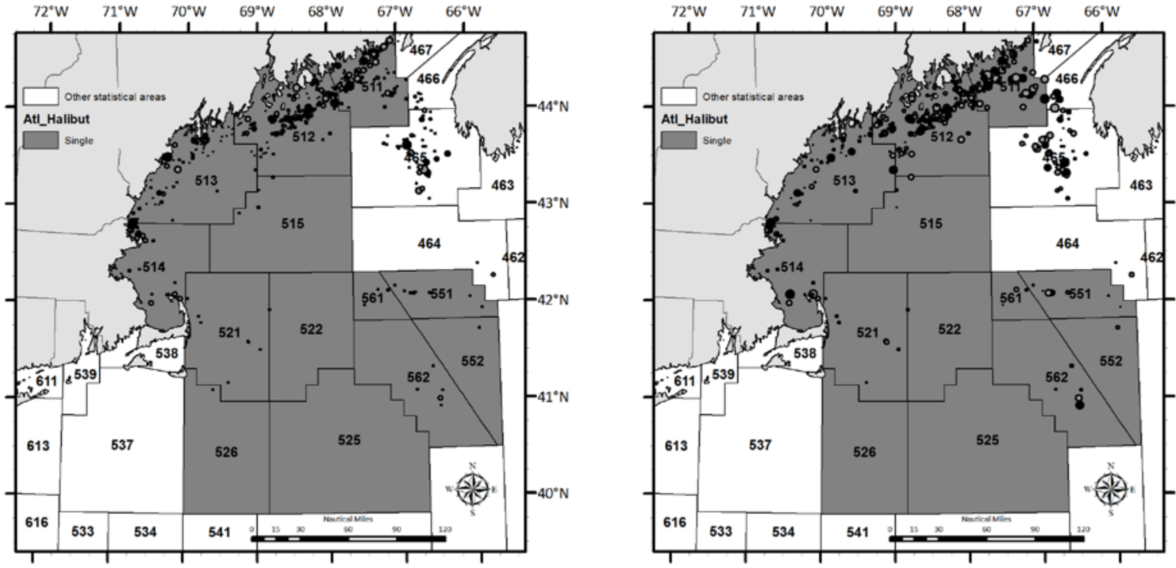
There is little information available on their habitat associations. Adults are found over sand, gravel or clay substrates, but not on soft mud or rock bottom (Klein-MacPhee 2002).

Spawning in the western Atlantic is believed to occur on the slopes of the continental shelf and on the offshore banks (McCracken 1958; Nickerson 1978; Neilson et al. 1993), at depths of at least 183 m (Scott and Scott 1988), over rough or rocky bottom (Collins 1887). Juvenile Atlantic halibut nursery grounds are in water 20-60 m in coastal areas with sandy bottoms (Haug 1990, Miller et al. 1991). There is no present day spawning population in the GOM (Klein-MacPhee 2002). Much of what we know about the habitat and spawning preferences of Atlantic halibut comes from other regions. Immature fish typically occurred on the southwestern Scotian Shelf, supporting the view that this area is an important rearing area for immature halibut (Neilson et al. 1993). Stobo et al. (1988) hypothesized that the area around Sable Island Gully on the Scotian Shelf may serve as a nursery area for juveniles before they begin to disperse. In Norwegian coastal waters, halibut spawning has been reported over soft clay or mud bottom, in deepwater (300-700 m) locations (Haug 1990).

Most of what we know about the food habits of halibut comes from smaller sized individuals. Dominant prey items include fish such as sculpin, cod, and silver hake, shrimp, and crabs, with the composition of their diet shifting with age.

Halibut once supported a substantial fishery, but the stock is currently depleted and landings are restricted. They are managed as a single GOM/GB stock. The 2012 assessment update indicated that the stock is overfished, and is currently at less than 10% of the target biomass. However, overfishing is not occurring; there is no directed fishery and exploitation rates are very low. There appears to be a slight increase in the stock biomass and a slight decrease in fishing mortality as compared to GARM III (2008).

Map 40 – Atlantic halibut stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



Total abundance (#/tow) **Total biomass (kg/tow)**

4.2.1.1.5 Atlantic wolffish

Atlantic wolffish (*Anarichus lupus*) was added to the Northeast Multispecies FMP via Amendment 16 (2009). Currently, the stock is overfished, but overfishing is not occurring (2012 Groundfish Assessment Update). The wolffish was recently proposed for listed under the Endangered Species Act. Ultimately it was not listed, but the 2009 Status Review document (AWBRT 2009) and the most recent stock assessment (NEFSC 2009) provide a comprehensive overview of what we know about the species distribution, spawning, habitat associations, etc.

Atlantic wolffish range as far north as Davis Strait, south regularly to Cape Cod, less often west along southern New England, and exceptionally to NJ (Rountree 2002). West of the Scotian shelf, their abundance is highest in the southwestern Gulf of Maine from Jeffreys Ledge to the Great South Channel. They are also abundant on the northeast peak of Georges Bank, and on Browns Bank. Smaller concentrations appear off SW Nova Scotia and throughout the central Gulf of Maine.

The wolffish is a benthic, cold-water fish that changes its depth distribution seasonally to maintain a narrow temperature range (see Kulka et al. 2004, Keats et al. 1985, Scott 1982a, Nelson and Ross 1992 for information about their distribution in different regions and season). Distribution by depth was evaluated in the status review document. Recreational catches of wolffish in the party and charter data are greatest in the southwestern Gulf of Maine and in the Great South Channel, as well as in shallower water (<100 m) north of Closed Area I, on the northern edge of Georges Bank, and on Nantucket Shoals.

Rocky, nearshore habitats are plentiful in the Gulf of Maine and appear to provide critical spawning habitat for Atlantic wolffish. Auster and Lindholm (2005) analyzed data collected during submersible (July 1999) and ROV surveys (May-September 1993-2003) of deep boulder reefs in the Stellwagen Bank National Marine Sanctuary at depths of 50-100 meters. Nineteen single and paired Atlantic wolffish were observed in 110 hours of observation. All used crevices under and between boulders on deep boulder reefs. Shell debris from bivalves and crustaceans was scattered at crevice entrances, evidence of “central place foraging activities.”

Based on the depth distribution information from the NEFSC trawl surveys in the Gulf of Maine region, the adults move into slightly shallower water in the spring where they have been observed with and without egg masses inhabiting shelters in deep boulder reefs in depths between 50 and 100 meters. Once they have finished guarding the eggs and resume feeding, adults move into deeper water where they have been collected over a variety of bottom types (sand and gravel, but not mud). Juvenile wolffish are found in a much wider variety of bottom habitats.

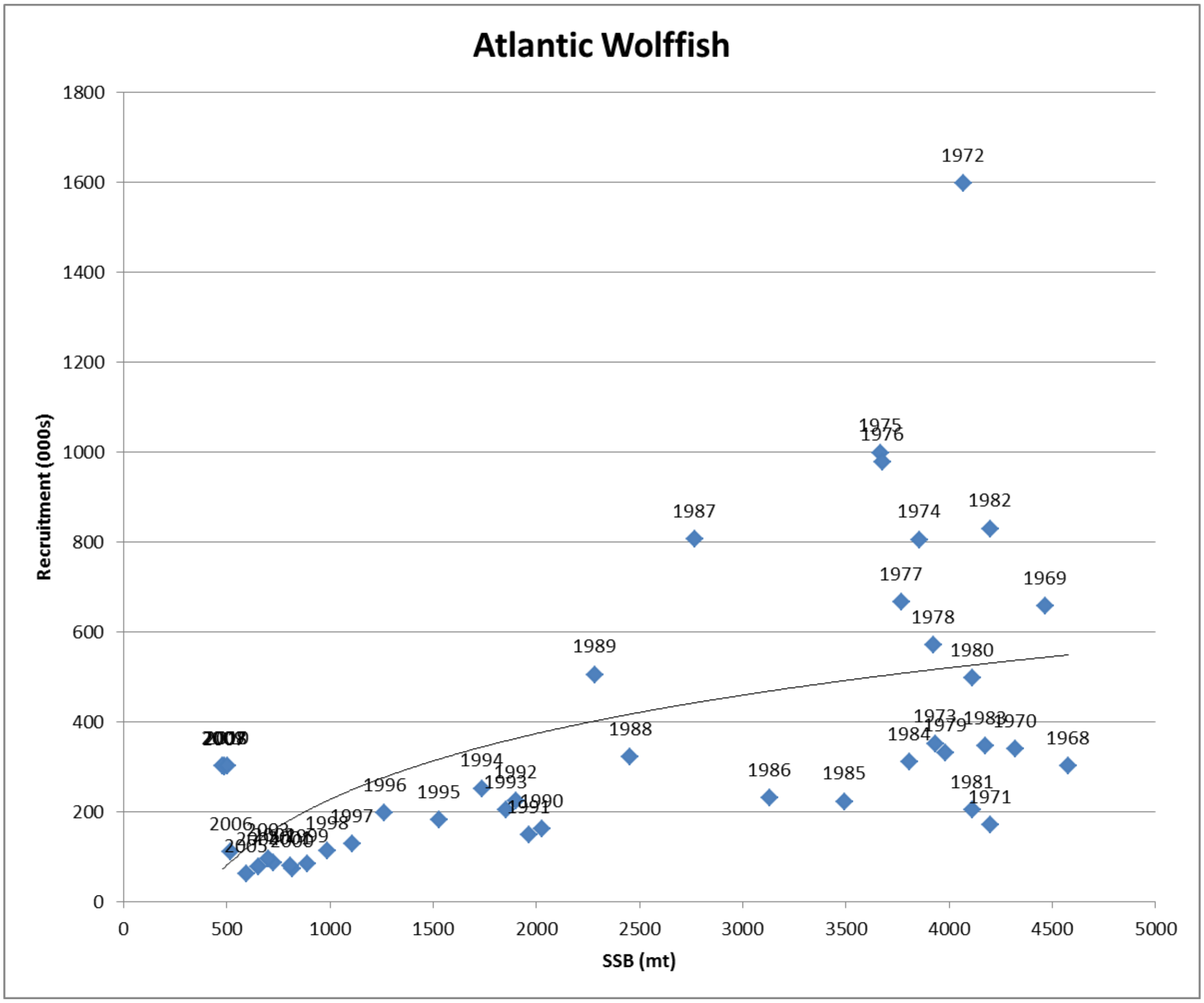
Similar associations with nearshore rocky spawning habitats have been observed in the Gulf of St. Lawrence and Newfoundland. However, the collection of “aggregations” of Atlantic wolffish eggs in bottom trawls fishing in 130 meters of water on LeHave Bank (Scotian Shelf) in March 1966 (Powles 1967; Templeman 1986) indicates that spawning is not restricted to nearshore habitats, and may not be restricted to rocky habitats.

It should be noted that trawl gear is not very suitable for catching wolffish in rocky habitats. Nonetheless, in summary, attempts to relate catches of Atlantic wolffish in bottom trawl surveys to substrate types are of limited value and somewhat contradictory, but the data indicate that the juveniles do not have strong habitat preferences, and that adults are more widely distributed over a variety of bottom types once they leave their rocky spawning grounds.

Wolffish feed almost exclusively on hard-shelled benthic invertebrates including mollusks, crustaceans, and echinoderms.

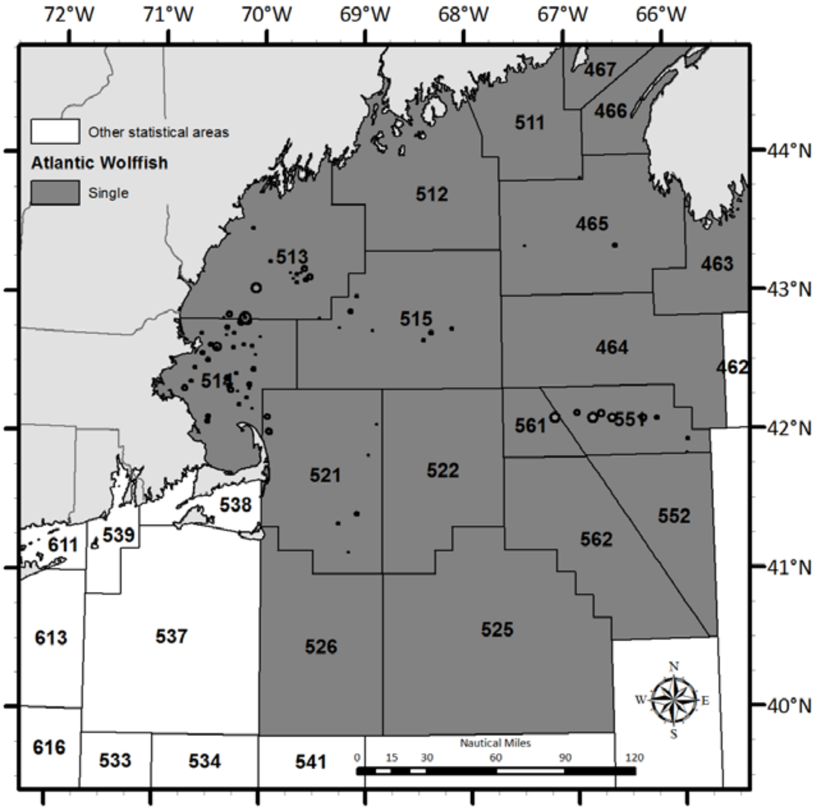
Stock recruitment appears to have increased between 2005-2012, while spawning biomass has decreased.

Figure 14 - Recruitment and spawning stock biomass estimates for Atlantic wolffish (NMFS stock assessments)



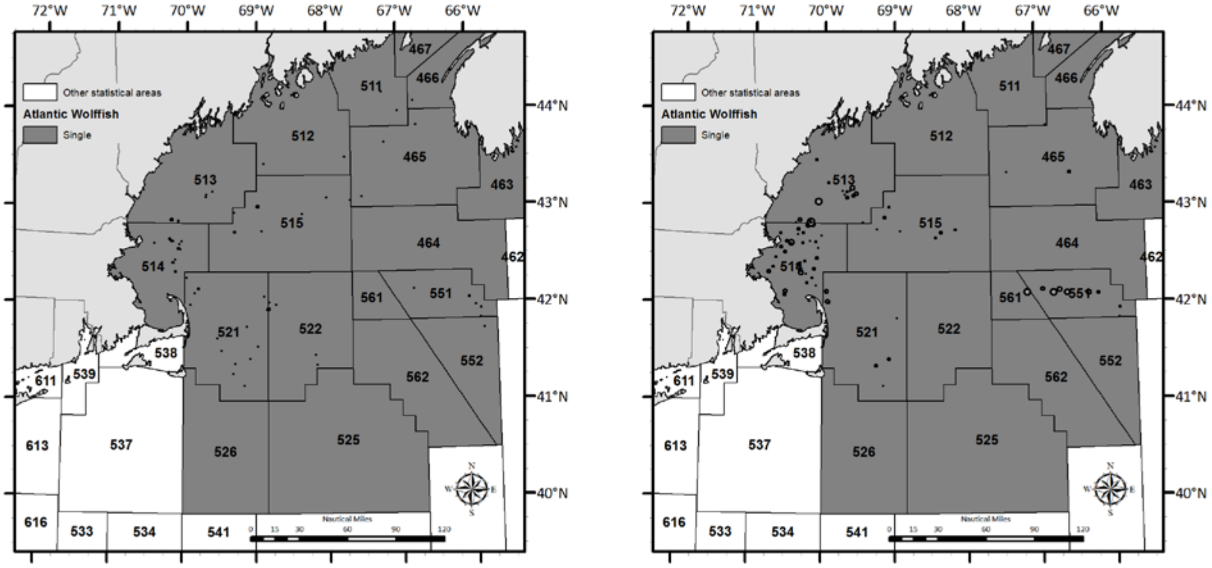
Map 41 – Atlantic wolffish stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

Total biomass (kg/tow)



Juvenile abundance < 50cm (#/tow)

Spawner biomass > 45cm (kg/tow)



4.2.1.1.6 Haddock

Haddock (*Melanogrammus aeglefinus*) are found in relatively shallow inshore waters in the Gulf of Maine and in moderate depths on Georges Bank. In the NEFSC trawl survey, catch rates for juveniles and adults are high on the northeast peak of Georges Bank, in the Great South Channel and in Closed Areas I and II, and in the southwestern Gulf of Maine (Brodziak 2005). Juveniles are found in slightly deeper waters in spring, while adults are found in slightly deeper waters in the fall (juveniles, 60-140 m spring, 40-120 fall; adults 50-140 spring, 60-160 fall). The seasonal migration pattern for haddock is very similar to cod: they occupy deeper water in the fall in order to remain in the same temperature range year round (Methratta and Link 2006a).

Haddock prefer gravel, pebbles, clay, broken shells, and smooth hard sand, particularly smooth areas between rocky patches (Klein-MacPhee 2002). These habitat types are common on Georges Bank, and less prevalent in the Gulf of Maine, which helps explain the increased abundance of haddock on Georges Bank (Brodziak 2005). In the southwestern Gulf of Maine, haddock catches were positively correlated with bottom reflectance (Auster et al. 2001). In the same area, Auster and Lindholm 2005 observed station-keeping adjacent to partially buried boulders as well as near boulders and cobbles with large globular sponges along the margins of deep boulder reefs. They considered haddock to be transient visitors to these reefs, and noted that bottom structure provides a refuge from flow.

Haddock do not frequent ledges, rocks, kelp, or soft oozy mud. Catch rates in the NEFSC bottom trawl survey are much higher in coarser substrates (coarse rock, fine rock, coarse sand (Methratta and Link 2006b). They are generally less selective for bottom type than cod, but feed on benthic prey more so than cod and are thus more closely associated with the seabed.

Like cod, young of the year haddock settle on a variety of sediment types on eastern Georges Bank, but by August they are found primarily on gravel pavement areas (Lough et al. 1989, Valentine and Lough 1991). Young of the year haddock do not inhabit shallow (<10 m) inshore areas in the GOM (Lazzari and Stone 2006).

Major spawning areas are those with suitable substrates. The most important location is the northeast peak of Georges Bank (Colton and Temple 1961; Lough and Bolz 1989). Other locations include Nantucket Shoals (Smith and Morse 1985), along the Great South Channel (Colton and Temple 1961), and Stellwagen Bank and Jeffreys Ledge in the Gulf of Maine (Colton 1972). Retention of larval haddock in the clockwise gyre around Georges Bank is important in determining year class strength; this retention is in turn influenced by interannual variation in oceanographic patterns (Brodziak 2005 and references therein). Although there is limited information on retention of larval haddock in the Gulf of Maine, Ames (1997) suggests that haddock eggs and larvae in coastal Gulf of Maine waters may be retained in suitable habitats by tidal currents. The timing of spawing on Georges Bank ranges from January to June, with peak activity between February and early April, depending on temperature (see Smith and Morse 1985 and other source document references for details).

Overholtz analyzed the dates, location and temperature preferences of spawning Georges Bank haddock from data collected on spring bottom-trawl surveys from 1977-1983, concluding that the northeast peak of Georges Bank is the most important haddock spawning area, peaking in late March and early April at bottom temperatures from 4-7°C (Overholtz 1987). Overholtz also noted that the area to the east of the Great South Channel at depths shallower than 100 m were important spawning areas at the same peak times and bottom temperatures.

Haddock have a varied diet consisting of polychaetes, crustaceans, mollusks, echinoderms, and fish. Fish are more important for larger individuals.

Haddock are managed as two stocks, Gulf of Maine and Georges Bank. Both stocks were last evaluated during a 2012 assessment updated. At the time, the GOM stock was not overfished, but overfishing was occurring. The stock showed lower biomass and higher recruitment estimates as compared to 2007 (previous assessment GARM III 2008), and a higher fishing mortality rate during 2010 as compared to 2007. The GB stock is not overfished and overfishing is not occurring. This stock showed both a lower biomass estimate as compared to 2007, and a lower fishing mortality rate. Recruitment was at an all-time high during 2010. *Transboundary information to be added.*

Figure 15 - Recruitment and spawning stock biomass estimates for Gulf of Maine haddock (NMFS stock assessments)

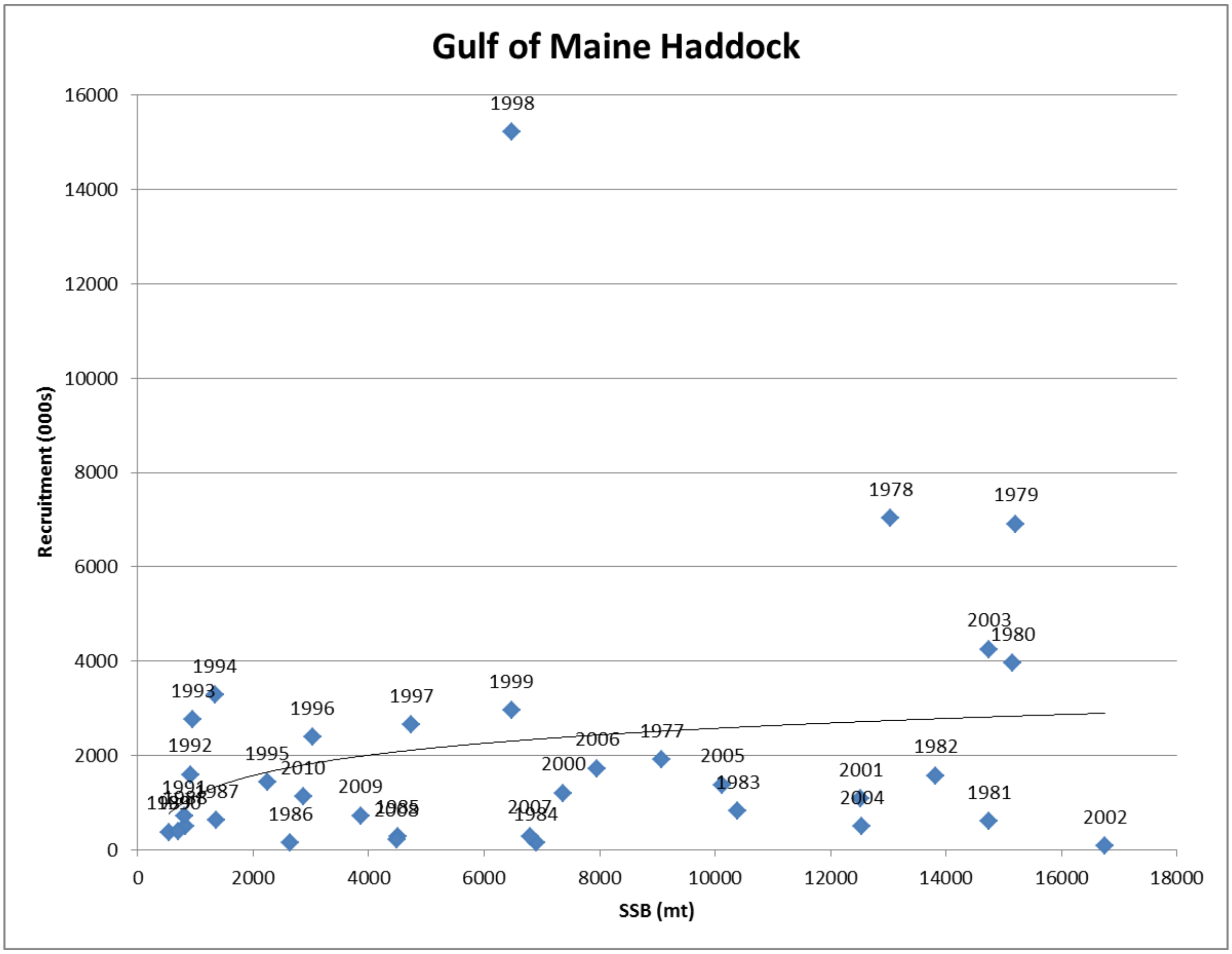
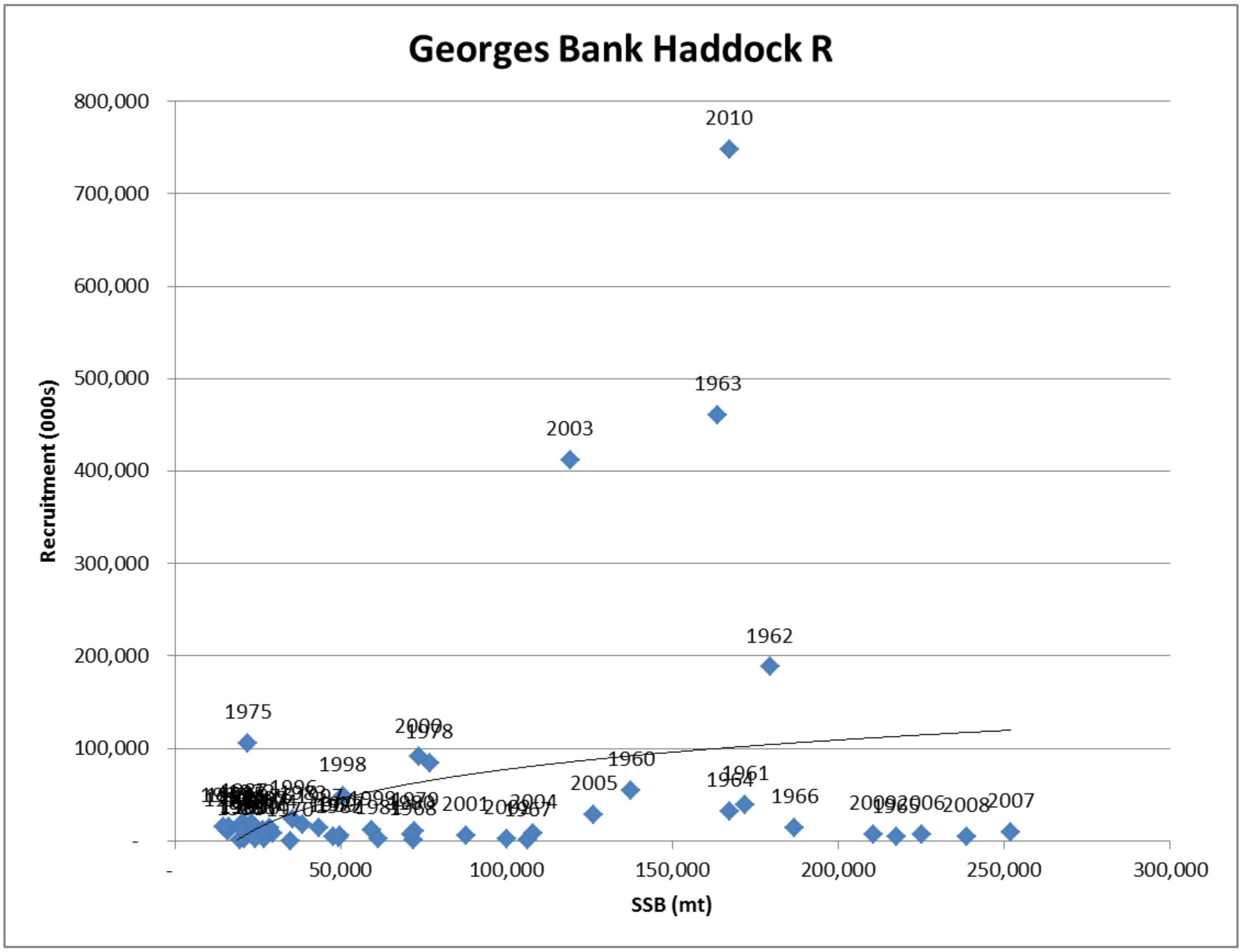
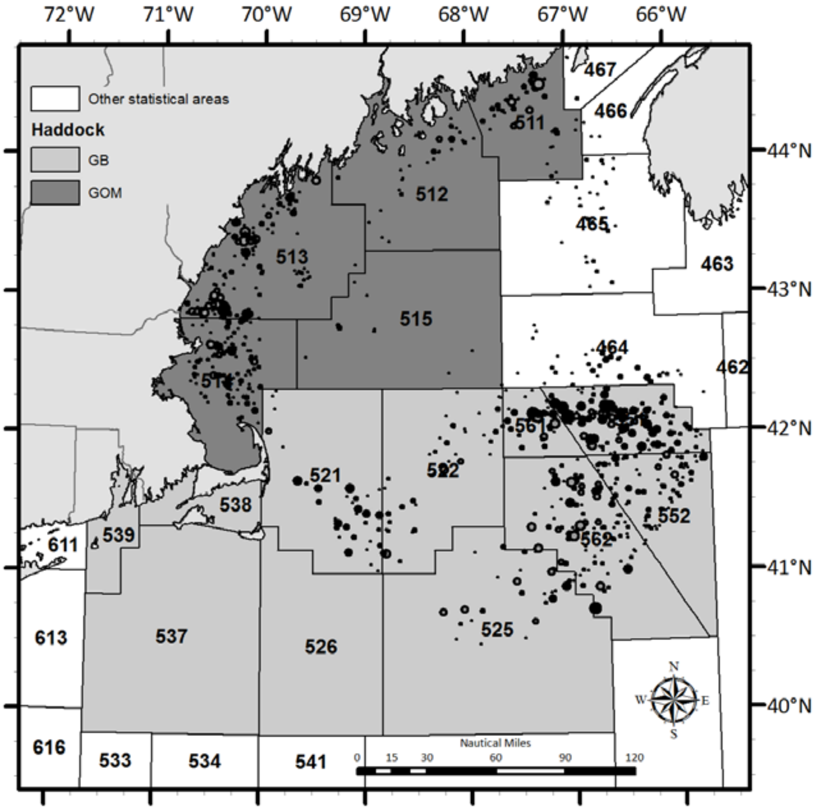


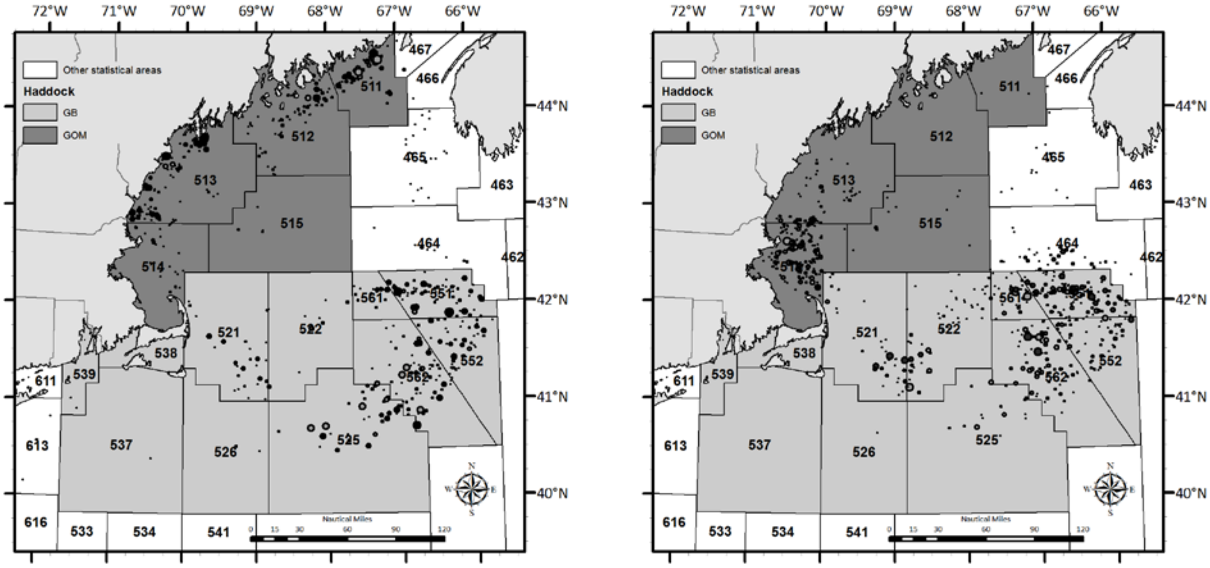
Figure 16 - Recruitment and spawning stock biomass estimates for Georges Bank haddock (NMFS stock assessments)



Map 42 – Haddock stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

Total biomass (kg/tow)




Juvenile abundance < 35cm (#/tow)

Spawner biomass > 50cm (kg/tow)

4.2.1.1.7 Ocean pout

In the NEFSC surveys, both juveniles and adult ocean pout (*Macrozoarces americanus*) are found in shallower, cool waters in the spring and in deeper, cool water areas during the fall (Methratta and Link 2006a). Juveniles occur mostly in the New York Bight area and in the southwestern Gulf of Maine, rarely in the remainder of the Gulf of Maine or on Georges Bank. In spring, the adults are very numerous in southern New England (inner/middle shelf), northern New Jersey, southwestern Gulf of Maine, and in the Great South Channel, and they also occur on Georges Bank. In the fall, fewer adults are found in deeper water in the same areas.

Ocean pout lack a swim bladder and are therefore strict bottom-dwellers. They are not known to form schools or aggregations (Steimle et al. 1999). Habitat preference depends on location (Klein-MacPhee and Collette 2002). Juveniles are found on a wide variety of substrates, including shells, rocks, algae, soft sediments, sand, and gravel. Adults prefer sand and gravel substrate on the shelf (including shells, Southern New England, Auster et al. 1991, 1995), but are also found on muddy, sandy, and pebble and gravel bottom types in the GOM (Bigelow and Schroeder 1953). In the NEFSC trawl survey area, the highest catch rates are on coarse sand (Methratta and Link 2006b). During ROV/submersible observations on deep boulder reefs in the southwestern Gulf of Maine, ocean pout were observed singly in crevices, on the sediment surface in the open between boulders, and as pairs within crevices (Lindholm and Auster 2005). Given spawning behavior, they were classified as seasonal residents of the reefs.

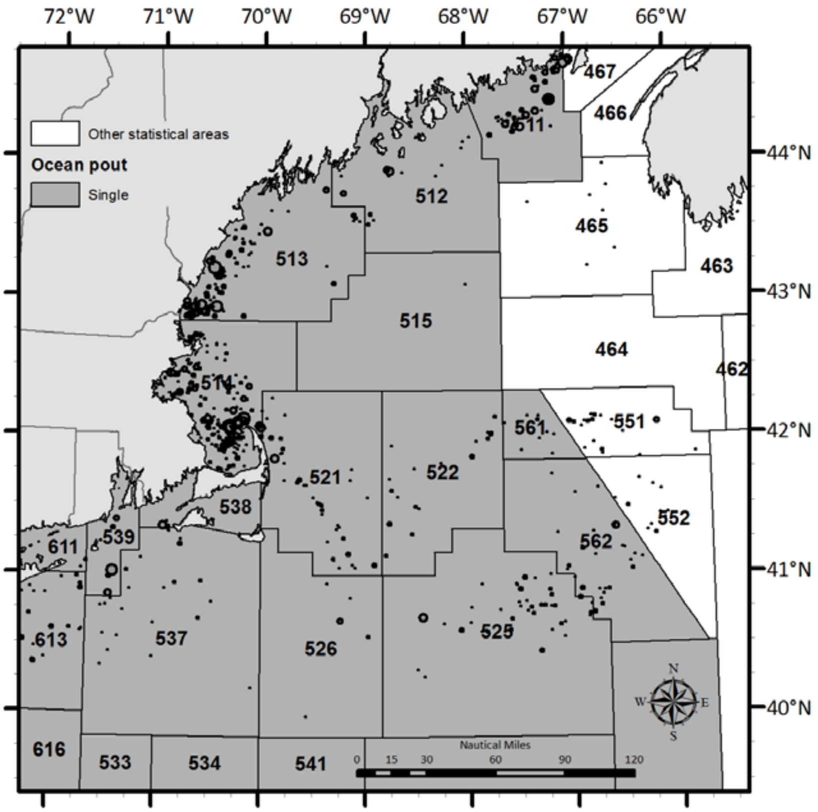
Spawning occurs in late summer through early winter, with a peak in September-October in the north and earlier peaks in the south. They spawn on hard bottom in sheltered areas in depths less than 100 meters (Keats et al. 1985). Eggs are demersal and are deposited in sheltered nests in depths <50 m (see Steimle et al. 1999); the ocean pout burrows tail first, and leaves a depression on the sediment surface (Auster et al. 1995).

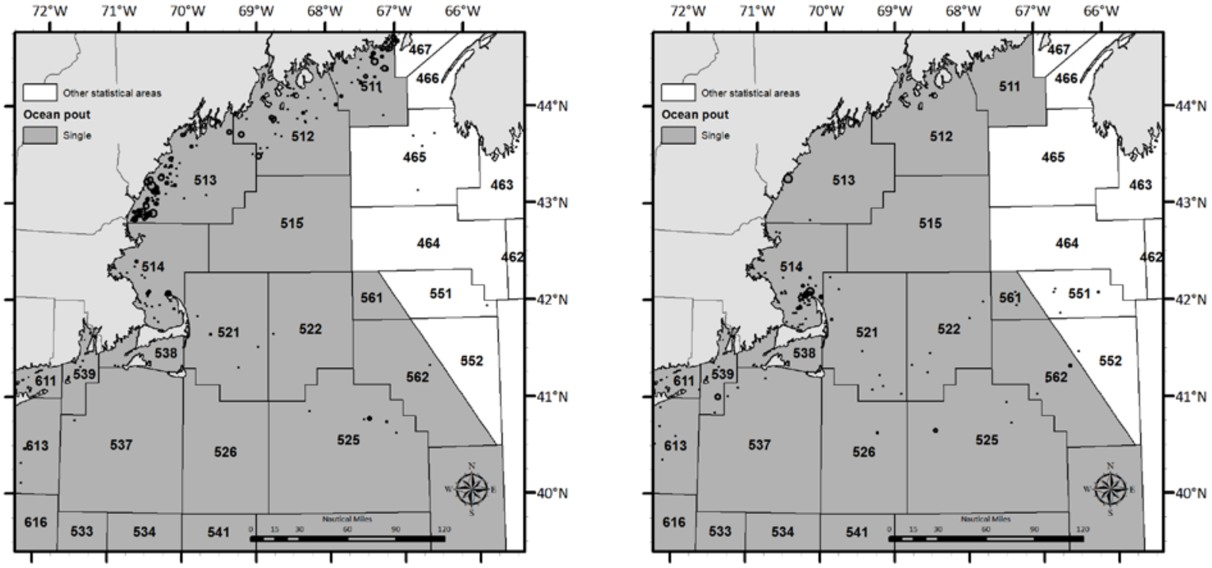
Juveniles consume mostly polychaete worms, amphipod crustaceans, scallops, and brittlestars. Adults have a similar diet but also eat crabs and sand dollars.

Ocean pout are managed in the Northeast Multispecies FMP. They are considered overfished, but overfishing is not currently occurring (2012 Assessment Update).

Map 43 – Ocean pout stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

Total biomass (kg/tow)




Juvenile abundance < 30cm (#/tow)

Spawner biomass > 60cm (kg/tow)

4.2.1.1.8 Offshore hake

Offshore hake (*Merluccius albidus*) are found along the shelf/slope break. Their distribution in the Northeast US extends from the southeastern flank of Georges Bank to Cape Hatteras.

At night, juveniles and adults are found in the water column. During the day, both life stages are found in mud, mud/sand, and sand habitats. As their common name implies, offshore hake have the deepest distribution of any of the four hake species managed by NEFMC.

There is little information available on the reproductive biology of offshore hake. Spawning appears to occur over a protracted period or even continually throughout the year from the Scotian Shelf through the Middle Atlantic Bight.

Offshore hake feed on pelagic invertebrates, e.g. euphausiids and other shrimps, and pelagic fish, including conspecifics.

Offshore hake, red hake, and silver hake were last assessed at the 51st Northeast Regional Stock Assessment Workshop held in November-December 2010 (NEFSC 2011). While a first attempt at a formal analytical assessment was attempted, the model was deemed not sufficient for use in providing management advice. It was determined that there is not sufficient evidence to make a status determination for the stock, and current reference points were rejected. The primary issues in determining reference points are that the surveys cover and unknown and variable portion of the stock, and that commercial catch data are not sufficient to understand trends.

4.2.1.1.9 Pollock

Pollock (*Pollachius virens*) are found primarily in the Gulf of Maine, and also in the deep waters of the Great South Channel and in the deeper waters off the southern edge of Georges Bank. In the NEFSC bottom trawl survey, juveniles (<38 cm) have a shallower distribution than adults and both age groups are found in shallower waters in the spring as compared to the fall. (juveniles 40-160 m spring, 40-180 m fall; adults 90-200 m spring and 80-300 m fall). The youngest pollock use inshore subtidal and intertidal zones (Cargnelli et al. 1999, age 0+ and 1+), shallow-water habitats <10 m in the GOM (Lazzari and Stone 2006, YOY), and shallow marsh creeks in southern New Jersey (Rountree and Able 1992, YOY).

Over the period between 1968-2007, pollock exhibited significant changes in their distribution int the spring NEFSC trawl survey, including: decrease in area occupied, decrease in maximum latitude, increase in minimum latitude, increase in mean temperature, and increase in mean depth (Nye et al. 2009).

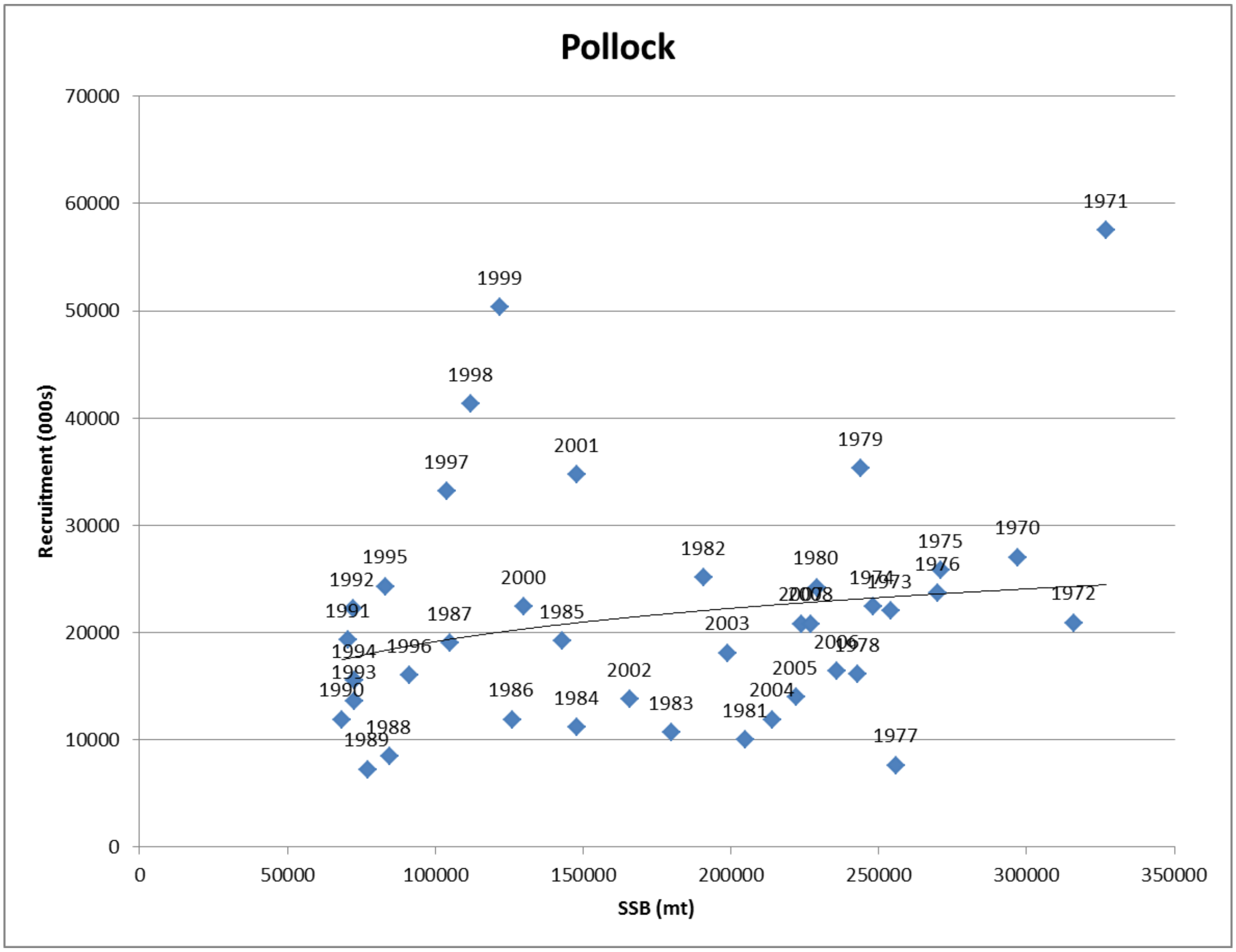
Although YOY juveniles have been associated with rocky shallow water habitats containing macroalgae and eelgrass (Rangeley and Kramer 1995, 1998), pollock found further offshore are not strongly associated with any particular substrate type, at least according to the NEFSC trawl survey. Simlarly, Scott (1982b) found that larger pollock on the Scotian shelf show little preference for bottom type. However, it should be noted that distribution and abundance information from the NEFSC bottom trawl survey is somewhat challenging to interpret because pollock is at times pelagic and schooling, which influences their catchability as compared to other fishes more closed associated with the bottom.

In the Gulf of Maine spawning occurs between November and February (Steele 1963; Colton and Marak 1969), peaking in December (Collette and Klein-MacPhee 2002). Important locations include Massachusetts Bay, Stellwagen Bank, and coastal areas from Cape Ann to the Isles of Shoals.

Juveniles and adults prey on pelagic species including crustaceans, especially euphausiids, mollusks and fish. Larval pollock consume copepods.

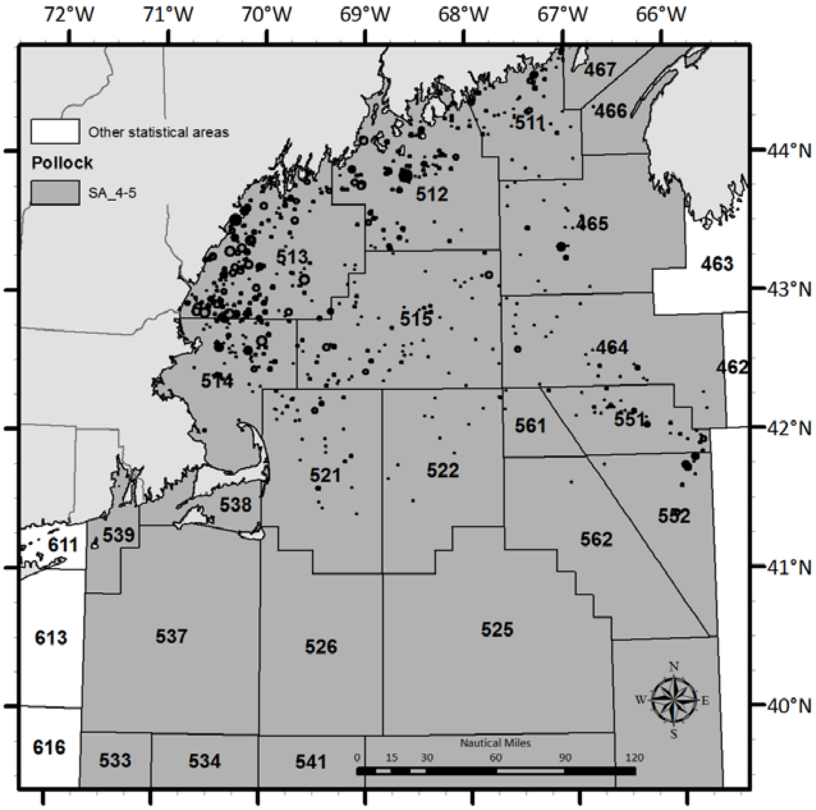
Pollock are managed as a single stock. During the 2010 assessment (NEFSC 2011), a new model that incorporates age structure, additional surveys, more comprehensive catch information, changes in selectivity, and uncertainty in the input data was used for the first time. The 2010 assessment implied that there is a large “cryptic” biomass of pollock not available to the survey or the fishery, and 2010 and later specifications were revised significantly upward as a result. The stock is not overfished and overfishing is not occurring.

Figure 17 - Recruitment and spawning stock biomass estimates for Pollock (NMFS stock assessments)

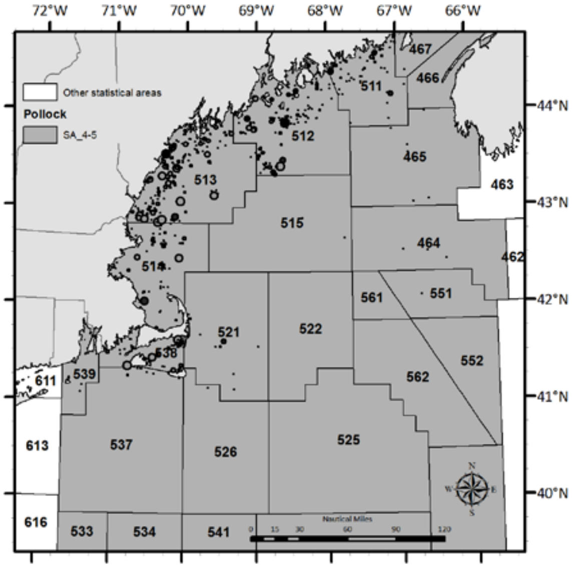


Map 44 – Pollock stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

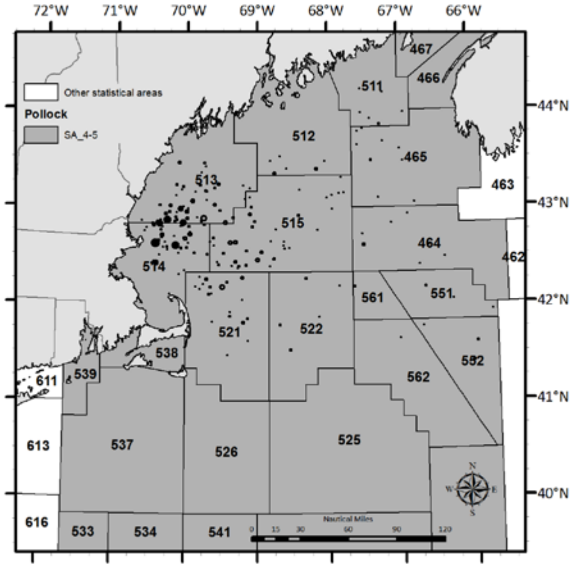
Total biomass (kg/tow)



Juvenile abundance < 35cm (#/tow)



Spawner biomass > 75cm (kg/tow)



4.2.1.1.10 Red hake

Red hake (*Urophycis chuss*) are found throughout the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic Bight.

They occur at a wide range of depths throughout the year, the juveniles in particular making seasonal migrations to follow preferred temperature ranges. Specifically, in the Mid-Atlantic Bight, the juveniles move into deeper waters in the fall, while on Georges Bank, they are found in shallower waters in fall and nearly absent in the spring, when they occur mostly on the northern edge of the bank. Overall, juveniles have a shallower distribution in the NEFSC trawl surveys, 0-30 m in spring and 40-80 m in fall, while adults are found between 60-300 m in spring, and 50-160 m in the fall.

During the warmer months, adults are most common in depths < 100 m; during colder months, they are most common in depths > 100 m. Fritz (1965) reported that they range from 30-370 m and that they are most common in the fall between 50-210 m. In the spring and fall, the adults remain in deeper water off the northern edge and southern flank of Georges Bank, and are found throughout the Gulf of Maine, especially the southwestern Gulf of Maine. Some adults move inshore in the Mid-Atlantic Bight in the spring, but do not exhibit the extensive seasonal migration as the juveniles do. In the Great South Channel, both life stages are mostly limited to depths >60 m; a few juveniles are found <60m in the fall.

Shelter is a critical habitat requirement for juvenile red hake (Steiner et al. 1982). Newly settled juveniles occur in depressions on the open seabed (Able and Fahay 1998). Young of the year red hake are found in shallow coastal and estuarine habitats associated with eelgrass and macroalgae on mud and sand sediments (Lazzari et al. 2003). Older juveniles commonly associate with shelter or structure, including: living sea scallops (*Placopecten magellanicus*) where they can be found under the scallops on the sediment or within their open mantle cavity (Steiner et al. 1982; Garman 1983; Able and Fahay 1998); Atlantic surfclam (*Spisula solidissima*) shells; seabed depressions made by larger fish or decapod crustaceans; moon snail egg case collars; anemone and polychaete tubes (Wicklund 1966; Ogren et al. 1968; Stanley 1971; Shepard et al. 1986); and submerged man-made objects, debris, and artificial reefs (Eklund 1988). Larger juveniles remain near scallop beds and other structures in coastal areas and embayments; later they join older fish in an offshore migration in the Middle Atlantic Bight.

Adults prefer soft sediments over gravel or hard bottoms, and can also be found in the water column (Collette and Klein-MacPhee 2002; Gottschall et al. 2000). Similar to juveniles, adults are not common on open sandy bottom, and instead occur in depressions, which they either find or create themselves (Auster et al. 1991). Adults also inhabit inshore artificial reefs off New York during the summer (Ogren et al. 1968); Eklund (1988) reported that they were most abundant on natural and artificial reefs off Delaware-Virginia during April to May.

Major spawning areas occur on the southwestern part of Georges Bank and on the continental shelf off southern New England and eastern Long Island. Spawning adults and eggs are also common in the marine parts of most coastal bays between Narragansett Bay, Rhode Island, and Massachusetts Bay, but rarely in coastal areas to the south or north (Jury et al. 1994; Stone et al.

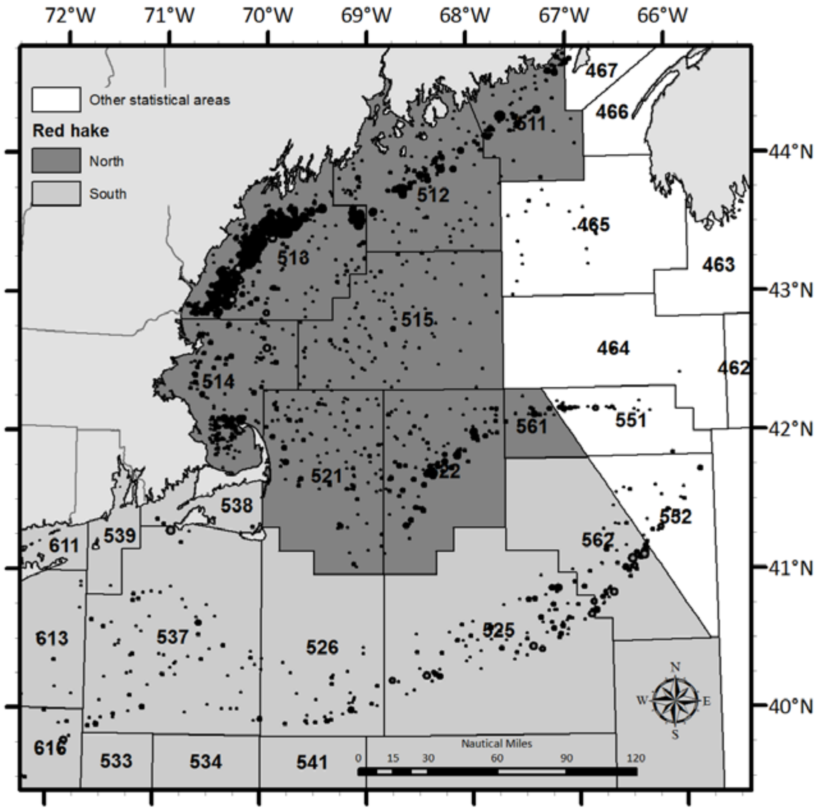
1994). Spawning begins earlier, around March, in the Mid-Atlantic Bight and later, around May or June, further north.

Juveniles consume small benthic and pelagic crustaceans, as well as polychaete worms. Larger juveniles and adults consume mostly decapods and gadids, in addition to amphipods, euphausiids, squid, and other types of fish. Prey selection varies by season and according to the size of the hake.

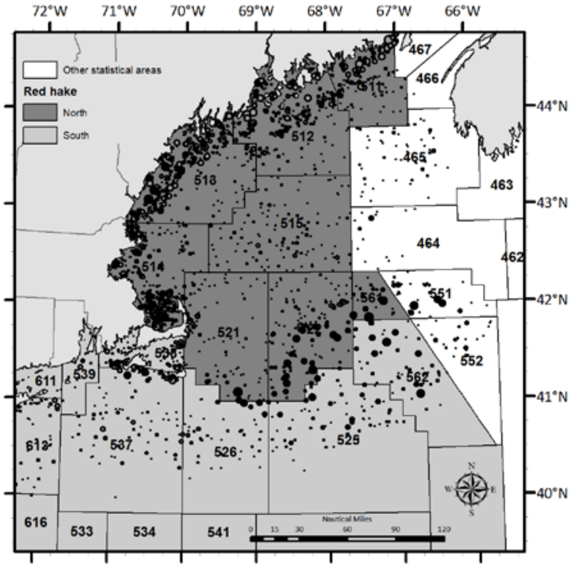
Northern and southern red hake are assessed separately. While a formal analytical assessment was attempted in 2010 (51st Stock Assessment Workshop, Nov-Dec 2010), the model was deemed not sufficient for use in providing management advice. The biomass reference point is based on catch per tow in the trawl survey, and the fishing mortality reference point is based on an exploitation index, i.e. fishery catch divided by the survey catch per tow biomass index. Based on reference points updated during the assessment, the stocks are not overfished and overfishing is not occurring.

Map 45 – Red hake stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

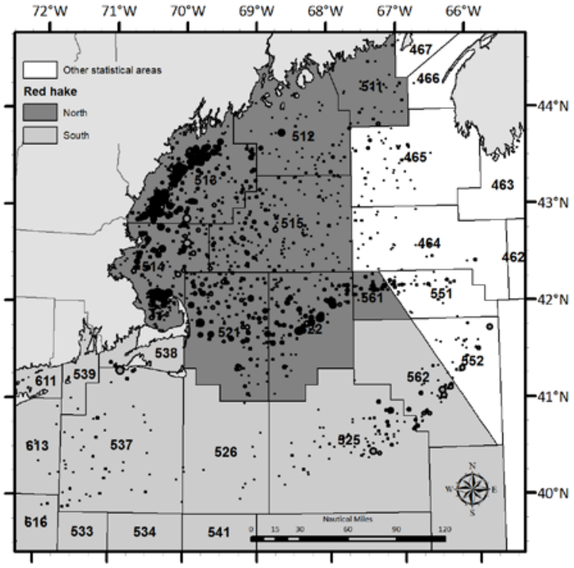
Total biomass (kg/tow)



Juvenile abundance < 20cm (#/tow)



Spawner biomass > 35cm (kg/tow)



4.2.1.1.11 Silver hake

Silver hake (*Merluccius bilinearis*) occur throughout the Gulf of Maine, and in moderate to deeper depths on Georges Bank and in the Mid-Atlantic Bight. In the NEFSC trawl survey, larger and older fish are found further north and in deeper waters, and smaller younger fish are found in relatively shallow waters (NEFSC 2006). Depth appears to be a more important determinant of silver hake distribution than temperature (NEFSC 2006).

In terms of substrate associations, in the NEFSC trawl survey, catch rates increase from fine sand to silt to clay; and are generally higher in all these than on coarser substrates (Methratta and Link 2006b). This is conclusion is consistent with an analysis relating survey catches to bottom reflectance in the southwestern Gulf of Maine, where trawl catches were significantly negatively correlated with bottom reflectance (low reflectance = soft substrates) (Auster et al. 2001). Silver hake have been observed at high densities in mud habitats bordering deep boulder reefs, resting on boulder surfaces, and foraging over deep boulder reefs in the southwestern Gulf of Maine (Auster and Lindholm 2005).

In terms of structural habitat feature associations, Auster et al. (1997) found that small silver hake (1.5-5 cm) in the Mid-Atlantic Bight were more abundant on silt-sand bottoms containing amphipod tubes at depths of 55 m. Steves and Cowen (2000) found amphipod tube mats to be associated with 0-group silver hake within the New York Bight. Auster et al. (2003) studied the small scale spatial distributions of both juvenile and adult silver hake within sand wave habitats and the diel patterns of habitat use on the southern side of Georges Bank and on Stellwagen Bank. Silver hake were not randomly distributed within sand wave habitats; there was a positive relationship between fish length and sand wave period. However, other factors, such as currents and available prey, may also influence their distribution in these habitats. Fish were in direct contact with these sand wave habitats with greater frequency during the day, and fish were observed in social or co-operative foraging (polarized groups of fish swimming in linear formation) during the day and at dusk. At one site in the Mid-Atlantic Bight, silver hake (12.6-27.6 cm) were found on flat sand, sand-wave crests, shell and biogenic depressions, but most often on flat sand (Auster et al. 1991). Silver hake were associated with particular microhabitats (e.g., sand-wave crests, biogenic depressions) at the 55 m site during the day but were randomly distributed during the night; this may be attributed to diel differences in feeding behavior (Auster et al. 1995). At the larger, regional scale within the New York Bight, juveniles showed high variability in abundance between stations in a study by Sullivan et al. (2000).

Steves and Cowen (2000) also suggest that early settlement patterns of silver hake are cued to a narrow interaction of temperature and depth, with a subsequent broadening of habitat preference as juveniles grow and local physical regimes shift. Steves et al. (2000) found that age-0 silver hake showed some movement in depth between their settlement and nursery areas within the outer shelf of the New York Bight; also, settlement did not peak until bottom temperature was > 9ºC.

This species makes greater use of the water column (for feeding, at night) than other two hakes and avoids gravel, rocky habitats, preferring fine sediments and deeper water (>70 m for adults).

Silver hake eggs and larvae have been collected in all months on the continental shelf in U.S. waters, although the onset of spawning varies regionally (Bigelow and Schroeder 1953; Marak and Colton 1961; Sauskan and Serebryakov 1968; Fahay 1974; Morse et al. 1987; Waldron 1988; Berrien and Sibunka 1999). The primary spawning grounds most likely coincide with concentrations of ripe adults and newly spawned eggs. These grounds occur between Cape Cod, Massachusetts, and Montauk Point, New York (Fahay 1974), on the southern and southeastern slope of Georges Bank (Sauskan 1964) and the area north of Cape cod to Cape Ann, Massachusetts (Bigelow and Schroeder 1953).

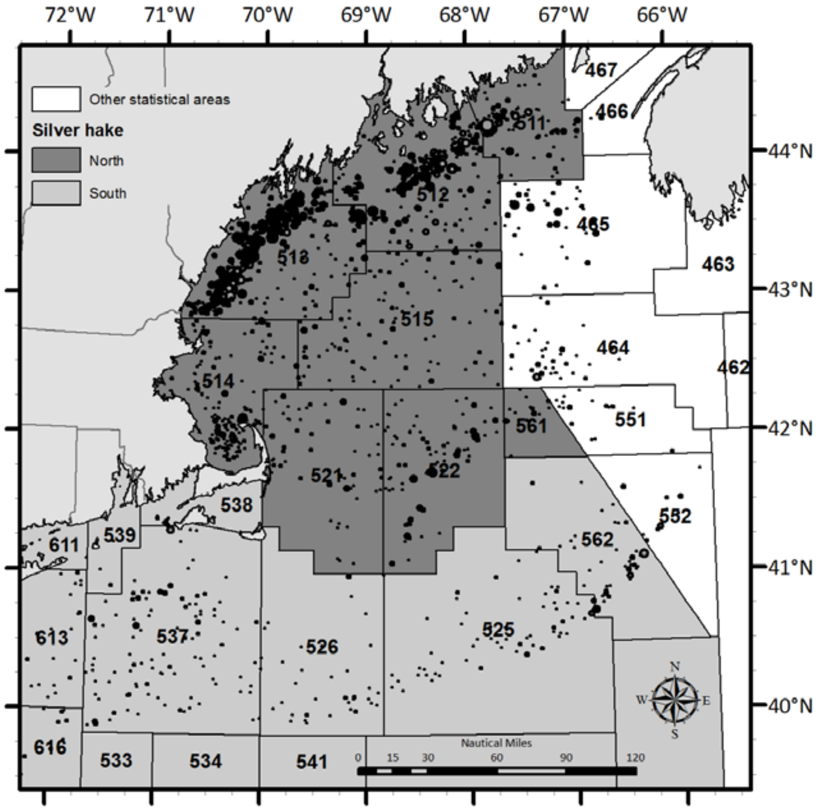
Spawning begins in January along the shelf and slope in the Middle Atlantic Bight. During May, spawning proceeds north and east to Georges Bank. By June spawning spreads into the Gulf of Maine and continues to be centered on Georges Bank through summer. In October, spawning is centered in southern New England and by December is observed again along the shelf and slope in the Middle Atlantic Bight. Peak spawning occurs May to June in the southern stock and July to August in the northern stock (Brodziak 2001).

Variations in diet in diet of silver hake are dependent upon size, sex, season, migration, spawning, and age with size having the most influence on diet. Silver hake larvae feed on planktonic organisms such as copepod larvae and younger copepodites. The diet of young silver hake consists of euphausiids, shrimp, amphipods, and decapods. All silver hake are ravenous piscivores that feed on smaller hake and other schooling fishes such as young herring, mackerel, menhaden, alewives, sand lance, or silversides, as well as crustaceans and squids.

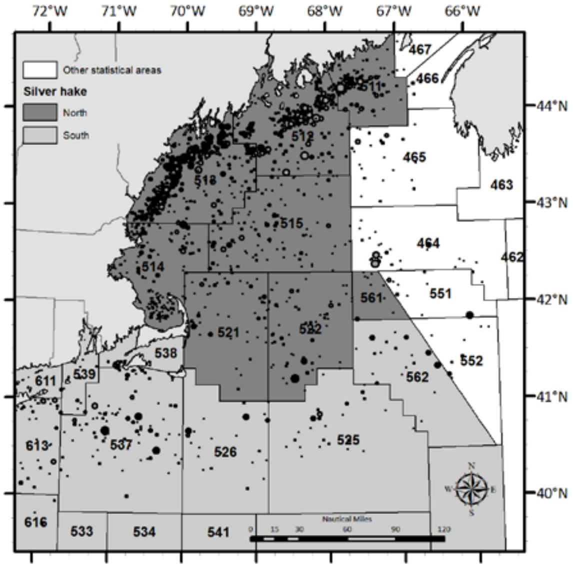
Silver hake, red hake, and offshore hake were last assessed at the 51st Northeast Regional Stock Assessment Workshop held in November-December 2010 (NEFSC 2011). Northern and southern silver hake are assessed separately. While a formal analytical assessment was attempted, the model was deemed not sufficient for use in providing management advice, due in part to questions about survey catchability across ages and years. Based on reference points updated during the assessment, the stocks are not overfished and overfishing is not occurring. The biomass reference point is based on catch per tow in the trawl survey, and the fishing mortality reference point is based on an exploitation index, i.e. fishery catch divided by the survey catch per tow biomass index.

Map 46 – Silver hake stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

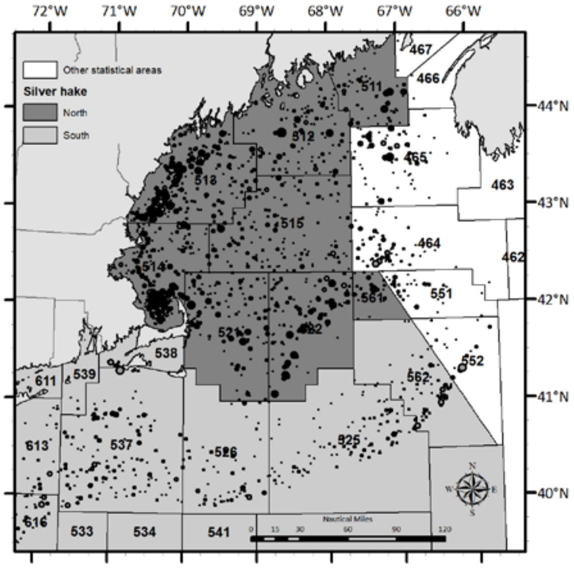
Total biomass (kg/tow)



Juvenile abundance < 20cm (#/tow)



Spawner biomass > 30cm (kg/tow)



4.2.1.1.12 White hake

White hake (*Urophycis tenuis*) occur predominantly in the deeper waters of the Gulf of Maine and along the edge continental shelf. The juvenile distribution extends into shallower waters in the Gulf of Maine, where they are most abundant, as well as into moderate depths over much of Georges Bank and in Southern New England. Young of the year hake are found shallow (less than 10 m) coastal Maine waters (Lazzari & Stone 2006). In the NEFSC trawl surveys, both lifestages are found in deeper waters in the spring (juveniles 80-300 m, adults 160-400 m) than in the fall (juveniles 30-120 m, adults 100-400 m). The Maine/New Hampshire survey, which occurs in inshore/nearshore GOM waters, finds juvenile white at depths of 50-190 m.

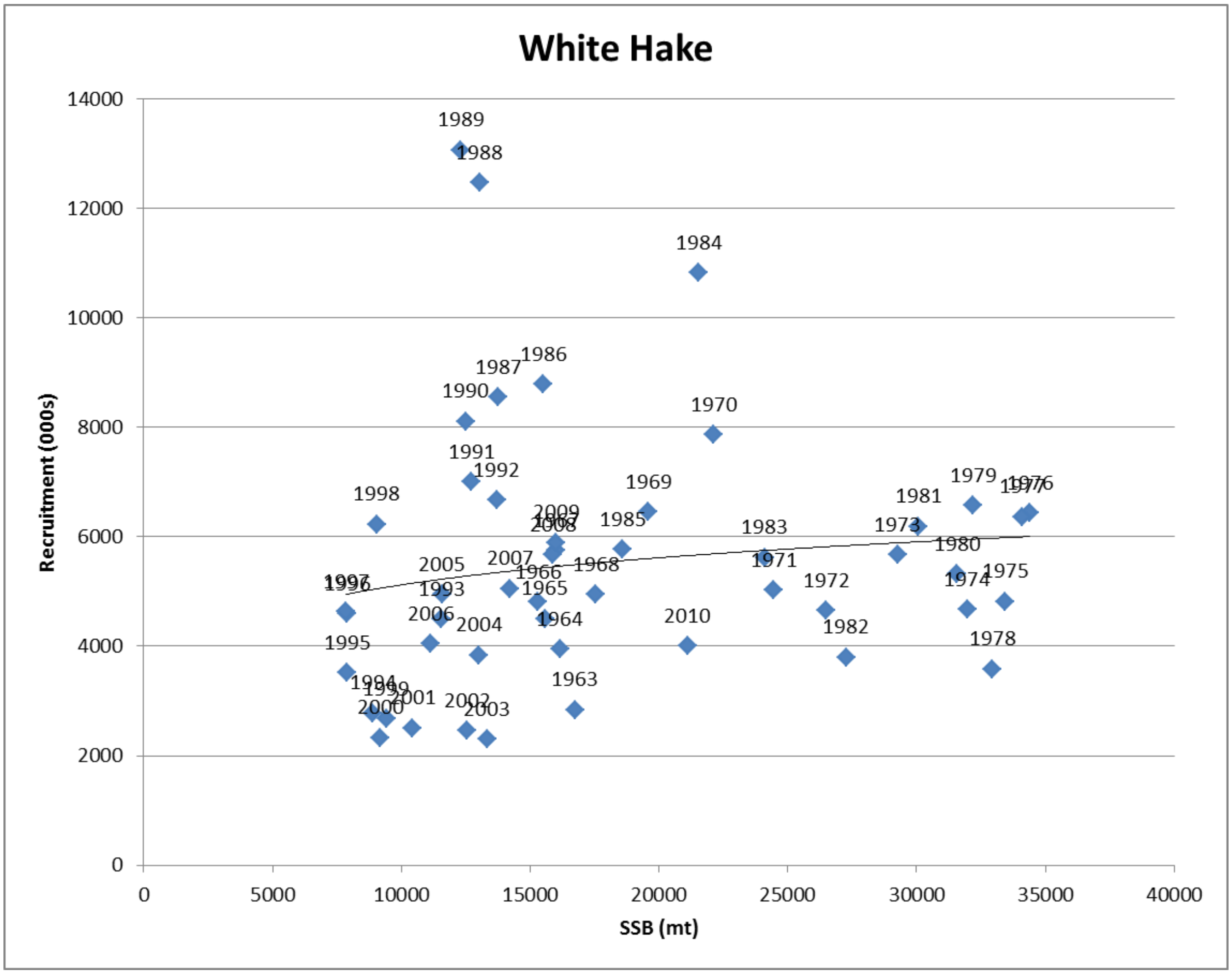
Juveniles and adults occur on mud and fine sand substrates (Chang et al. 1999). Eelgrass is an important habitat for demersal juveniles (Bigelow and Schroeder 1953; Fahay and Able 1989; Heck et al. 1989). Younger fish are spatially segregated from older year classes by occupying shallow areas, but they are not tied to eelgrass, other vegetation, or structured habitats (Markle et al. 1982; Able and Fahay 1998, also see Lazzari & Stone 2006). Although white hake are adapted to a wider range of depths and temperatures, juvenile and adult white hake co-occur with adult red hake (Klein-MacPhee 2002; off Canadian maritimes, see Markle et al. 1982). They appear to have a stronger preference than red hake for fine sediments (regional analysis in Methratta and Link 2006b, southwestern Gulf of Maine analysis in Auster et al 2001). In fact, sediment associations for white hake more closely resemble those of whiting.

The spawning contribution of the Gulf of Maine population is negligible (Fahay and Able 1989). The timing and extent of spawning in the Georges Bank-Middle Atlantic Bight stock has not been clearly determined. However, based on the distribution and abundance of pelagic juveniles, as well as circulation patterns throughout the region, Fahay and Able (1989) suggested that the southern stock spawns in early spring (April-May) in deep waters along the continental slope, primarily off southern Georges Bank and the Middle Atlantic Bight (Lang et al. 1996).

Juveniles prey on polychaetes and crustaceans, while adults feed on crustaceans, mollusks, and fish. Larger adults feed almost exclusively on fish.

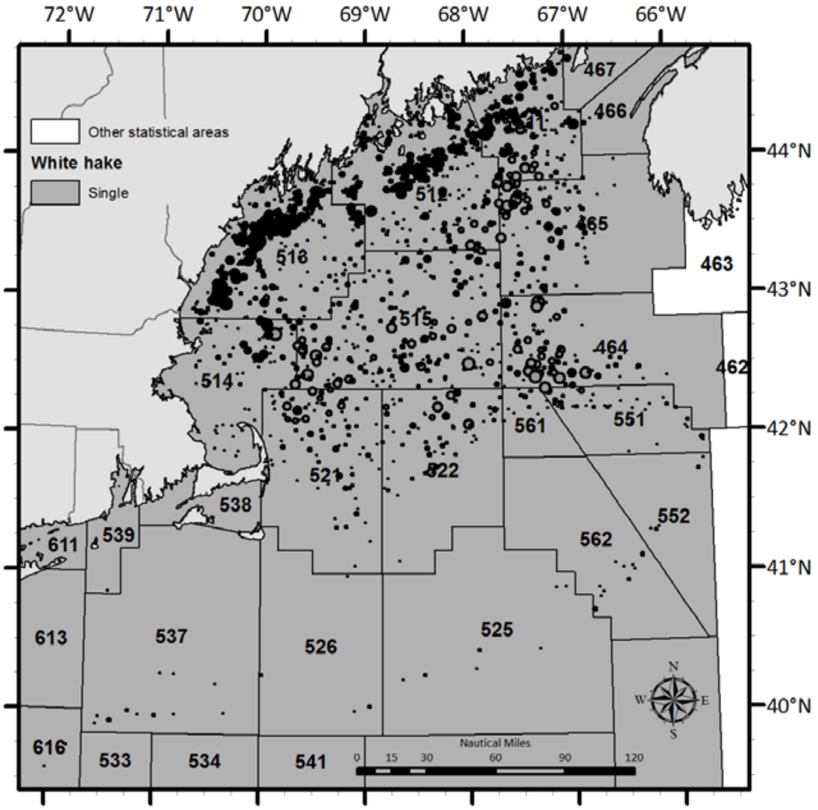
White hake are assessed as a single stock. During the 2008 Groundfish Assessment Review Meeting, 2007 fishing mortality was estimated to be above the threshold F_{msy}, and biomass estimates were below the threshold, ½ B_{msy} using an age structured production model. The stock was assessed through 2011 at the 56th Northeast Regional Stock Assessment Workshop. The June 2013 report indicated that the stock was not overfished nor was overfishing occurring. This status determination was made using a new statistical catch-at-age model (ASAP) and relative to reference points updated at the assessment. Specifically, spawning stock biomass in 2011 was estimated at 26,877 mt, above the ½ SSBMSY threshold of 16,200 mt, and 2011 fully selected fishing mortality was estimated to be 0.13, 66% of the reference point of 0.2.Recruitment increased during 2008 and 2009, but decreased between 2009 and 2010 (Figure 18).

Figure 18 – Recruitment and spawning stock biomass estimates for white hake (NMFS stock assessments)



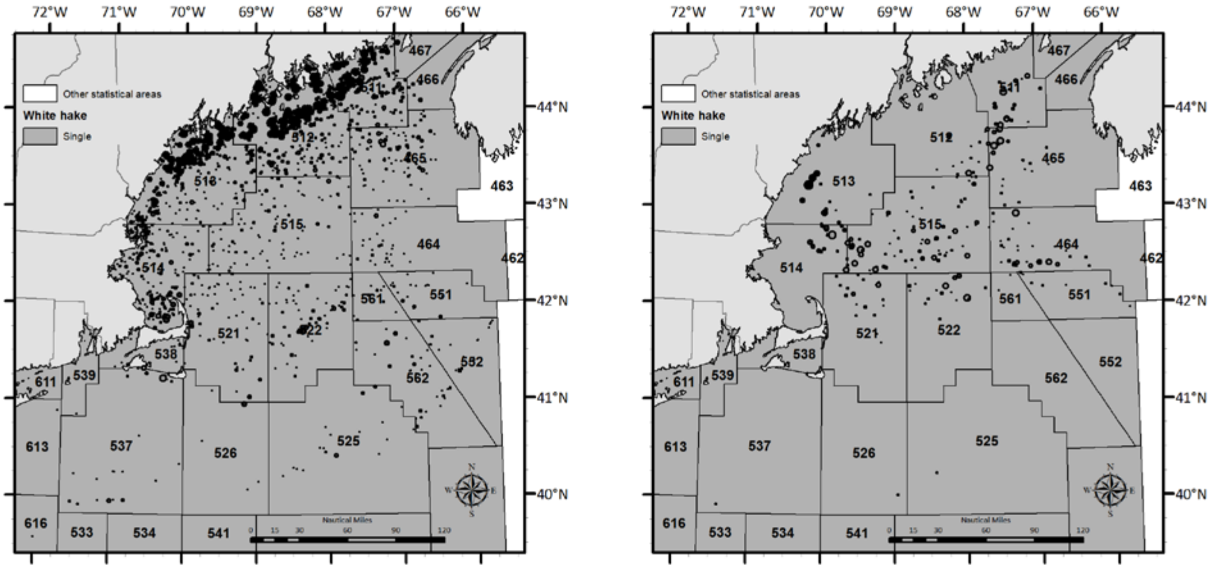
Map 47 – White hake stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile groundfish habitat and critical spawning areas.

Total biomass (kg/tow)



Juvenile abundance < 40cm (#/tow)

Spawner biomass > 75cm (kg/tow)



4.2.1.1.13 Windowpane flounder

Windowpane flounder (*Scophthalmus aquosus*) occur inshore out to moderate depths in the Gulf of Maine, on Georges Bank, and in southern New England and the Mid-Atlantic Bight. The depth range in the NEFSC trawl surveys for juveniles is 0-60 m fall and spring, and for adults is 0-50 spring and 0-70 fall. They are found in deeper waters in the Gulf of Maine, according to the ME/NH trawl survey, with juveniles mostly found at 20-100 m and adults found at 50-130 m.

Windowpane flounder are caught on sandy bottoms off southern New England and southwards but also frequent softer and muddier grounds in the GOM (Klein-MacPhee 2002). Mean biomass in the Georges Bank-Gulf of Maine region is generally associated with intermediate-sized sediments, with the highest catch rate on fine rock, but with very high variance (Methratta and Link 2006b).

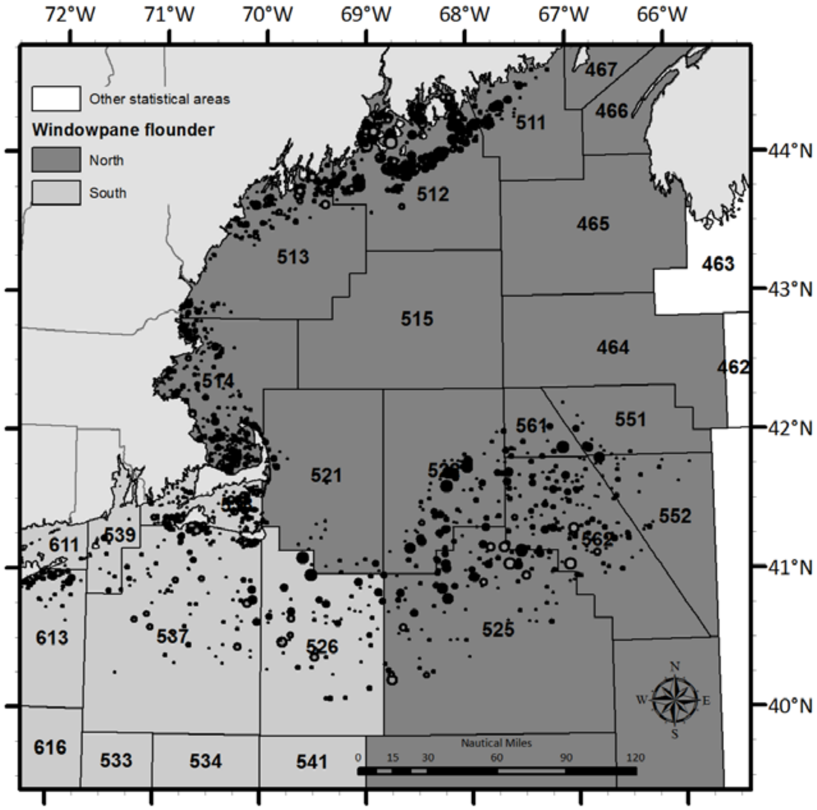
Based on the 1973-2005 NEFSC food habits data, windowpane flounder feed primarily on shrimp, amphipods, sand lance, and other fish species, with fish increasing in importance in the diet in older flounder.

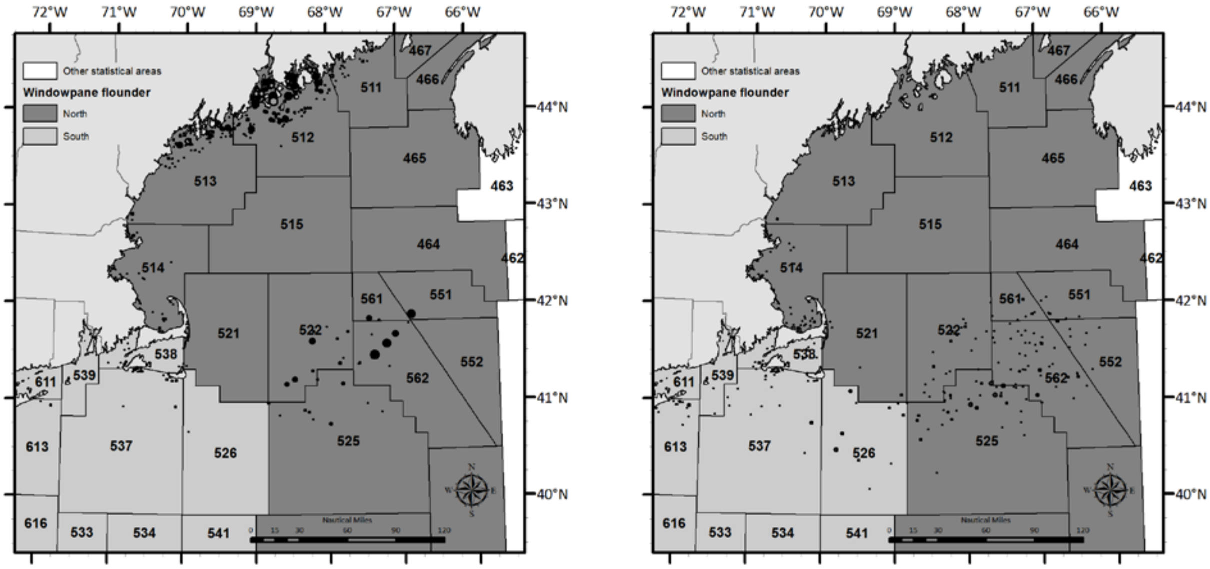
Windowpane flounder appear to spawn throughout most of the year, based on examinations of reproductive state in adults and the presence of eggs and larvae in survey catches. Peak spawning occurs in the Mid-Atlantic Bight in May, and on Georges Bank during the summer months. There is evidence for a split spawning season (spring and autumn) in parts of the Mid-Atlantic Bight.

Historically, most windowpane flounder have been landed with otter trawls. Most discarding occurs in the large mesh bottom trawl fishery, although discards also occur in the scallop dredge fishery. Currently, possession of both GOM-GB and SNE-MAB windowpane flounder is prohibited, so recent landings are very low. Note that for both stocks (Map 48), the catch and survey biomass time series were entirely revised during the recent ‘update’ assessment, mostly because shallow depths cannot be sampled by the new survey vessel, the R/V H. B. Bigelow. Reference points were also revised. The 2012 update indicated that northern stock is overfished with overfishing occurring, while the southern stock is not. For the northern stock, fishing mortality is down and biomass is up from GARM III (2008). For the southern stock, biomass now exceeds the target and it is no longer overfished as GARM III indicated.

Map 48 – Windowpane flounder stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile groundfish habitat and critical spawning areas.

Total biomass (kg/tow)




Juvenile abundance < 15cm (#/tow)

Spawner biomass > 30cm (kg/tow)

4.2.1.1.14 Winter flounder

Winter flounder (*Pseudopleuronectes americanus*) has a similar, although slightly shallower distribution than yellowtail flounder. This fish is found in shallow inshore areas out to moderate depths in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic Bight to around Delaware Bay. Their distribution tends to be deeper in the fall than in the spring, and adults have a slightly deeper distribution than the juveniles. In the southern part of their distribution, juveniles also occur further north in the spring, when they are concentrated in coastal waters from Delaware Bay to southern New England, vs. in the fall, when they are concentrated from the NY Bight to southern New England. Adults are similarly distributed in coastal waters, but also abundant on Georges Bank, with a fishery on Georges Shoal. See Methratta and Link 2006a and Methratta and Link 2007 for more information.

Methratta and Link (2006b) found that winter flounder caught in the NEFSC trawl surveys had higher mean biomass on fine rock (6 kg/tow) than on coarse rock and coarse sand (2-3 kg/tow) and very low biomass (<1 kg/tow) on fine sand and silt (Methratta and Link 2006b). They are not known to rely on complex structures for shelter.

Winter flounder have been described as opportunistic/omnivorous predators, feeding on a wide variety of different species. Polychaetes and crustaceans make up the bulk of their diet (Link et al 2002).

Except for the winter flounder found on Georges Bank, the species moves inshore to spawn in the late winter and early spring, with peak activity earlier or later depending on latitude. Their demersal eggs tend to be found in very shallow waters. The species is managed as three stocks based on mixing/lack of mixing during reproduction: Southern New England/Mid-Atlantic, Georges Bank, and Gulf of Maine. The stock definitions are based on both tagging and meristic (e.g. counting fin rays) studies (see recent stock assessment documents for references).

DeCelles and Cadrin analyzed the movement and spawning patterns of winter flounder using acoustic telemetry and concluded that there were two contingent spawning groups of flounder in the region: coastal spawners and estuarine spawners (DeCelles and Cadrin, 2010). The majority of the tagged winter flounder were shown to exhibit coastal spawning behavior, with the spawning season peaking from March to May. DeCelles and Cadrin focused their analysis within the Plymouth Estuary and Plymouth Bay in the southern portion of the Gulf of Maine (see Figure 19). Acoustic telemetry was used to track adult winter flounder, with 72 total specimens fitted with acoustic transmitters in areas where adult winter flounder were historically abundant (DeCelles and Cadrin, 2010). The winter flounder were then released in close proximity to their capture site.

Figure 19 – Map of the research site showing the locations in Plymouth Bay and Plymouth estuary where winter flounder were tracked with passive acoustic telemetry. DeCelles and Cadrin, 2010

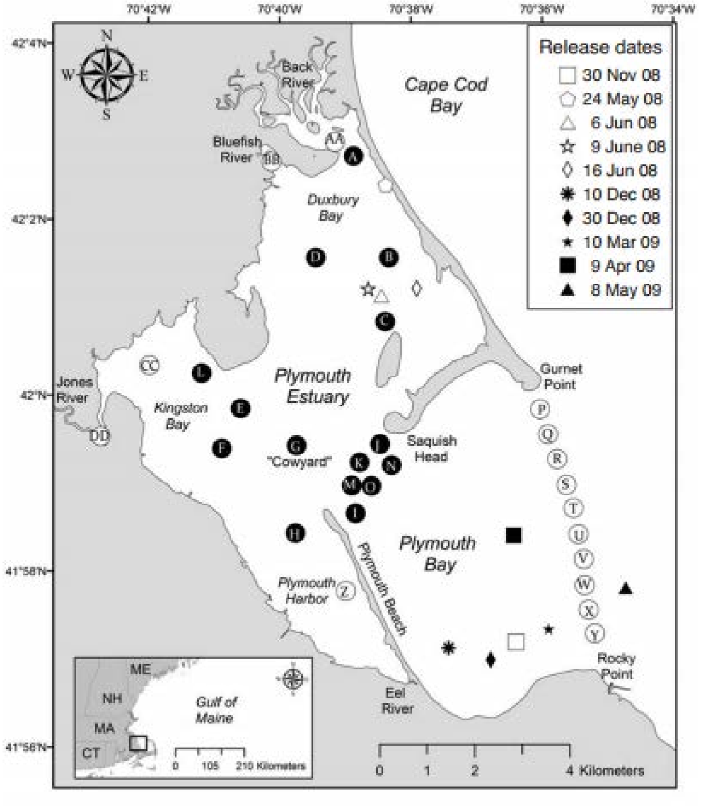


Figure 20 - Recruitment and spawning stock biomass estimates for Gulf of Maine winter flounder (NMFS stock assessments)

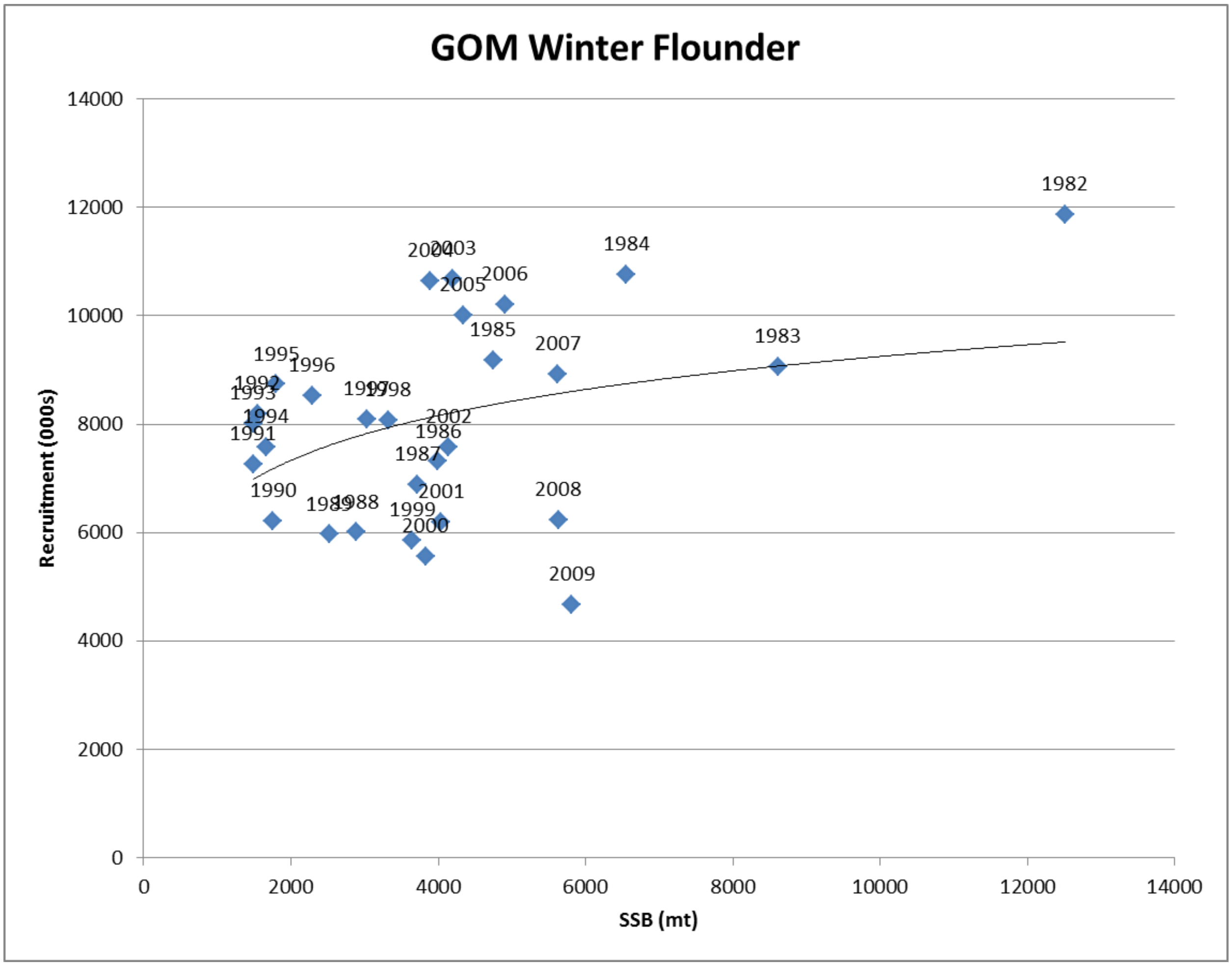


Figure 21 - Recruitment and spawning stock biomass estimates for Georges Bank winter flounder (NMFS stock assessments)

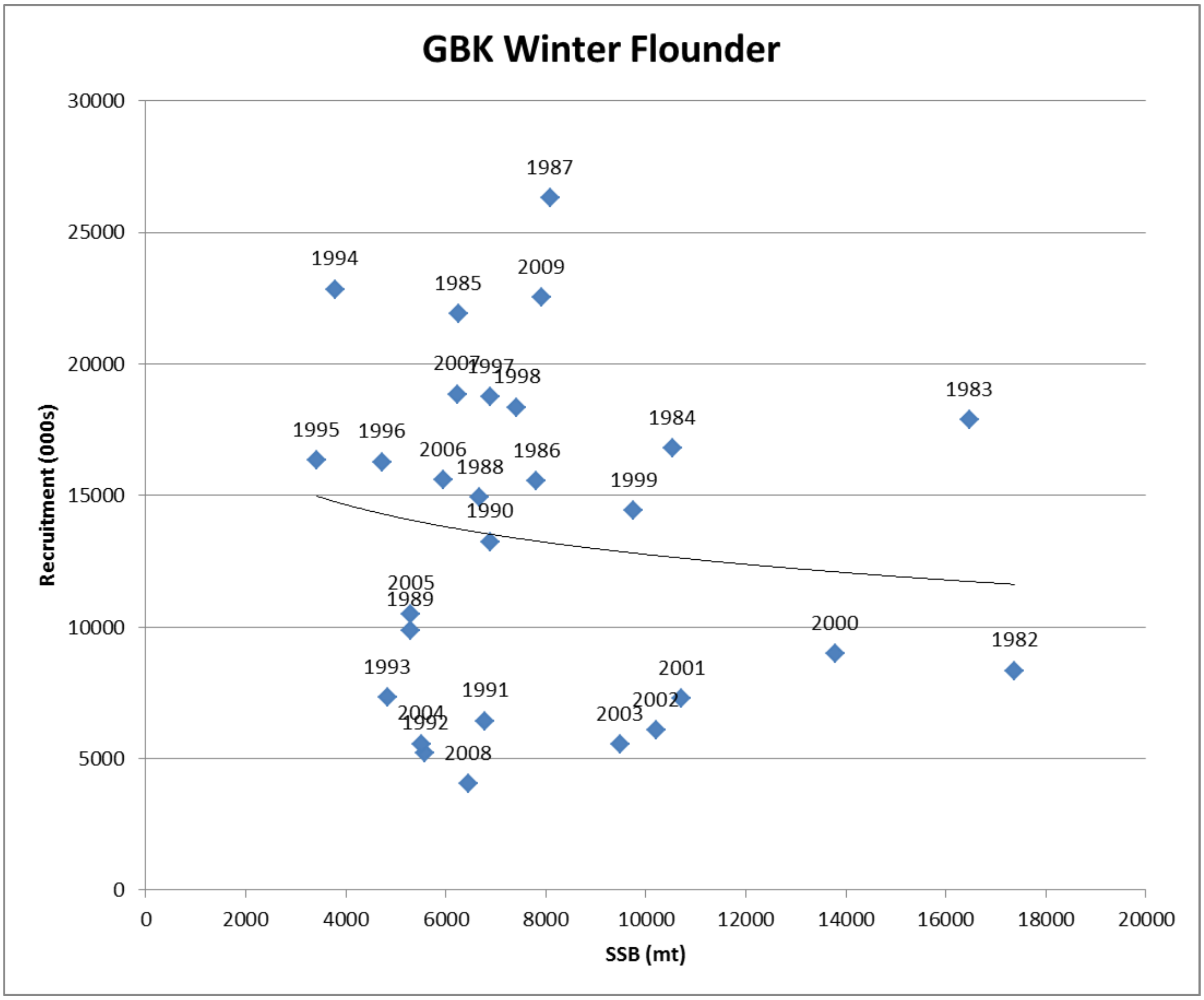
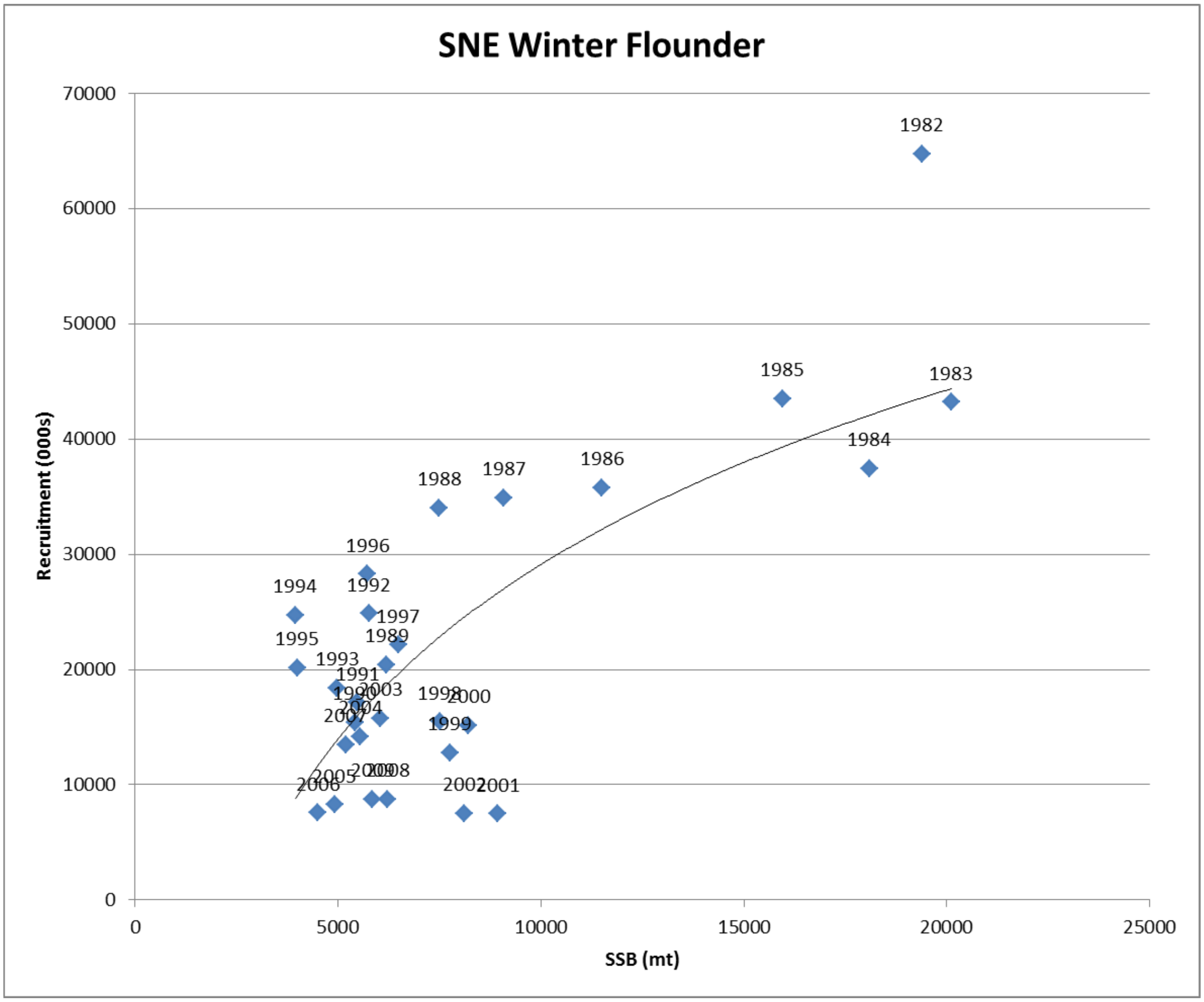


Figure 22 - Recruitment and spawning stock biomass estimates for Southern New England winter flounder (NMFS stock assessments)



Map 49). The 52nd Stock Assessment Workshop (2011) did not reach a conclusion on the status of GOM winter flounder, but noted that overfishing was probably not occurring. The statistical catch at age model could not account for conflicting trends in catch and survey data, and the fallback area-swept method provided trends only. Spawning stock biomass for Gulf of Maine winter flounder increased between 2003-2009. Recruitment was very low in 2009. The 52nd SAW used a virtual population analysis modeling approach to determine that the Georges Bank stock was not overfished with overfishing not occurring, and noted declines in fishing mortality over time. Spawning stock biomass and recruitment for the Georges Bank stock increased between 2004 and 2009The 52nd SAW found that SNE/MA winter flounder was overfished during 2010, but that overfishing was not occurring. The SNE/MA assessment relies on a statistical catch at age modeling approach, and both the natural mortality rate assumption and the assessment model itself were updated in 2010. The 52nd SAW noted that SNE/MA landings had recently been low. The assessment also noted very low spawning stock biomass and recruitment in 2009.

Figure 20 - Recruitment and spawning stock biomass estimates for Gulf of Maine winter flounder (NMFS stock assessments)

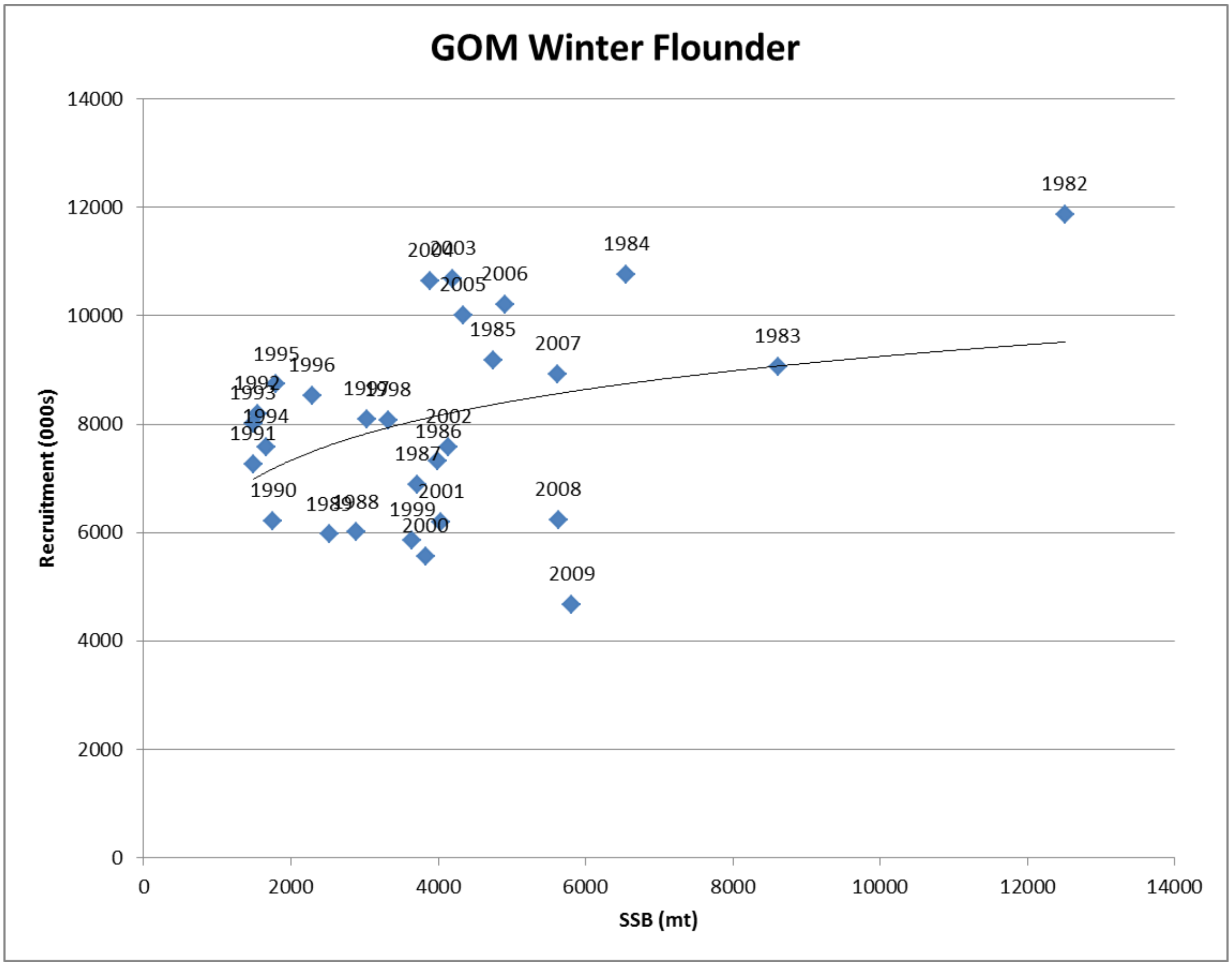


Figure 21 - Recruitment and spawning stock biomass estimates for Georges Bank winter flounder (NMFS stock assessments)

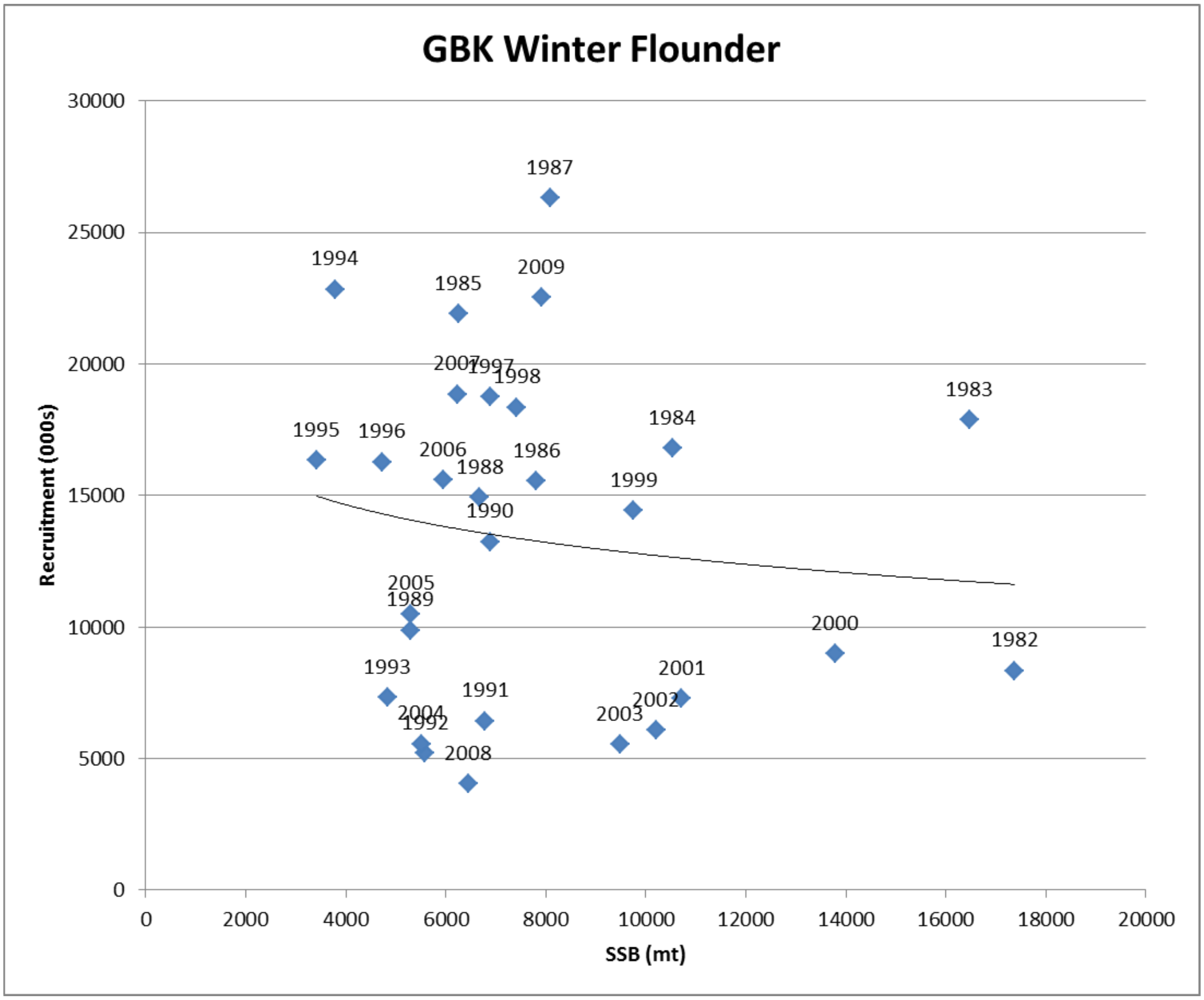
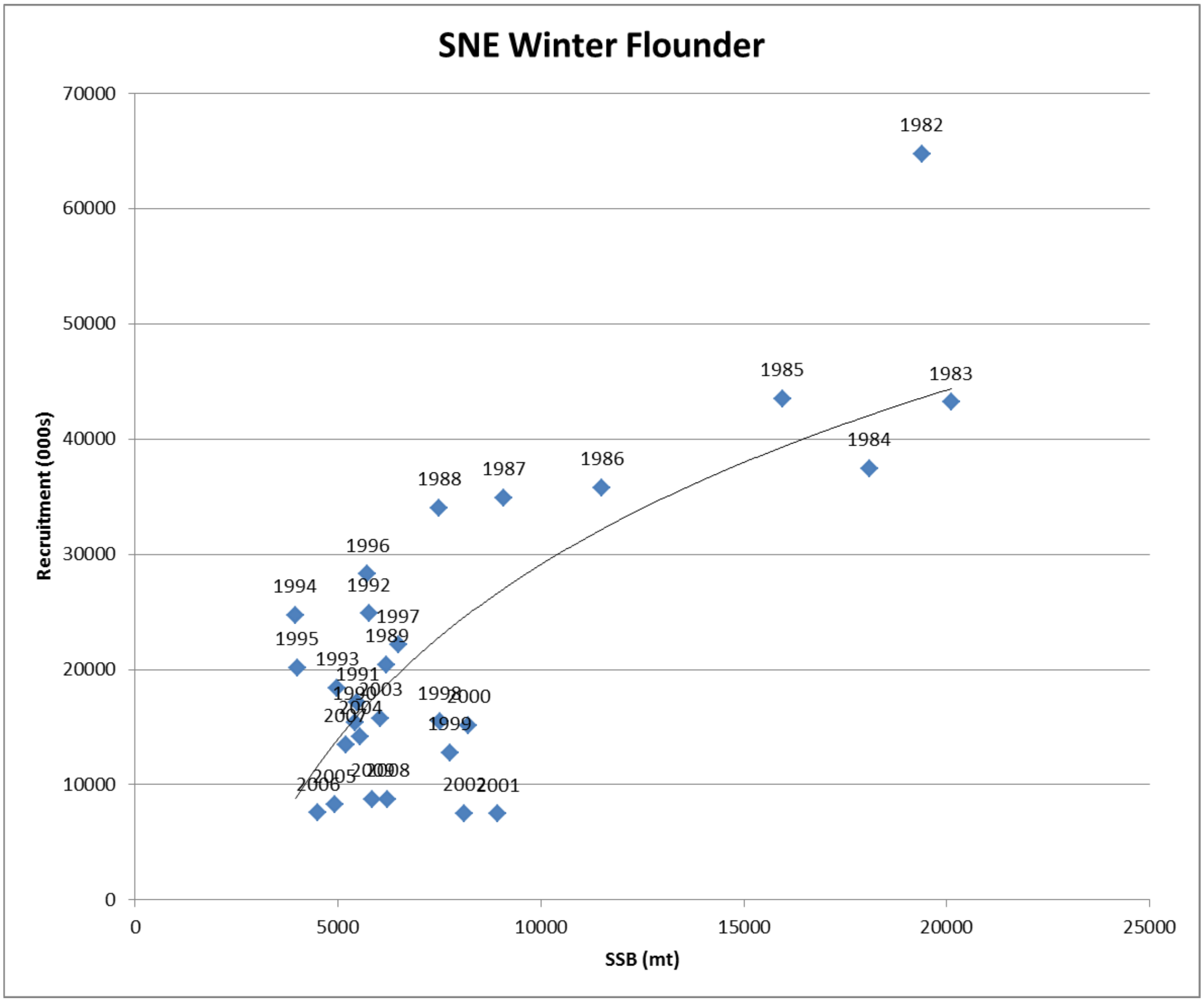
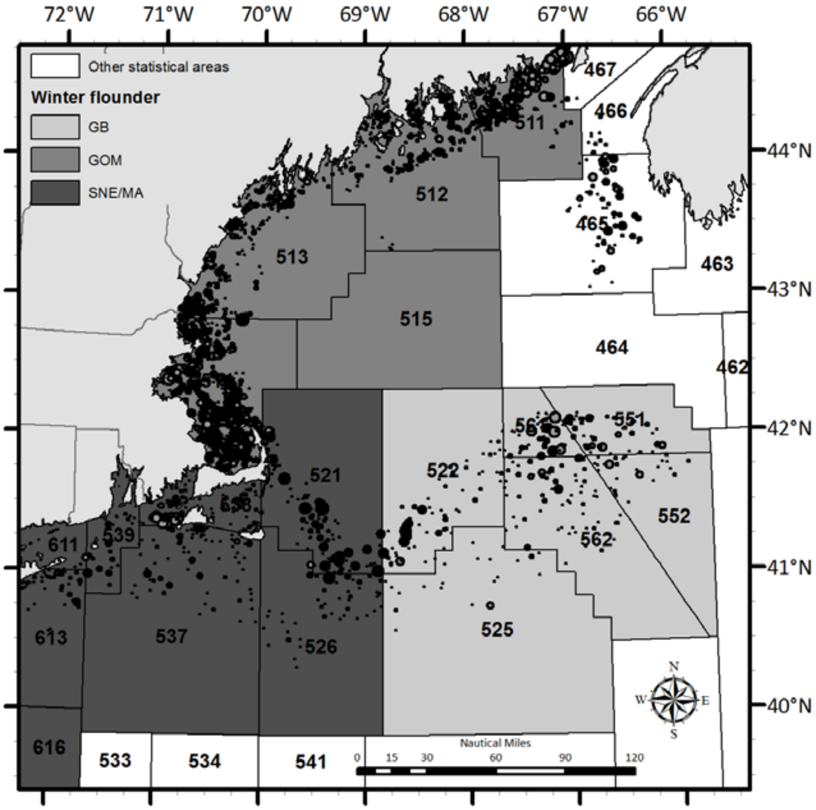


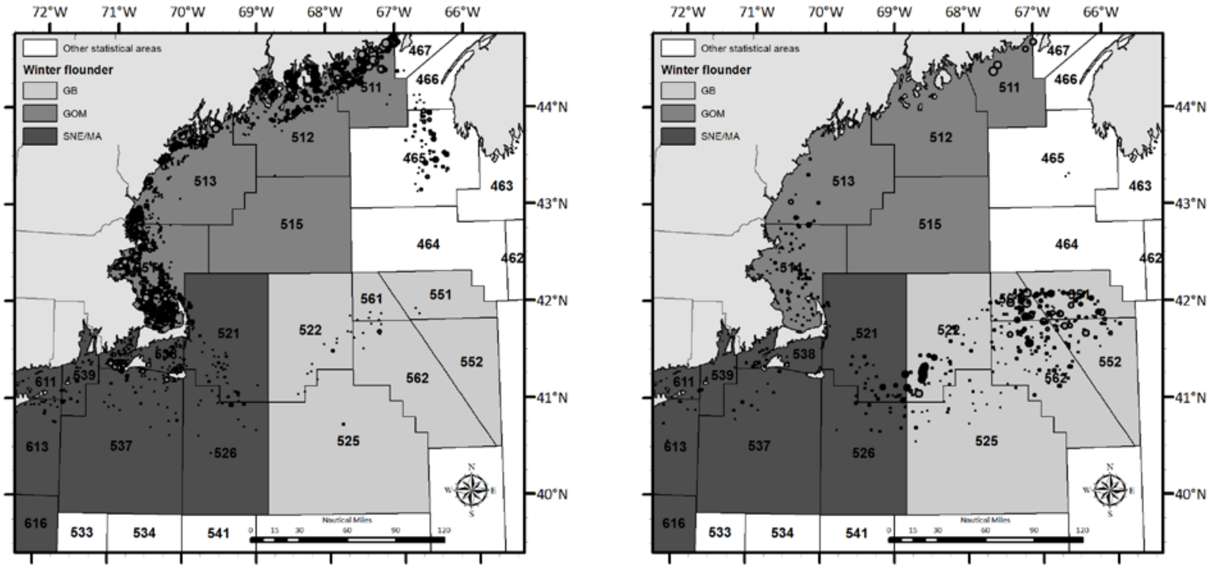
Figure 22 - Recruitment and spawning stock biomass estimates for Southern New England winter flounder (NMFS stock assessments)



Map 49 – Winter flounder stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

Total biomass (kg/tow)




Juvenile abundance < 30cm (#/tow)

Spawning biomass > 45cm (kg/tow)

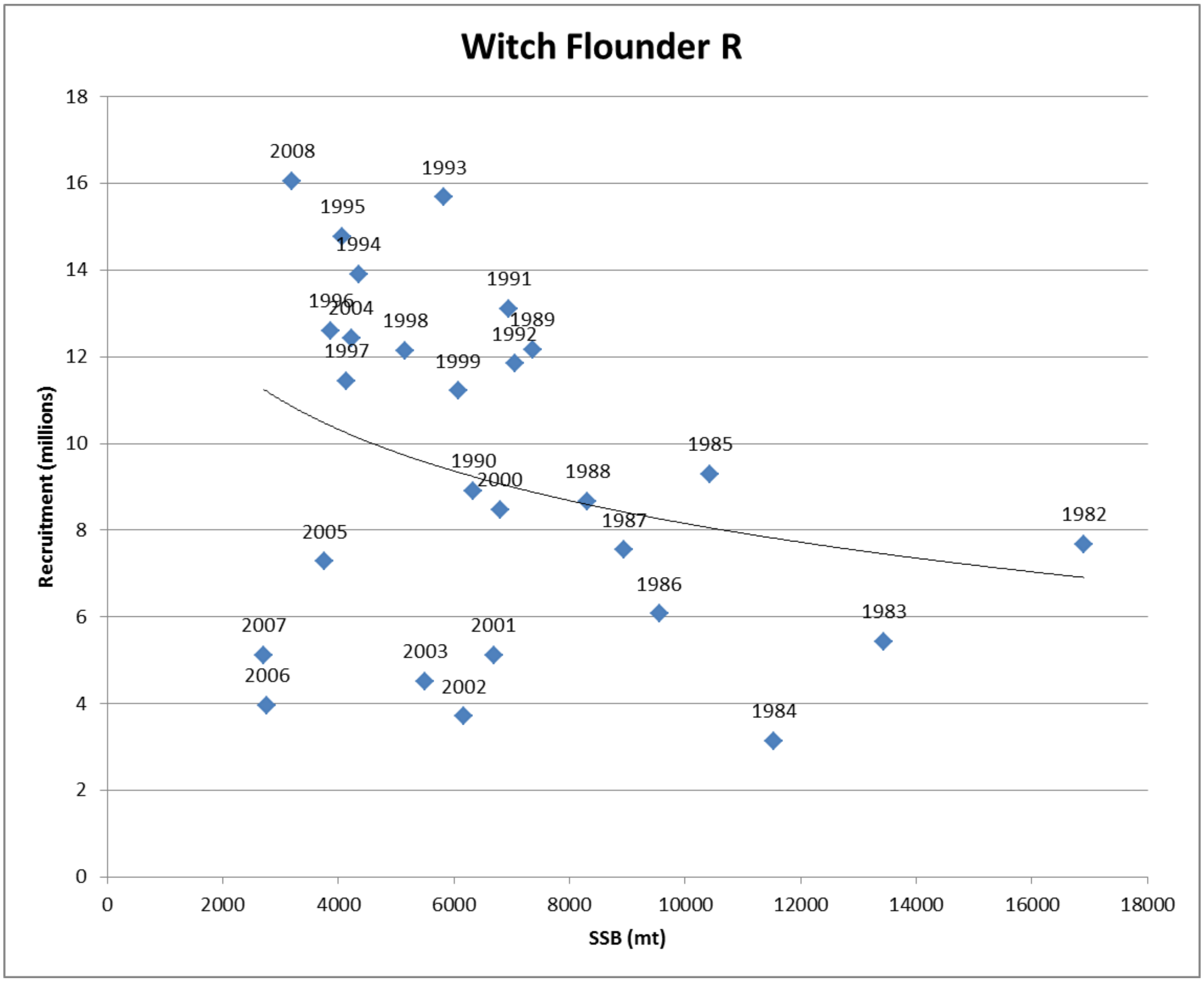
4.2.1.1.15 Witch flounder

Witch flounder (*Glyptocephalus cynoglossus*) is a deeper-water flounder that occurs throughout the Gulf of Maine and along the shelf/slope break along Georges Bank and the Mid-Atlantic Bight. In the NEFSC trawl surveys, juveniles (≤29 cm) are found at depths of 80-400m during both spring and fall, while adults are in shallower waters during the fall, 100-200m, and move into deeper areas in the spring (100-400 m). Highest catches in the survey occur in the Gulf of Maine, generally north of 43 degrees north latitude, and in selected areas along the shelf break.

The witch flounder is very closely tied to mud/silt, muddy-sand, and clay substrate (Powles and Kohler 1970; Martin and Drewry 1978; Scott 1982b; MacDonald et al. 1984) and rarely occurs on any other bottom type. The 1973-2005 NEFSC food habits data for witch flounder verify that polychaetes are by far the most important food source of witch flounder. This close association with soft substrate may be the result of their preference for polychaete prey (Susan Wigley, NEFSC, Woods Hole Laboratory, personal communication). Auster et al. (1991) showed small scale habitat associations of witch flounder with depressions in mud bottom. This association could possibly serve as a means of evading strong currents. In the GOM-GB region, witch flounder catch rates trended to higher values with decreasing sediment grain size (Methratta and Link 2006b).

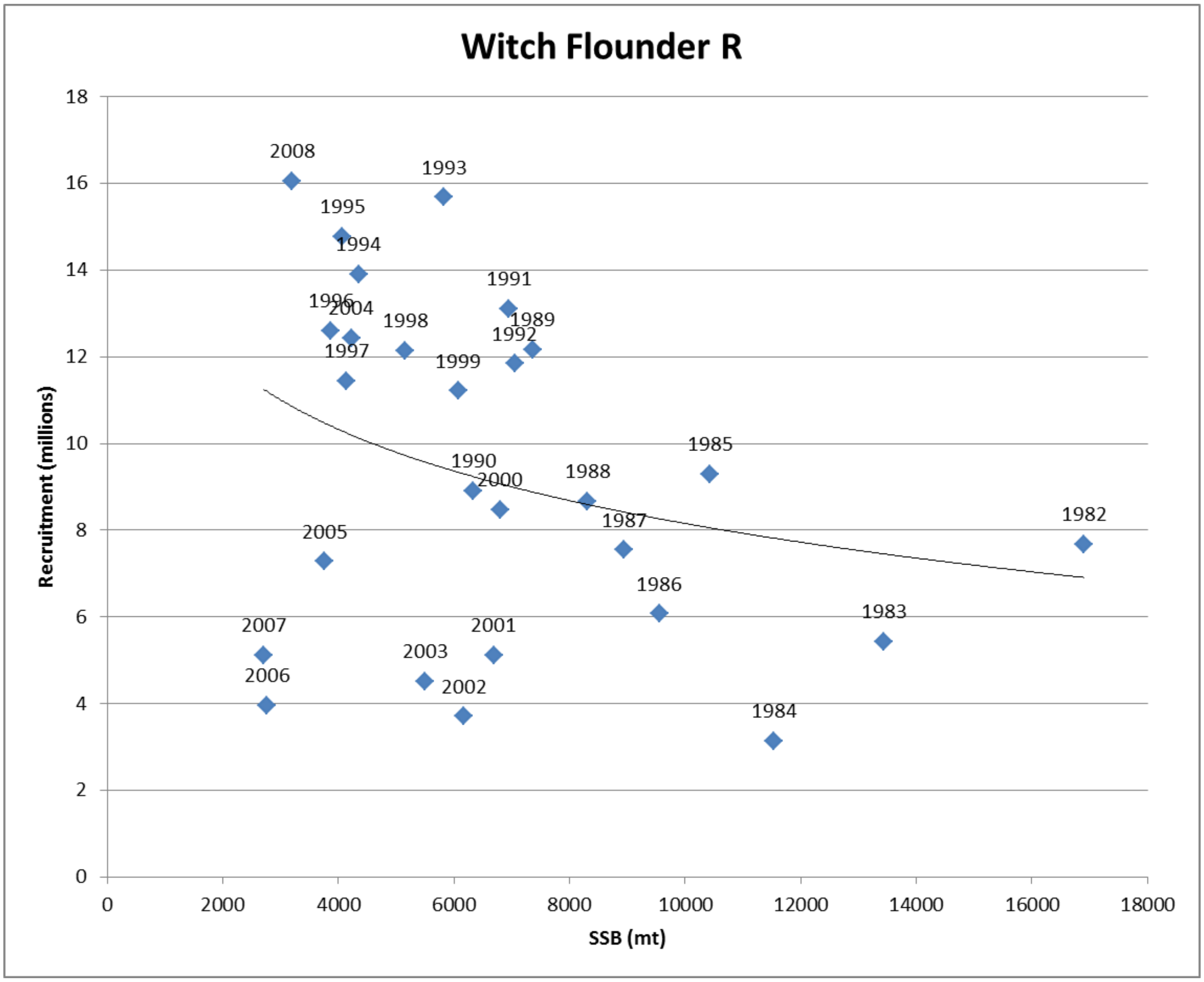
Witch flounder spawn from March to November, with peak spawning occurring in summer. The general trend is for spawning to occur progressively later from south to north (Martin and Drewry 1978; Brander and Hurley 1992). The MARMAP offshore ichthyoplankton surveys found the highest egg densities in the Gulf of Maine and Massachusetts Bay in May and June. The western and northern areas of the Gulf of Maine tend to be the most active spawning sites (Burnett et al. 1992). In the Middle Atlantic Bight, the most important spawning grounds are off Long Island (Smith et al. 1975). Wigley and Burnett (2003) examined the deep-water population of witch flounder on the continental slope and concluded that deep-water witch flounder are de-coupled from those in the GOM/GB region and probably reflect local spawning populations.

Most witch flounder are landed with otter trawls. Discards, which make up a small fraction of total catch, have been estimated for the large and small mesh otter trawl and also the shrimp trawl fisheries. The stock remains at low abundance and the current estimate of fishing mortality is high. The NEFSC trawl survey catches very few witch flounder overall, and at low abundance, the data may not be sufficient to provide reliable abundance and biomass estimates (see section 7.0 of assessment update document). As of the 2012 update assessment, witch flounder, which is managed as a single stock throughout its range (Figure 23 - Recruitment and spawning stock biomass estimates for witch flounder (NMFS stock assessments)



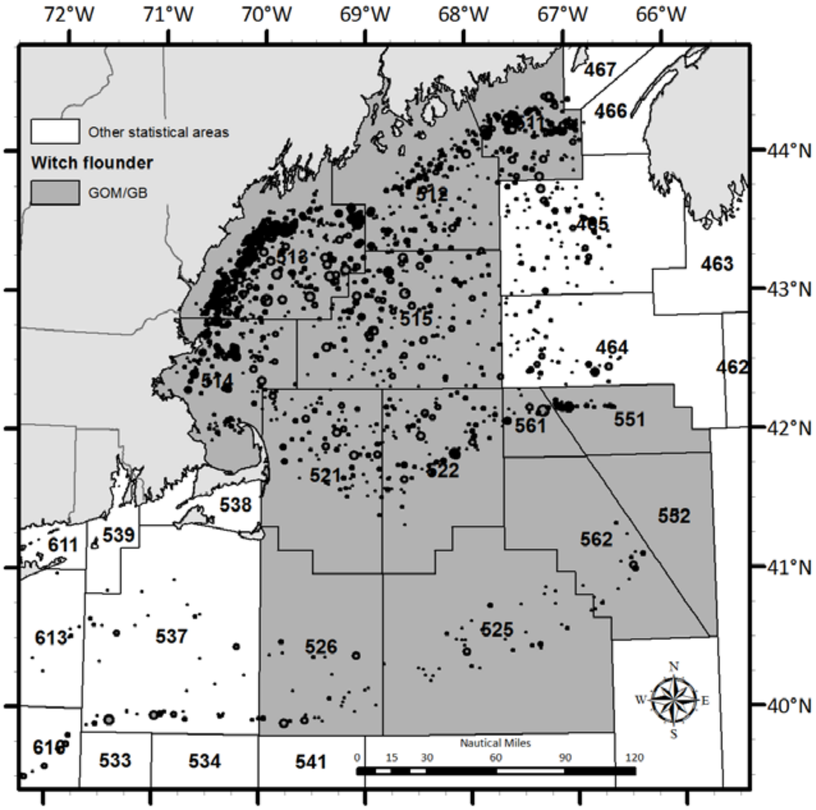
Map 50), was overfished with overfishing occurring during 2010. The assessment report commented that fishing mortality on witch flounder is very high relative to the reference point. The assessment noted that recruitment was very high in 2008, while spawning stock biomass had only slightly increased from 2006.

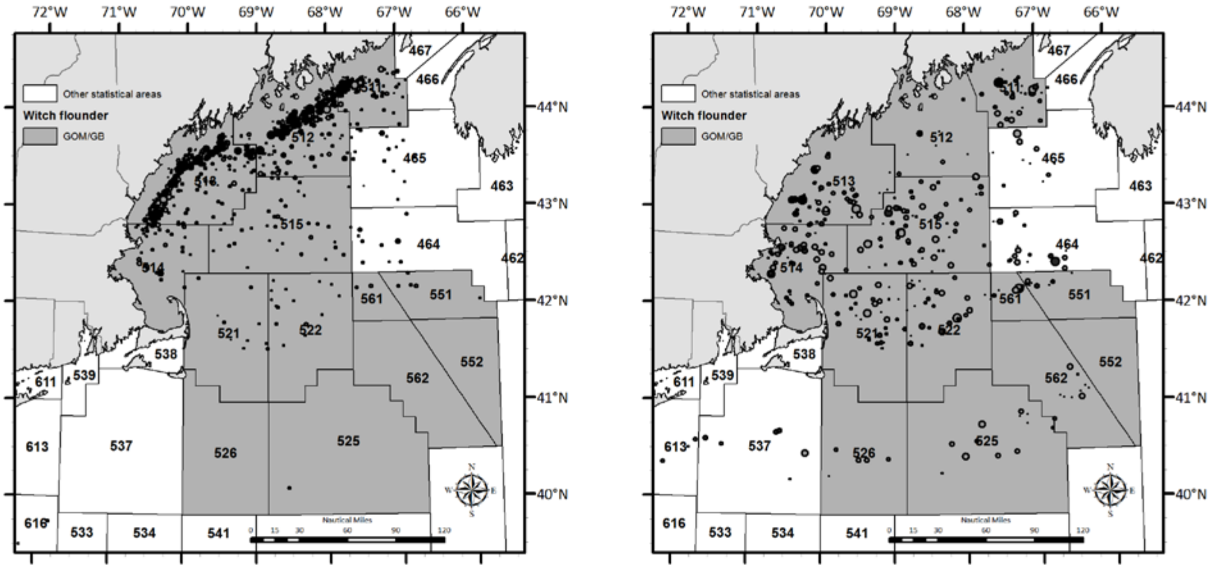
Figure 23 - Recruitment and spawning stock biomass estimates for witch flounder (NMFS stock assessments)


Witch Flounder R
Recruitment (millions)
SSB (mt)
0
2
4
6
8
10
12
14
16
18
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
2008
1993
1995
1994
1991
1996
2004
1998
1989
1992
1997
1999
1985
1990
2000
1988
1987
2005
1982
1986
1983
2007
2001
2003
2006
2002
1984

Map 50 – Witch flounder stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

Total biomass (kg/tow)




Juvenile abundance < 20cm (#/tow)

Spawner biomass > 45cm (kg/tow)

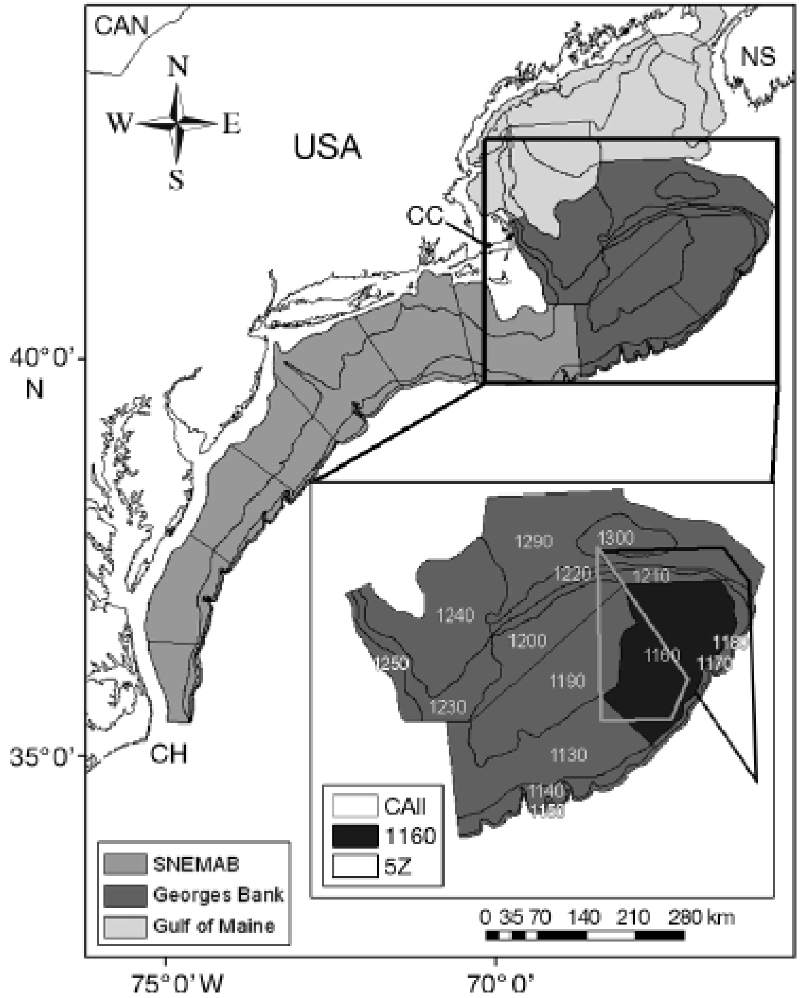
4.2.1.1.16 Yellowtail flounder

Yellowtail flounder (*Limanda ferruginea*) are distributed from Labrador to Cape Henry, Virginia. This is a common species in bottom trawl surveys in the southwest Gulf of Maine (GOM), on Georges Bank (GB), and in the Mid-Atlantic Bight (MAB) as far south as 39˚N (off Cape May, NJ) (Johnson et al. 1999). During 1990-2002 Northeast Fishery Science Center spring and fall bottom trawl surveys in GB-GOM region, small 0-20 cm yellowtail were caught in low numbers in the southwest GOM, on GB, and in Southern New England (SNE); larger 20-40 cm yellowtail were abundant in the southwest GOM and in deeper water on eastern GB (the southern part of Closed Area II), but were also common in SNE and elsewhere on GB (Methratta and Link 2007). EFH includes inshore waters of the GOM and on the continental shelf on GB and in the MAB. Young of the year juveniles use continental shelf waters in the Mid-Atlantic (NY Bight) as nursery habitat, settling predominantly at mid-shelf study sites at depths of 40-70 m (Steves et al. 1999; Sullivan et al. 2006). In the Mid-Atlantic, juveniles and adults move out of inner shelf waters (e.g. NY Bight) in the fall; otherwise, there is very little evidence of seasonal migration (this can be seen by comparing spring/fall survey distribution charts in Johnson et al. 1999 and NEFSC 2004).

Yellowtail flounder prefer sand and muddy sand, and avoid rocks, stony ground, and very soft mud (Klein-MacPhee 2002). In GOM-GB region, catch rates were highest on coarse sand, about three times higher than on coarse and fine rock, with very low catches on fine sand and silt (Methratta and Link 2006b). Smaller fish were associated with larger grain size sediments (Methratta and Link 2007). Young of the year juveniles in the New York Bight settled in the available habitat (bare sand, shell hash, sand dollars) or associated with clean sand substrates, which often included peaks of sand wave crests (Sullivan et al. 2006).

Comparing the prediction of three different models of habitat use, Pereira et al. 2012 concluded that eastern Georges Bank, specifically within Closed Area II, provided a high quality sand habitat for yellowtail flounder. Pereira et al. 2012 performed a geospatial analysis of habitat use of yellowtail flounder on Georges Bank to reach this conclusion. The prediction of the three tested models (the constant density model, the proportional density model and the basin model) were compared with survey data on yellowtail flounder in Georges Bank that took place in the spring and fall. The high quality sand habitat for yellowtail flounder is shown in Map 51.

Map 51 – Yellowtail flounder preferred sand habitat (Pereira et al. 2012).



Based on Marine Resources Monitoring, Assessment and Prediction (MARMAP) ichthyoplankton survey data from 1977-1987 (see Johnson et al. 1999), spawning begins in February or March, occurring first in the northern half of the Mid-Atlantic and then extending rapidly into SNE and GB. In April and May, spawning increased in intensity in these areas, and began in the Gulf of Maine. Eggs were found in the GOM from April to September, with peak abundance between April and June.

Smolowitz et al. analyzed the bycatch rates of 14 trips using scallop dredges within Closed Area I and II from October 2010 to April 2012, indicating that peak spawning for yellowtail flounder on Georges Bank within Closed Area I and II is around May/June and peak spawning for winter flounder is around February/March (Smolowitz et al. 2012). The bycatch rates for yellowtail flounder were found to be highest from August to October (Smolowitz et al. 2012). Smolowitz et al. summarized this data in a final report submitted for the 2011 sea scallop research set-aside.

Yellowtail flounder is managed as three stocks in U.S. waters – Cape Cod/Gulf of Maine, Georges Bank, and Southern New England/Mid-Atlantic (Map 52). The Georges Bank stock is managed as a transboundary resource with Canada and joint assessment activities are conducted via the Transboundary Resource Assessment Committee. Status of the Cape Cod/GOM stock was updated in March 2012, with the status determination overfished with overfishing occurring. There was little change in biomass form the 2008 GARM III estimate, although the update showed a decrease in fishing mortality rate between 2007 (GARM III) and 2010 (2012 update). Stock recruitment decreased from 2008 to 2009.

The assessment for the Southern New England/Mid-Atlantic stock was updated in June 2012 (54th SAW Summary Report, NEFSC Ref Doc 12-14, July 2012). Projections based on two alternative recruitment scenarios both indicated the overfishing was not occurring in 2011. The different recruitment assumptions produced conflicting results as to whether biomass was above the reference point, but the stock assessment review committee concluded that the “recent recruitment” scenario was most likely, which would mean that the stock is not overfished.

The Transboundary Resource Assessment Committee reviewed the status of the Georges Bank stock in June 2012 (TRAC Status Report 2012/10, Revised). Spawning stock biomass was estimated at 4,600 mt in 2011, and fishing mortality on fully recruited flounder (age four and over) was estimated to be 0.31 in 2011, above the overfishing reference point of F_{ref}=0.25. Recruitment has recently been low, and if observed retrospective patterns continue, fishing mortality rates are expected to increase and biomass is expected to decrease in the next assessment.

Figure 24 - Recruitment and spawning stock biomass estimates for Cape Cod/Gulf of Maine yellowtail flounder (NMFS stock assessments)

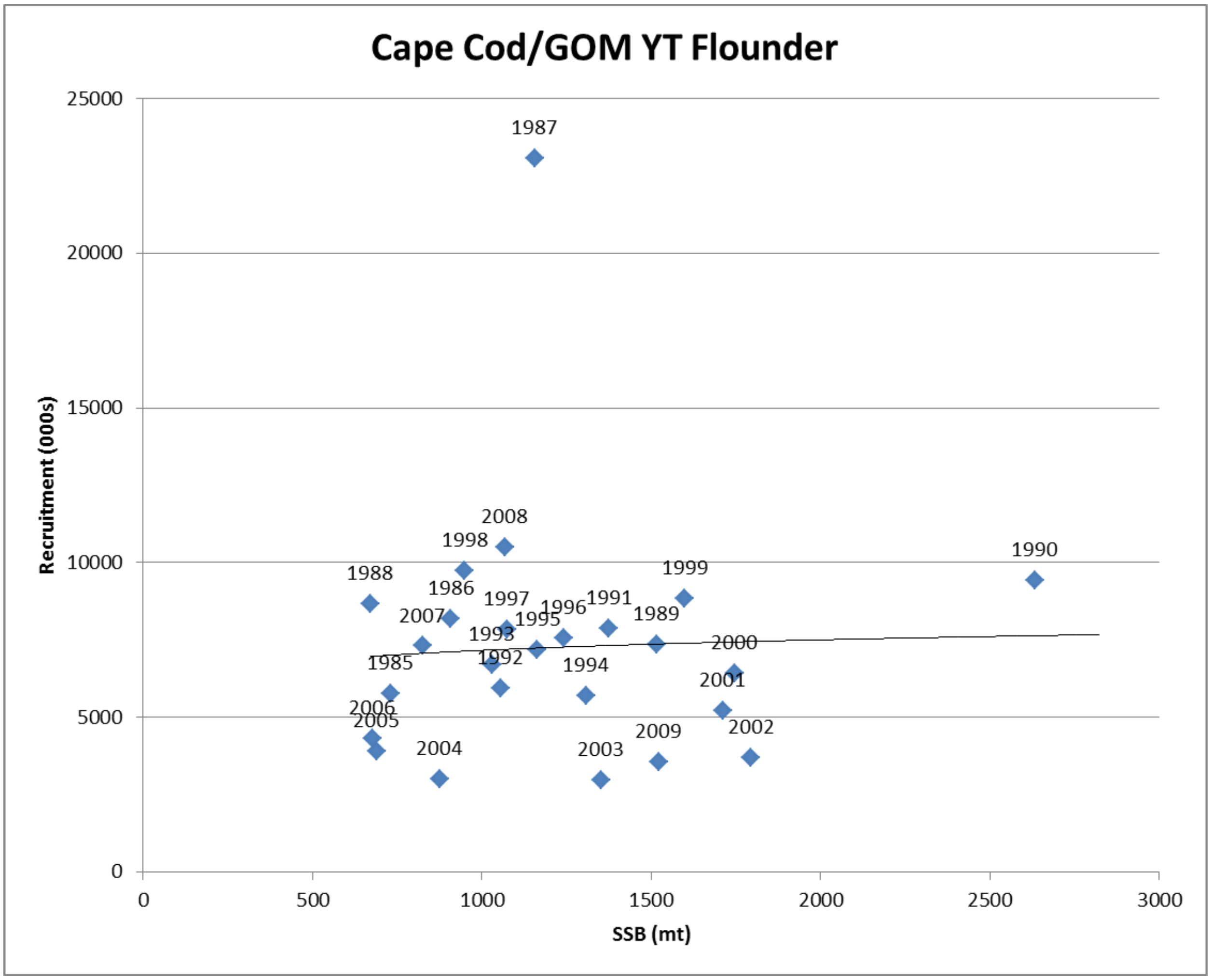
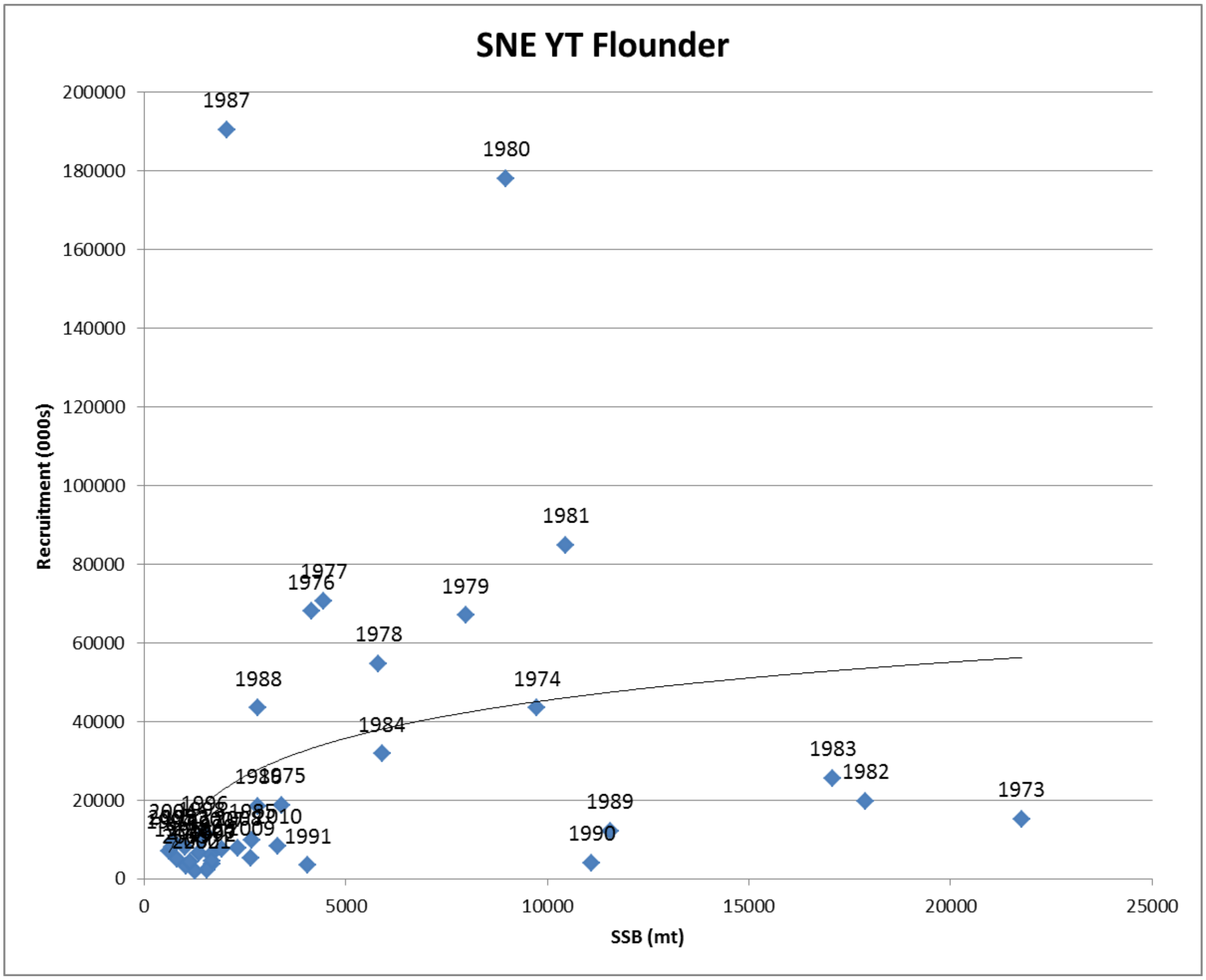
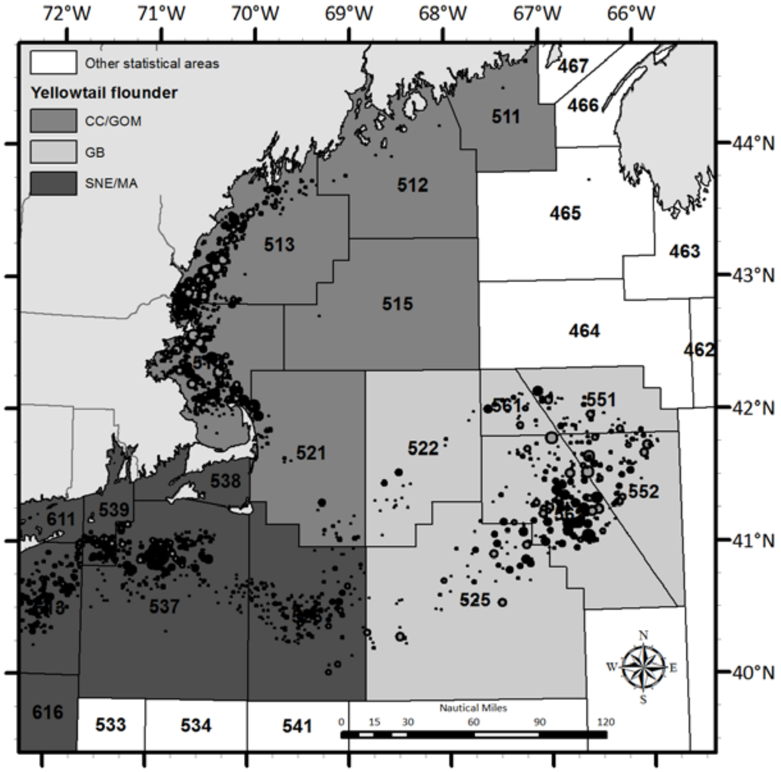


Figure 25 - Recruitment and spawning stock biomass estimates for Southern New England yellowtail flounder (NMFS stock assessments)



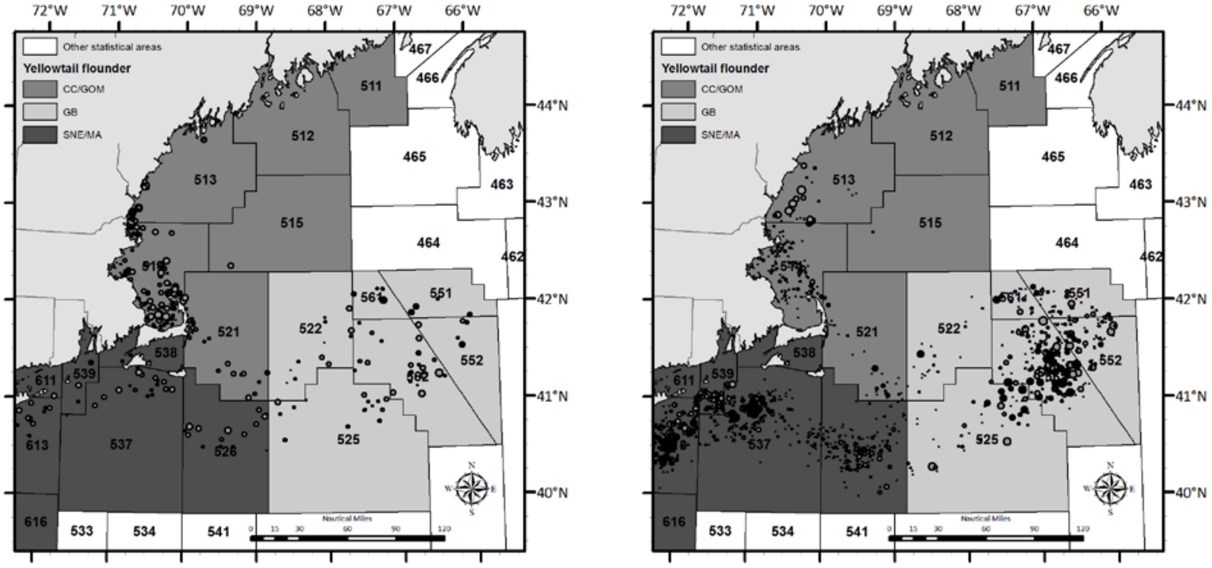
Map 52 – Yellowtail flounder stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black. Small juvenile and large spawner size thresholds correspond to sizes used in the hotspot analysis (Section 4.2.2) to help identify critical juvenile habitat and spawning areas.

Total biomass (kg/tow)



Juvenile abundance < 15cm (#/tow)

Spawner biomass > 40cm (kg/tow)



4.2.1.2 Monkfish

Juvenile and adult monkfish (*Lophius americanus*, also referred to as goosefish) are common and widespread in mud habitats throughout the Gulf of Maine, and in muddier and deeper (<50 m) shelf-slope waters from the Hague Line to Cape Hatteras.

In broad scale surveys of the Gulf of Maine/Georges Bank/Northern Mid-Atlantic Bight region, monkfish remain in deep water during both fall and spring, and are generally associated with fine-grained sediments, i.e. silt and clay (Methratta and Link 2006a). Pairwise comparisons showed monkfish biomass in kilograms per tow was lower in fine rock (granule-pebbles, 2-8 mm grain size) than in silt or clay. Results of more targeted bottom trawling in the southwestern Gulf of Maine on isolated mud bottom versus mud that is next to rocky bottom shows that monkfish were equally abundant (number/tow) in both habitats, but adult fish on edge of structured habitat had more to eat and were in better condition (Smith et al 2008). The northern portion of WGOM closed area was not found to be a good nursery area for juveniles: they were more abundant and had more to eat outside the closed area (Smith et al. 2008).

Monkfish spawn between spring and early fall with a peak in May-June. Spawning occurs earlier in low latitudes and later in the northern part of their range. Their eggs are deposited in a veil, which remains in the surface currents for a few weeks before it disintegrates and the larvae hatch. Based on their size and shape, it appears that the egg veils are designed for surface current transport (http://www.nefsc.noaa.gov/read/popdy/monkfish/MonkfishEggveilReporting/)

Monkfish are opportunistic predators that feed on a wide variety of benthic and pelagic species, depending on availability. However, the major prey items of juveniles and adults are squid and fish. Juveniles consume silver hake and flounders, and adults eat a wide range of fish species.

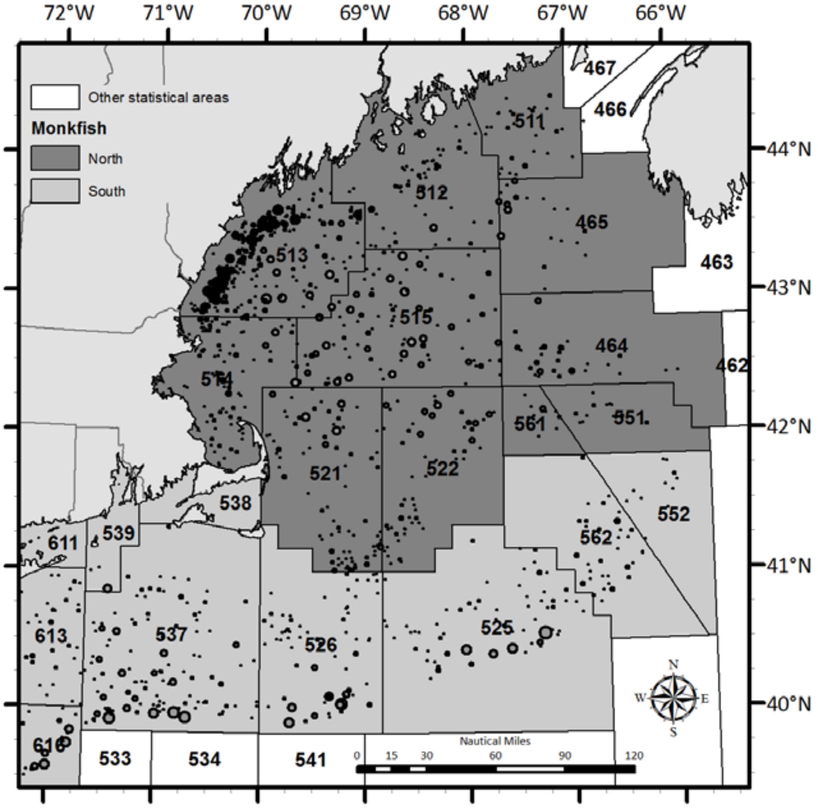
Monkfish north of Georges Bank and south of Georges Bank are managed separately, and both reference points and the assessment model were updated during the 2007 assessment. While both the 2007 and 2010 assessments suggested that the stocks are not overfished and overfishing is not occurring, there are considerable uncertainties in many assessment inputs and outputs (Northeast Data Poor Stocks Working Group 2007, 50th SAW 2010). The 2009 biomass estimate for the northern component is above the threshold, but about half the biomass estimated for 2006 (50th SAW 2010).

Relatively infrequent catches in various surveys contribute uncertainty to the assessment, although the R/V Henry B. Bigelow catches more monkfish and covers the entire range of the species in U.S. waters (Richards et al. 2012, 50th SAW 2010). Another issue is that the rate of mixing between the two populations is not well known (Richards et al. 2012). There are also questions about monkfish growth and aging, commercial landings and discards, natural mortality rates, and sex ratios. Tagging studies are underway to investigate mixing, growth, and aging questions (some results presented in Richards et al. 2012).

The most recent assessment was conducted in 2013, with the terminal year of the assessment being 2011. Long-term assessments of total biomass at Fmax were recommended in SAW 50 assessment (2010) and utilized for management purposes in 2012 and updated in the current assessment. The current 2013 assessment indicates that monkfish are not overfished in the northern or southern management area, however there are high levels of uncertainty regarding BRPs due to weaknesses in the input data.

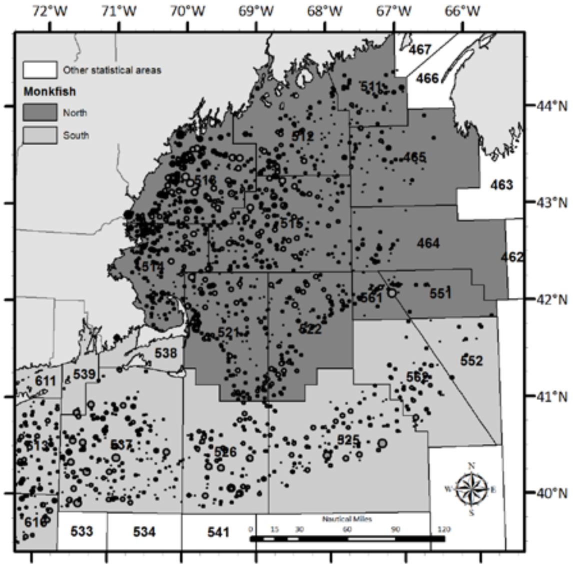
The 2013 assessment also emphasized a high degree of uncertainty. The 2013 assessment states: “The assessment results continue to be uncertain due to cumulative effects of under-reported landings, unknown discards during the 1980’s, uncertainty in survey indices, and incomplete understanding of key biological parameters such as age and growth, longevity, natural mortality and stock structure contributing to retrospective patterns primarily in the northern management area.”

Map 53 – Monkfish stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

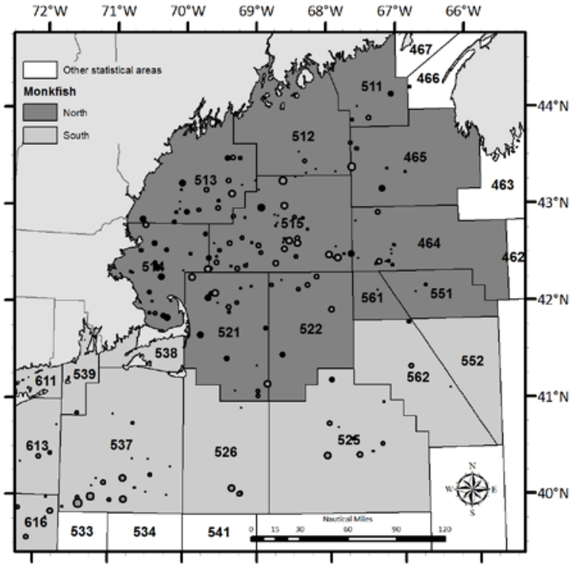


Total biomass (kg/tow)

Juvenile abundance < 35cm (#/tow)



Spawning biomass > 75cm (kg/tow)



4.2.1.3 Skates

Seven species of skate are managed by NEFMC. Collectively they are distributed across the full range of shallow inshore to deep offshore waters, ranging from eastern Maine to Cape Hatteras. In general skates do not undertake large scale migrations, but they do exhibit movements inshore in winter/spring and offshore into deeper waters during summer and fall. Skates do not have an egg or larval stage; hatching from leathery egg cases as juveniles that resemble small adults.

Because individual species are in some cases difficult to distinguish in commercial landings and at-sea observer data, especially at smaller sizes/ages, the skates are managed as a complex. Assessment of the status of various skate species is based on Northeast Fisheries Science Center trawl survey indices. The assessment approach was last reviewed at the December 2008 Data Poor Stocks Working Group meeting (report available at http://nefsc.noaa.gov/publications/crd/crd0902/). Status is updated annually based on the most recent trawl survey catch indices.

4.2.1.3.1 Smooth skate

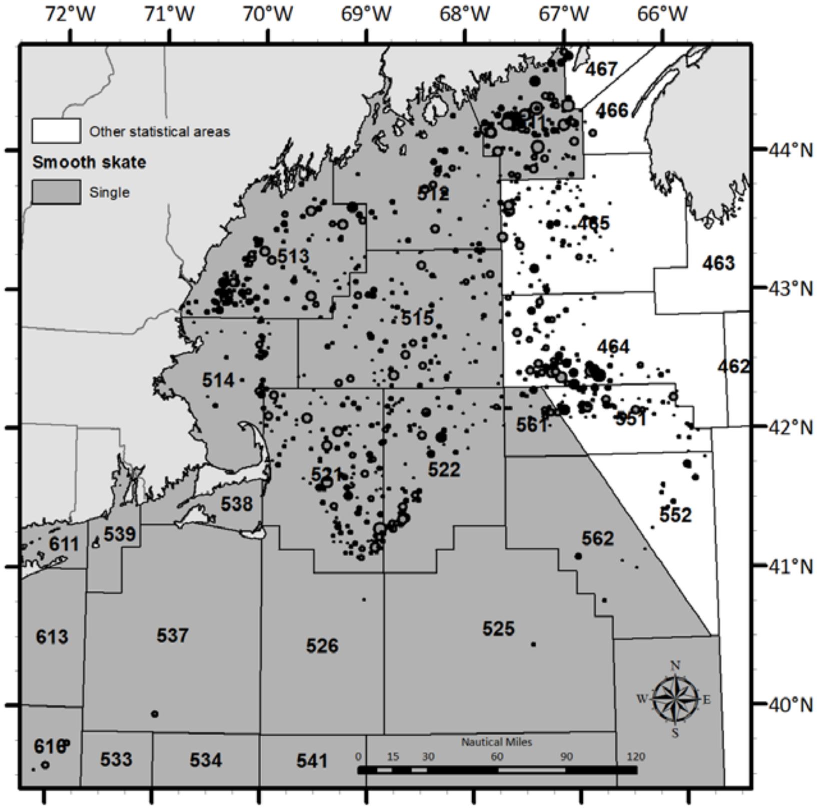
Smooth skate (*Malacoraja senta*) are found throughout the Gulf of Maine and along the shelf/slope transition to Cape Hatteras. The species is found mainly in deeper waters, although it does occur in some inshore areas including bays and estuaries along the Maine coast.

Smooth skates are most often found on soft mud substrate, but also occur on sand/shell/gravel/pebble substrates. They feed mainly on epifaunal crustaceans, primarily shrimp and euphausiids, and appear to be reproductively active year round.

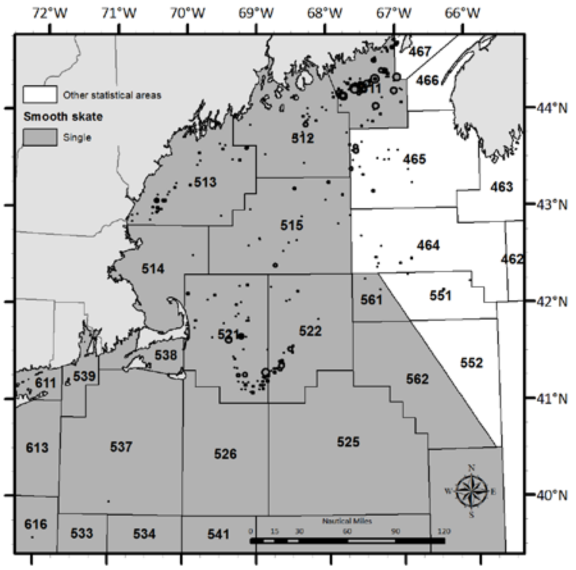
As of the 2008 DPSWG meeting, smooth skate biomass was at the overfished threshold reference point of 0.14 kg/tow. Based on the coefficient of variation in the survey index, the species is not experiencing overfishing. Data collected through spring 2013 indicate that the status remains not overfished/overfishing not occurring.

Map 54 – Smooth skate stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

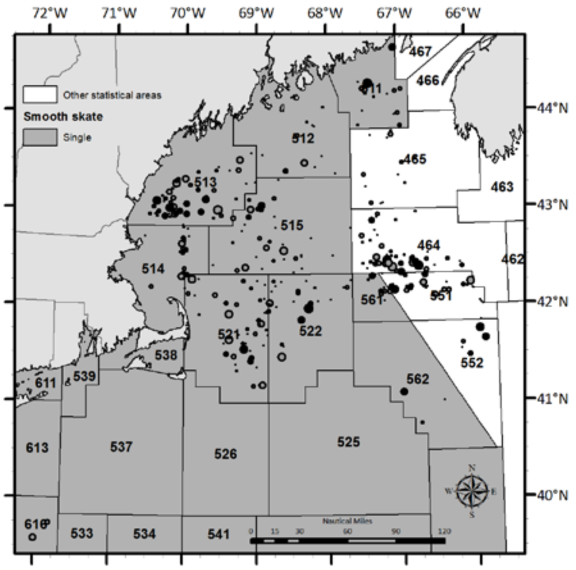
Total biomass (kg/tow)



Juvenile abundance < 50cm (#/tow)



Spawning biomass > 55cm (kg/tow)



4.2.1.3.2 Thorny skate

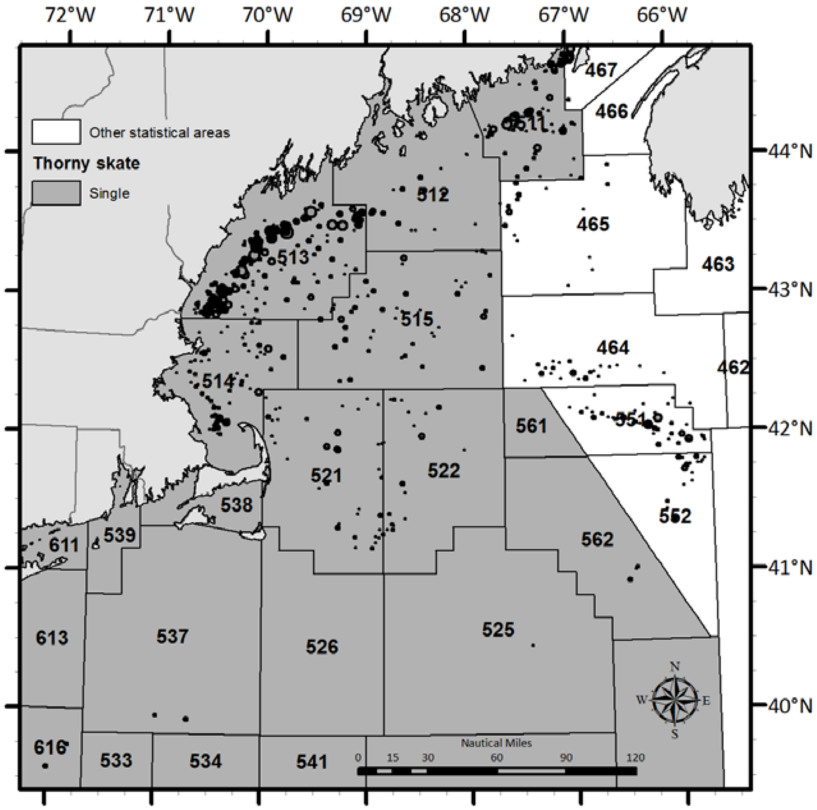
Thorny skate (*Amblyraja radiata*) is most abundant in moderately deep waters of the Gulf of Maine, although the species does occur in shallower inshore waters as well, including in the full-salinity zones of certain coastal Maine bays and estuaries. They are found over various substrates including sand, gravel, broken shell, pebbles, to soft mud (Bigelow and Schroeder 1953; McEachran 2002). Scott (1982) found thorny skates on all substrates, with the highest catch rates on sand and gravel deeper than 100 m.

Thorny skate are opportunistic predators, eating a wide variety of benthic invertebrates. Dietary composition does change with size/age. Like smooth skates, thorny skates reproduce year round (Templeman 1982, Sulikowski et al. 2005), although the percentage of mature females with capsules is higher during the summer (McEachran 2002).

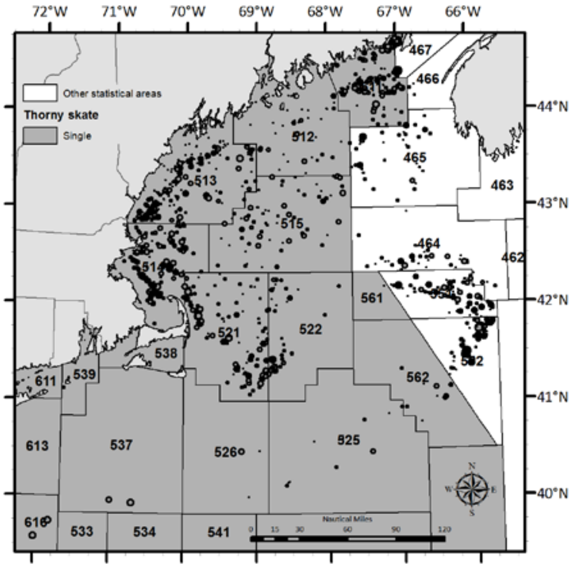
As of the 2008 DPSWG meeting, thorny skate biomass was at 0.42 kg/tow, which is below the overfished threshold reference point of 2.06kg/tow indicating that the species is overfished. Based on the coefficient of variation in the survey index, the species is also experiencing overfishing. Through spring 2013, the three year moving average catch per tow decreased to 0.18 kg/tow, which indicates that the stock is still overfished, and that biomass has decreased since the 2008 meeting. This reduction in the survey index means that overfishing is occurring on thorny skate.

Map 55 - Thorny skate stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

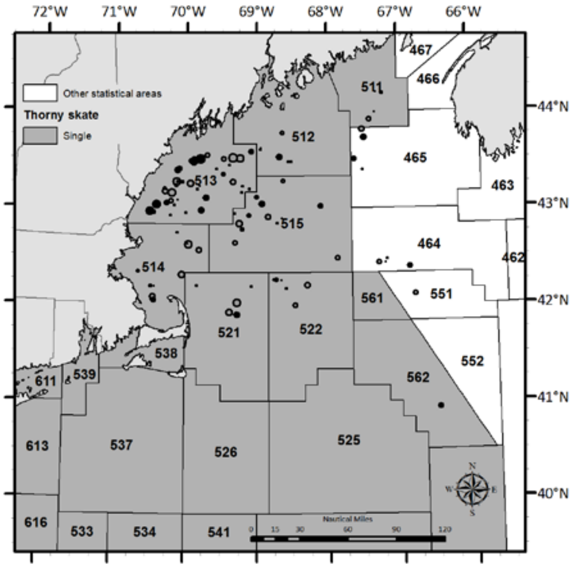
Total biomass (kg/tow)



Juvenile abundance < 70cm (#/tow)



Spawning biomass > 85cm (kg/tow)



4.2.1.3.3 Barndoor skate

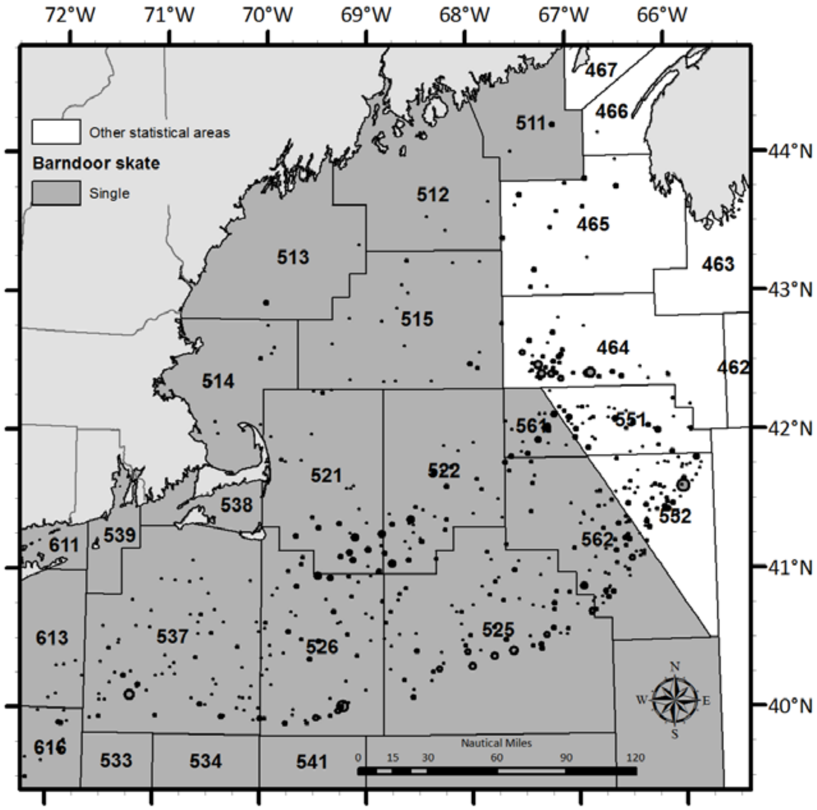
Barndoor skate (*Dipturus laevis*) is mainly distributed over Georges Bank, with concentrations on the southeastern part of the bank and in the northern, deeper parts of the Great South Channel. They are also found in Southern New England. Juveniles and adults are common in moderate depths beginning at 51 m and 61 m respectively, with the adult distribution extending into deeper waters. Barndoor skate have been found on both mud and sand/sand-gravel substrates, although sand is more common in the areas of high abundance over Georges Bank. The barndoor is the largest of the northeast region skate species, and consumes a wide variety of prey types, including benthic invertebrates and benthic fish.

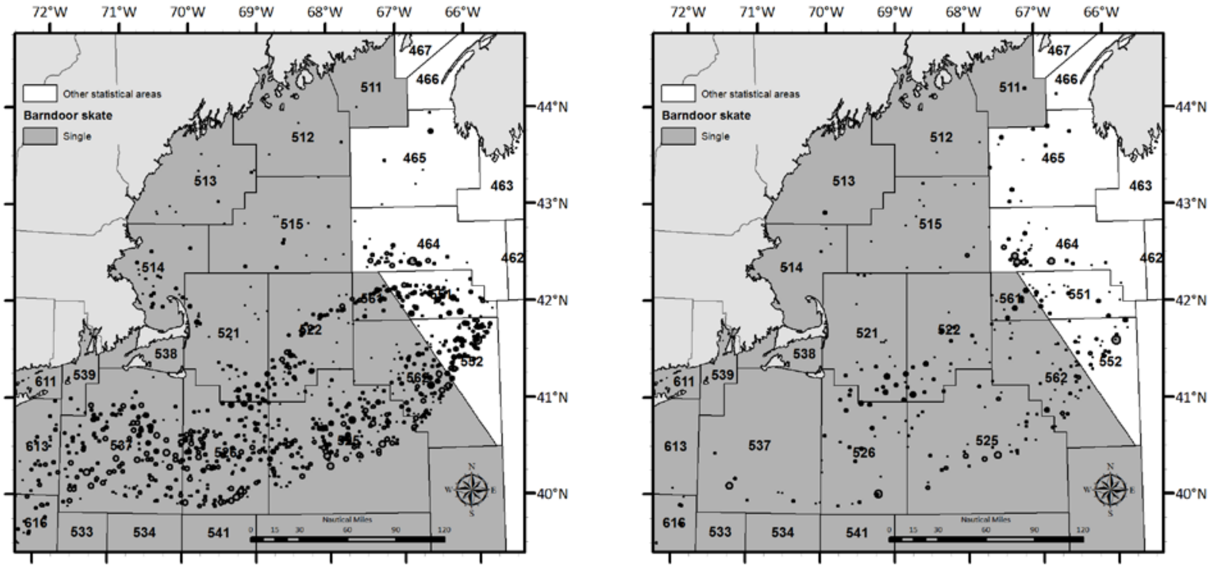
The peak spawning times of barndoor have not been well characterized. Females containing fully formed egg capsules have been taken in December and January (Vladykov 1936; Bigelow and Schroeder 1953), although it is not known if egg capsule production and deposition is restricted to the winter (McEachran 2002).

As of the 2008 DPSWG meeting, barndoor skate biomass was at 1.00 kg/tow, which is above overfished threshold reference point of 0.81 kg/tow indicating that the species is not overfished. Survey catch per tow was very low for many years and an endangered species act listing was requested, but the index been increasing since the late 1990s. Based on the coefficient of variation in the survey index, the species is not experiencing overfishing. Data collected through spring 2013 indicate that the status remains not overfished/overfishing not occurring.

Map 56 - Barndoor skate stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

Total biomass (kg/tow)




Juvenile abundance < 85cm (#/tow)

Spawning biomass > 100cm (kg/tow)

4.2.1.3.4 Little skate

The geographical distribution of little skate (*Leucoraja erinacea*) includes the southwestern Gulf of Maine, specifically Cape Cod Bay and inshore north of Cape Ann, Georges Bank, Southern New England, and the Mid-Atlantic Bight. The highest abundances are on Georges Bank and in Southern New England. They are occasionally caught in ME/NH trawl survey. Little skate are generally found on sandy or gravelly bottoms, but also occur on mud (Bigelow and Schroeder 1953; McEachran and Musick 1975; Langton et al. 1995; Packer and Langton, unpublished manuscript). In southern New England, at a depth of 55 m, little skate was associated with particular microhabitat features on the surface of the sediment during the day, including biogenic depressions and flat sand, but were randomly distributed at night (Auster et al. 1995). Skates are known to remain buried in depressions during the day and are more active at night (Michalopoulos 1990).

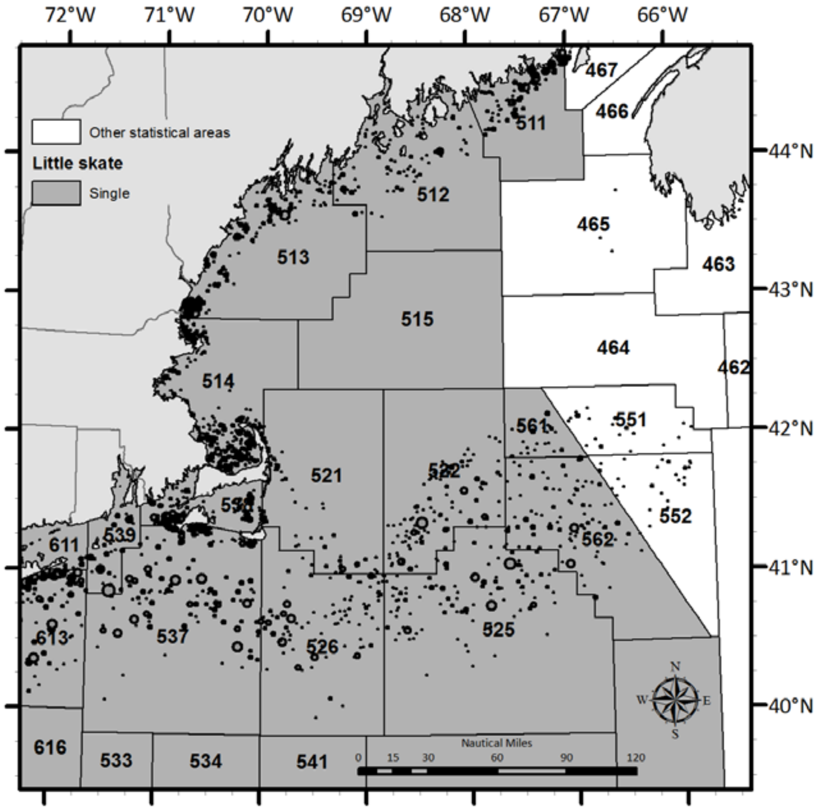
Generally, invertebrates such as decapod crustaceans and amphipods are the most important prey items, followed by polychaetes. Isopods, bivalves, and fishes (sand lance, alewives, herring, cunners, silversides, tomcod, and silver hake) are of minor importance. Little skate also eat hydroids, copepods, ascidians and squid.

Egg cases are found partially to fully developed in mature females year-round but several authors report that they are most frequently encountered from late October-January and from June-July (Fitz and Daiber 1963; Richards et al. 1963; Scott and Scott 1988). Little skate gestation is at least six months after the cases are deposited (Bigelow and Schroeder 1953, Richards et al. 1963).

As of the 2008 DPSWG meeting, little skate biomass was at 5.04 kg/tow, which is above overfished threshold reference point of 3.51 kg/tow indicating that the species is not overfished. Based on the coefficient of variation in the survey index, the species is not experiencing overfishing. Data collected through spring 2013 indicate that the status remains not overfished/overfishing not occurring.

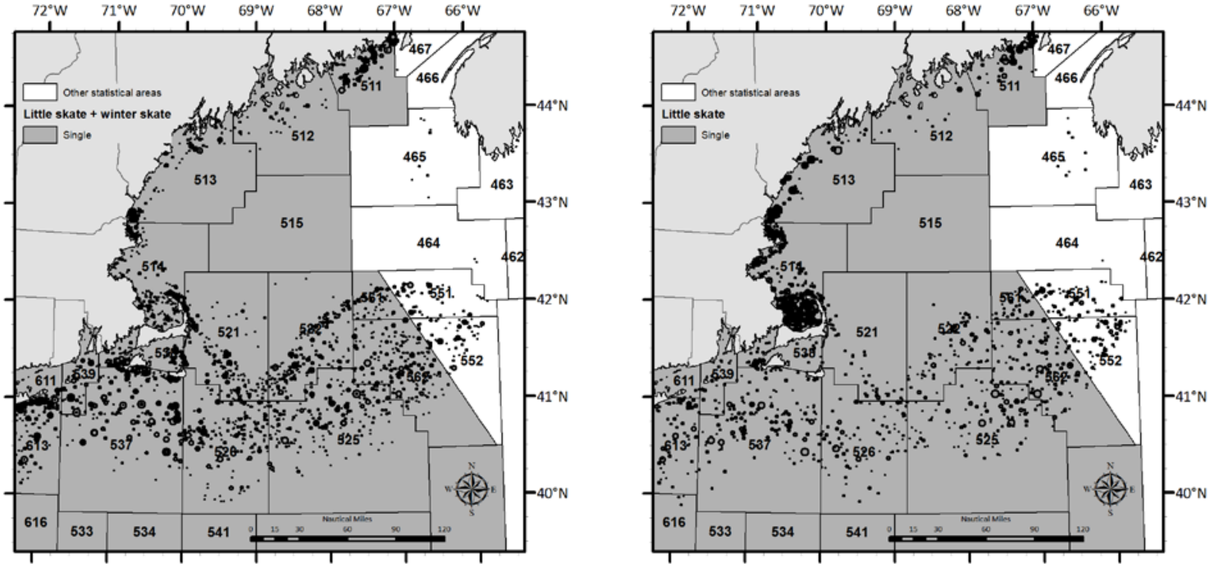
Map 57 – Little skate stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

Total biomass (kg/tow)



Juvenile abundance < 45cm (little skate) and <70cm (winter skate) (#/tow)

Spawning biomass > 50cm (kg/tow)



4.2.1.3.5 Winter skate

Similar to little skate, the geographical distribution of winter skate (*Leucoraja ocellata*) includes the southwestern Gulf of Maine, specifically Cape Cod Bay and inshore north of Cape Ann, Georges Bank, Southern New England, and the Mid-Atlantic Bight. The highest abundances are on Georges Bank. Relative to other skates (smooth, thorny, barndoor), winter skate has a fairly shallow distribution. Bigelow and Schroeder (1953) stated that this species is confined to sandy and gravelly bottoms but Tyler (1971) reported it from mud bottoms in Passamaquoddy Bay. In Long Island Sound during the spring, winter skate were most abundant on sand bottoms in the Mattituck Sill and Eastern Basin (Gottschall et al. 2000). On the Scotian Shelf, Scott (1982b) reports that the distribution of winter skate was confined to sand and gravel bottoms and Scott (1982b) suggests that bottom type, rather than depth, appears more important in determining the distributions of winter skate.

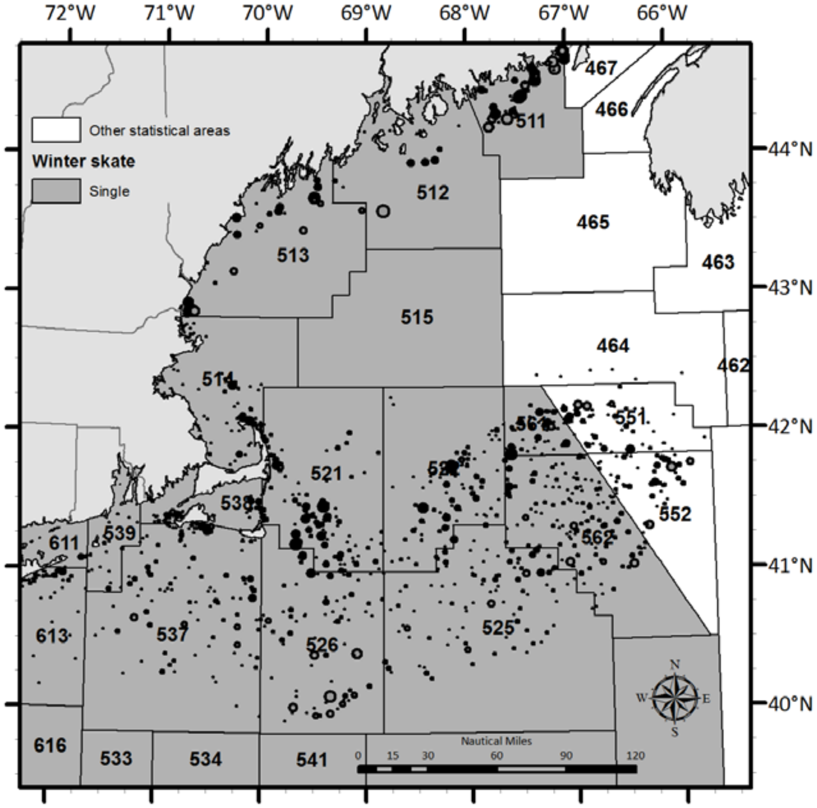
According to the NEFSC food habits database, crustaceans make up more than half the diet of smaller winter skates (<61 cm TL), and fish dominate the diet for larger skates (>91 cm TL). The proportion of polycheates in the diet increases until skates are 81 cm TL. Prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult winter skate include: sand lance (17%), bivalve mollusks (13%), polychaetes (12%), other fish (8%), and gammarid amphipods (7%).

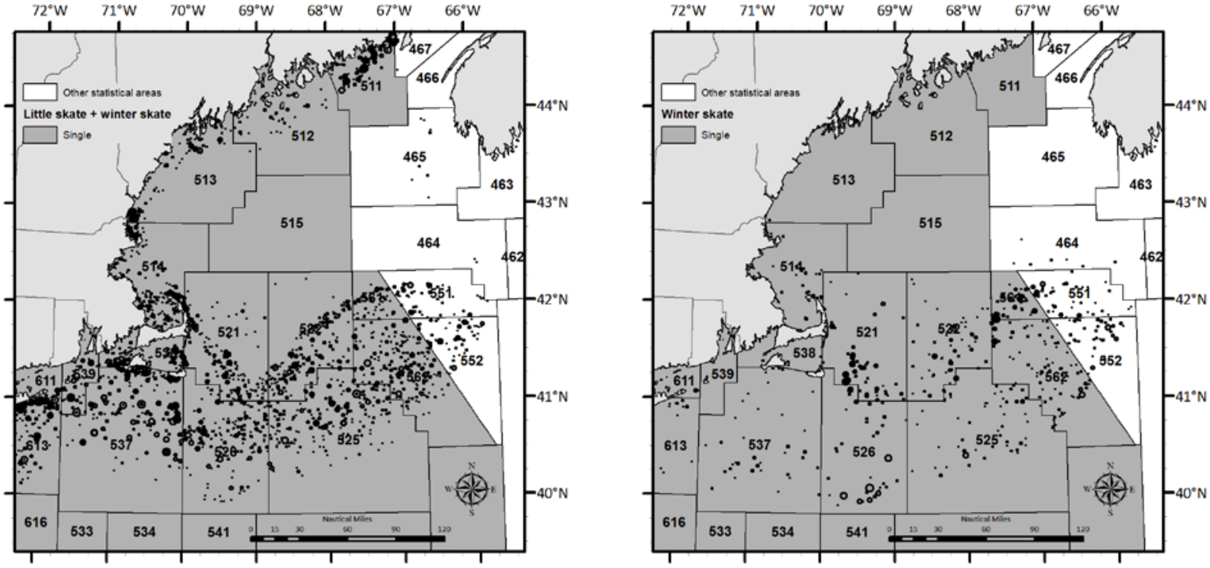
Bigelow and Schroeder (1953) report egg deposition to occur during summer and fall off Nova Scotia and, quoting Scattergood, probably in the Gulf of Maine as well. They also state that egg deposition continues into December and January off southern New England. Sulikowski et al. (2004) found that egg-case production is highest in the fall in the Gulf of Maine off New Hampshire. However, the presence of reproductively capable females during most months of the year and spermatocysts within the male testis year round implies that reproduction could occur at other times of the year.

As of the 2008 DPSWG meeting, winter skate biomass was at 2.93 kg/tow, which is above overfished threshold reference point of 2.83 kg/tow indicating that the species is not overfished. Based on the coefficient of variation in the survey index, the species was not experiencing overfishing at that time. However, the most recent assessment update indicates a 23% decrease in survey catch per tow during 2010-2012 as compared to 2009-2011, which means that overfishing is occurring on the stock. At 6.68 kg/tow, the stock is still above the biomass threshold, so it is not overfished.

Map 58 – Winter skate stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

Total biomass (kg/tow)




Juvenile abundance < 45cm (little skate) and <70cm (winter skate) (#/tow)

Spawner biomass > 85cm (kg/tow)

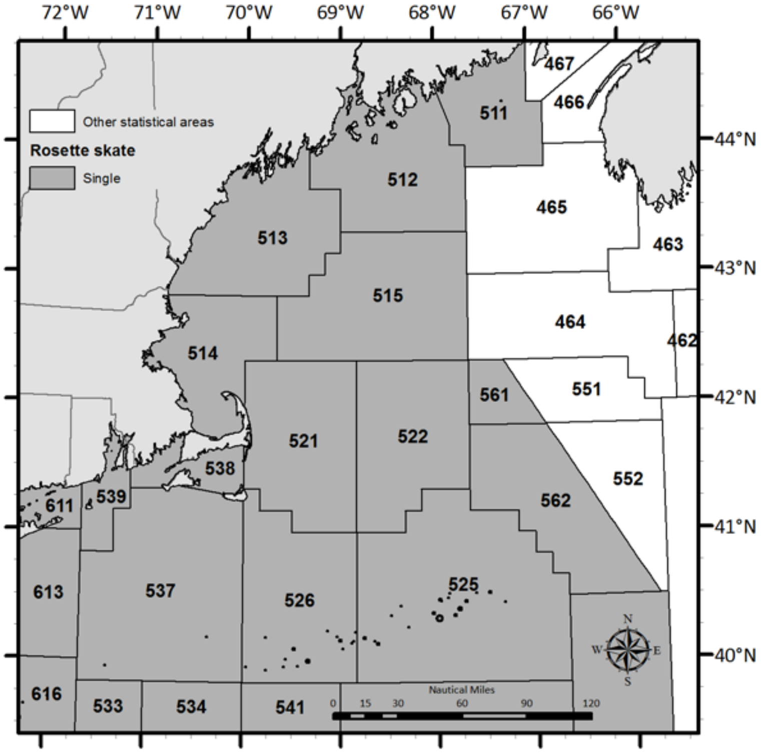
4.2.1.3.6 Rosette skate

The rosette skate (*Leucoraja garmani virginica*) occurs along the shelf/slope break in the Mid-Atlantic Bight, primarily on sand and mud substrates. Rosette skate feed primarily on crustaceans and polychaetes. North of Cape Hatteras the egg capsules are found in mature females year-round but are most frequent during the summer (McEachran 1970).

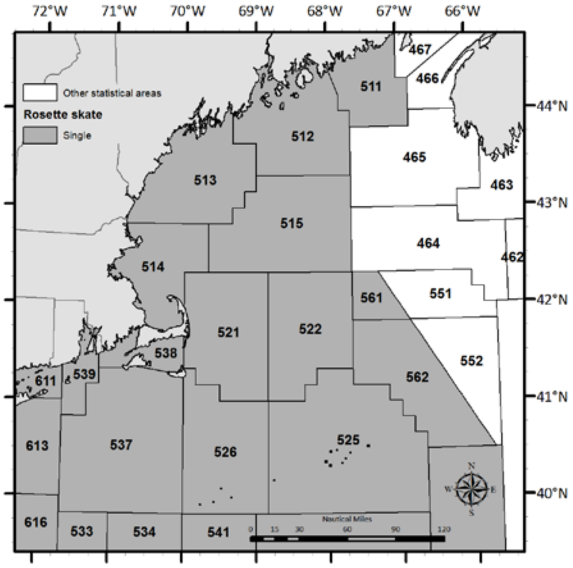
Biomass trends for rosette skate (measured as catch in kg/tow during the NEFSC trawl surveys) have been increasing since the late 1980s and the species is currently above the target biomass index. Catchability of rosette skate in the spring and fall surveys is relatively poor, but more are caught in the now-defunct winter survey, which used a chain sweep and focused on offshore survey strata in southern New England and the Mid-Atlantic Bight. According to the Data Poor Stocks Working Group (2008), in 2007 the species was not overfished and overfishing was not occurring. Data collected through spring 2013 indicate that the status remains not overfished/overfishing not occurring.

Map 59 – Rosette skate stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

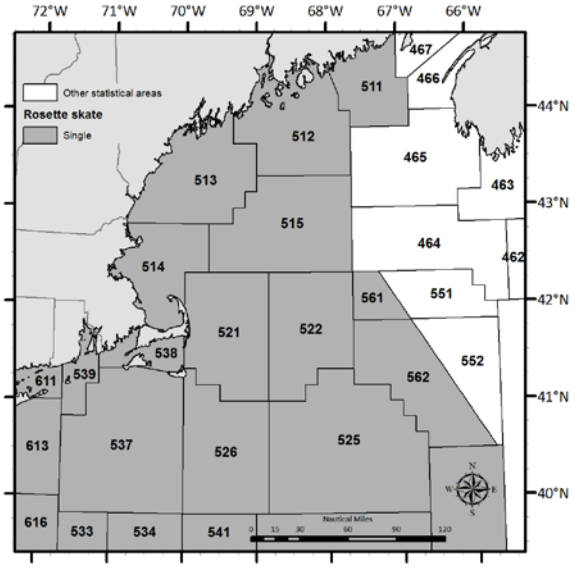
Total biomass (kg/tow)



Juvenile abundance < 40cm (#/tow)



Spawner biomass > 55cm (kg/tow)



4.2.1.3.7 Clearnose skate

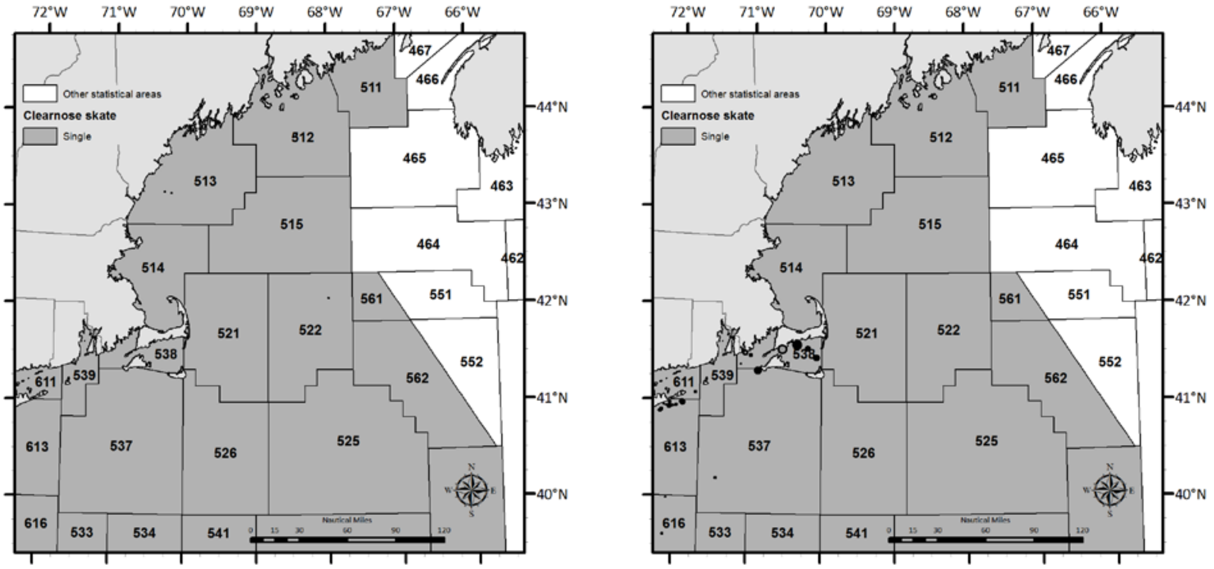
The distribution of adult clearnose skate (*Raja eglanteria*) is concentrated along the coast from New Jersey to Cape Hatteras, with the highest spring and fall trawl survey abundances south of Chesapeake Bay. The spatial distribution of juvenile EFH extends further south based on the inshore SEAMAP survey. Of all the skates, clearnose has the shallowest distribution.

Clearnose skate are found primarily on sand and mud, but also occur in gravel habitats. They feed primarily on fish, crabs, and *Loligo* squid.

Mating and egg deposition in clearnose skates takes place from December to mid-May (Rasmussen et al. 1999). North of Cape Hatteras the egg cases are deposited in the spring and summer; in Delaware Bay, Fitz and Daiber (1963) reported spawning to occur only in the spring. Off the central west coast of Florida, egg deposition occurs from December through mid-May (Luer and Gilbert 1985).

Biomass trends for clearnose skate (measured as catch in kg/tow during the NEFSC trawl surveys) have generally been increasing since the mid-1980s. Although there has been a decline in the last few years, and the species is currently above the threshold biomass index, although not above the target. Like the rosette skate, catchability of clearnose skate in the spring and fall surveys is relatively poor, but more are caught in the now-defunct winter survey, which used a chain sweep and focused on offshore survey strata in southern New England and the Mid-Atlantic Bight. According to the Data Poor Stocks Working Group (2008), in 2007 the species was not overfished and overfishing was not occurring. Data collected through spring 2013 indicate that the status remains not overfished/overfishing not occurring.

Map 60 - Clearnose skate stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



Juvenile abundance < 40cm (#/tow)

Total biomass (kg/tow)

4.2.1.4 Atlantic sea scallop

Scallops (*Placopecten magellanicus*) are distributed throughout Georges Bank and the Mid-Atlantic Bight in shallow to moderate water depths. Local concentrations of scallops may be very high in some areas. They also occur in selected locations in the Gulf of Maine, including inshore areas as well as some offshore banks and ledges. The species generally inhabits waters less than 20^{o} C and depths that range from 30-110 m on Georges Bank, 20-80 m in the Mid-Atlantic, and less than 40 m in the near-shore waters of the Gulf of Maine.

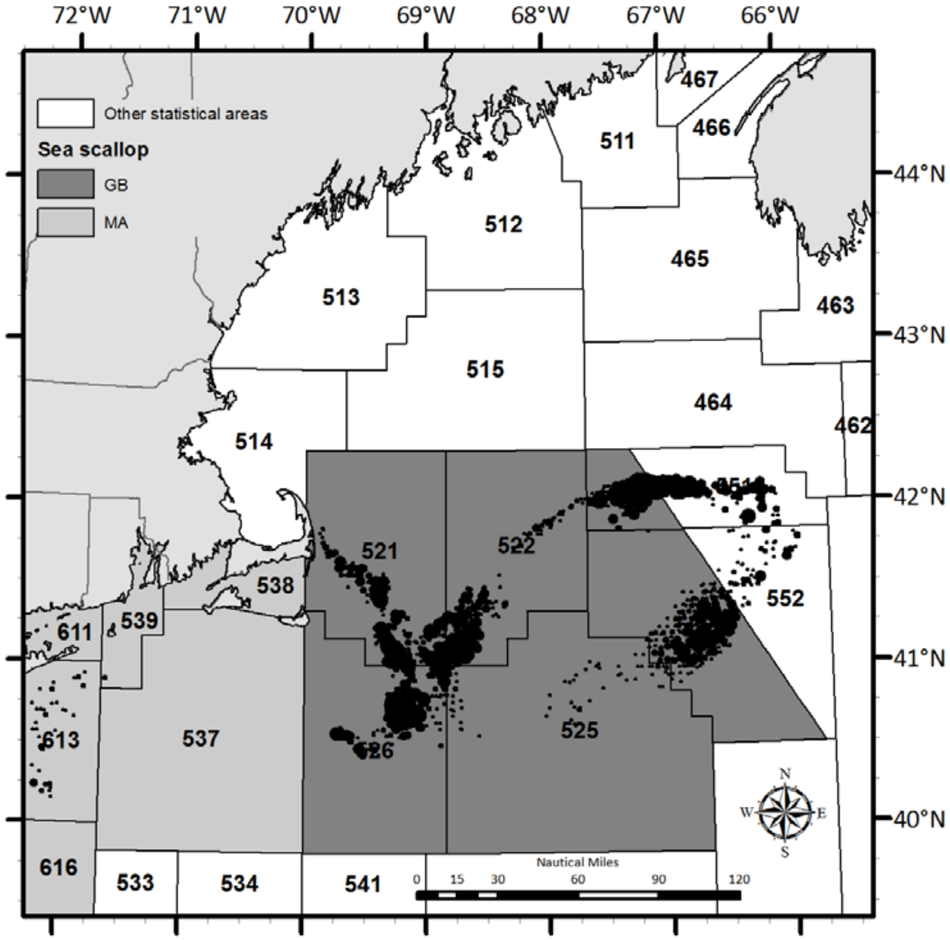
Egg and larval stages are pelagic until the larvae settle to the seabed. Spat survival enhanced on sedentary branching plants or animals, and on hard surfaces. Juveniles and adults occur on sand, gravel, and areas of mixed sand and gravel substrates. They are also associated with shell debris. Once settled, scallops are generally sessile, although they do exhibit local movements, e.g. for predator avoidance. Larval sea scallops are pelagic filter feeders and juveniles and adults are benthic suspension feeders.

Scallop spawning times vary by location. Generally spawning occurs in summer in the southern part of their US distribution, and into fall in the northern areas. A biannual spawning cycle has been documented south of Hudson Canyon, with both spring and fall events (DuPaul et al. 1989; Schmitzer et al. 1991; Davidson et al. 1993). Scallops beds generally spawn synchronously in a short time, going from completely ripe to completely spent in less than a week (Posgay and Norman 1958; Posgay 1976), although more continuous spawning has been reported (Naidu 1970 - Newfoundland coastal waters, Langton et al. 1987 - possibly in the Gulf of Maine, MacDonald and Thompson 1988 - off New Jersey in June and July).

All sea scallops in the US EEZ are managed as a single stock per Amendment 10 to the fishery management plan. However, assessments focus on two main parts of the stock and fishery that contain the largest concentrations of sea scallops: Georges Bank and the Mid-Atlantic, which are combined to evaluate the status of the whole stock. The formal stock status update was prepared through fishing year 2009 as part of Stock Assessment Review Committee 50 (NEFSC 2010). SARC 50 estimated that overall fishing mortality in 2009 was 0.38. As this is equal to but not above the F_{MSY} threshold, overfishing did not occur in 2009.

Currently, the stock is above the biomass threshold. Abundance and biomass on Georges Bank increased from 1995-2000 after implementing closures and effort reduction measures. Biomass and abundance then declined from 2006-2008 because of poor recruitment and the reopening of portions of groundfish closed areas. Biomass increased on Georges Bank in both 2009 and 2010, mainly due to increased growth rates and strong recruitment in the Great South Channel, along with continuing concentrations on the Northern Edge and in the central portion of Closed Area I. In general, Mid-Atlantic biomass is declining. This is primarily from depletion of the large biomass in Elephant Trunk and several years of poor recruitment (2009-2011). However, stronger Mid-Atlantic recruitment has been observed in 2012 and 2013. Once these scallops grow larger, biomass in the Mid-Atlantic is expected to increase. Relatively little is known about scallop biomass in the Gulf of Maine. A 2012 dredge survey conducted mostly in inshore areas found that biomass was generally patchy, and that scallops on some of the offshore features (Platts Bank, Fippennies Ledge) had relatively low meat weights for their size as compared to other areas.

Map 61 – Sea scallop stock boundaries and catch/tow from summer NMFS scallop dredge survey, 2002-2013.



4.2.1.5 Atlantic herring

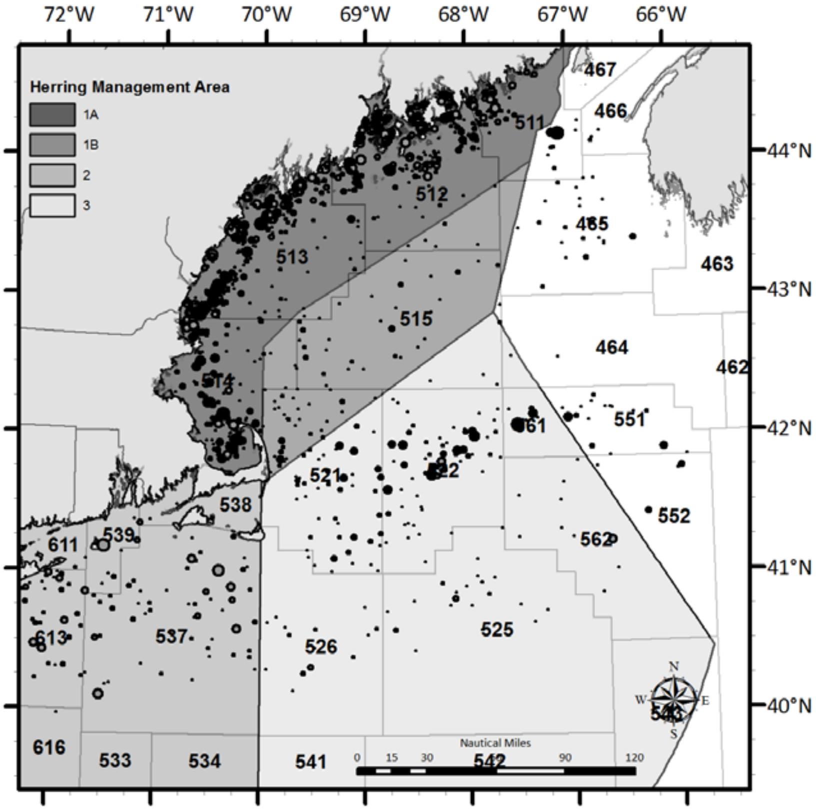
Herring (*Clupea harengus*) are found throughout the region except in the deepest waters off the shelf. With the exception of their demersal eggs, herring are a pelagic species, feeding on various types of zooplankton. The eggs are deposited in benthic habitats with boulders, coarse sand, cobble/pebble, gravel, and/or macroalgae, not on mud or on fine sand. Strong bottom currents enhance survival. The spawning season in the Gulf of Maine-Georges Bank region begins in July and lasts until December. Spawning begins earlier in the northern areas of the Gulf.

In U.S. waters of the Gulf of Maine, herring eggs have been observed along the eastern Maine coast, at several other locations along the Maine coast (e.g., outer Penobscot Bay and near Boothbay), on Jeffreys Ledge and Stellwagen Bank, and on eastern Georges Bank. Nantucket Shoals is known to be an important spawning ground based on the concentrations of recently-hatched larvae that were repeatedly collected there during the 1970s and 1980s (Grimm 1983; Smith and Morse 1993). High concentrations of recently-hatched larvae have also been collected in the vicinity of Cultivator Shoals on western Georges Bank, in the vicinity of Stellwagen Bank and Jeffreys Ledge, and on the outer continental shelf in southern New England (Grimm 1983; Smith and Morse 1993). High densities of recently-hatched larvae have also been observed in Saco Bay and Casco Bay on the southern Maine coast (Graham et al. 1972b, et al. 1973).

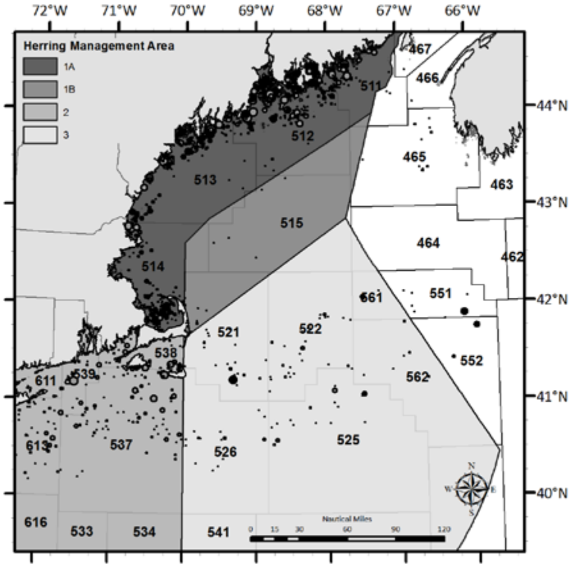
Herring are managed as a single stock, which is currently not overfished with overfishing not occurring. The stock was most recently assessed in 2012 during Stock Assessment Workshop 54. This benchmark stock evaluation included many significant changes from the 2009 Transboundary Resource Assessment Committee assessment. During the 2012 assessment, a new model was accepted, assuming a higher natural mortality rate. The revised natural mortality rate was consistent with data on consumption of herring by predators, and largely resolved retrospective patterns observed in the 2009 assessment. The assessment noted that the large number of age-1 fish in 2009 constitute a significant component of projected future yield.

Map 62 – Atlantic herring management areas and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

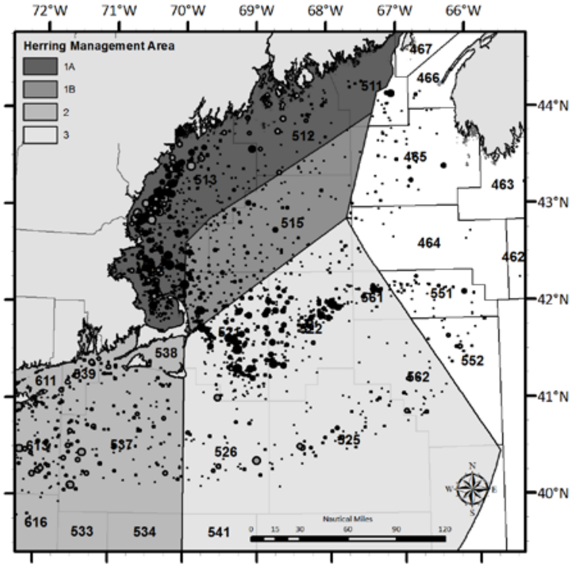
Total biomass (kg/tow)



Juvenile abundance < 20cm (#/tow)



Spawner biomass > 25cm (kg/tow)



4.2.1.6 Deep-sea red crab

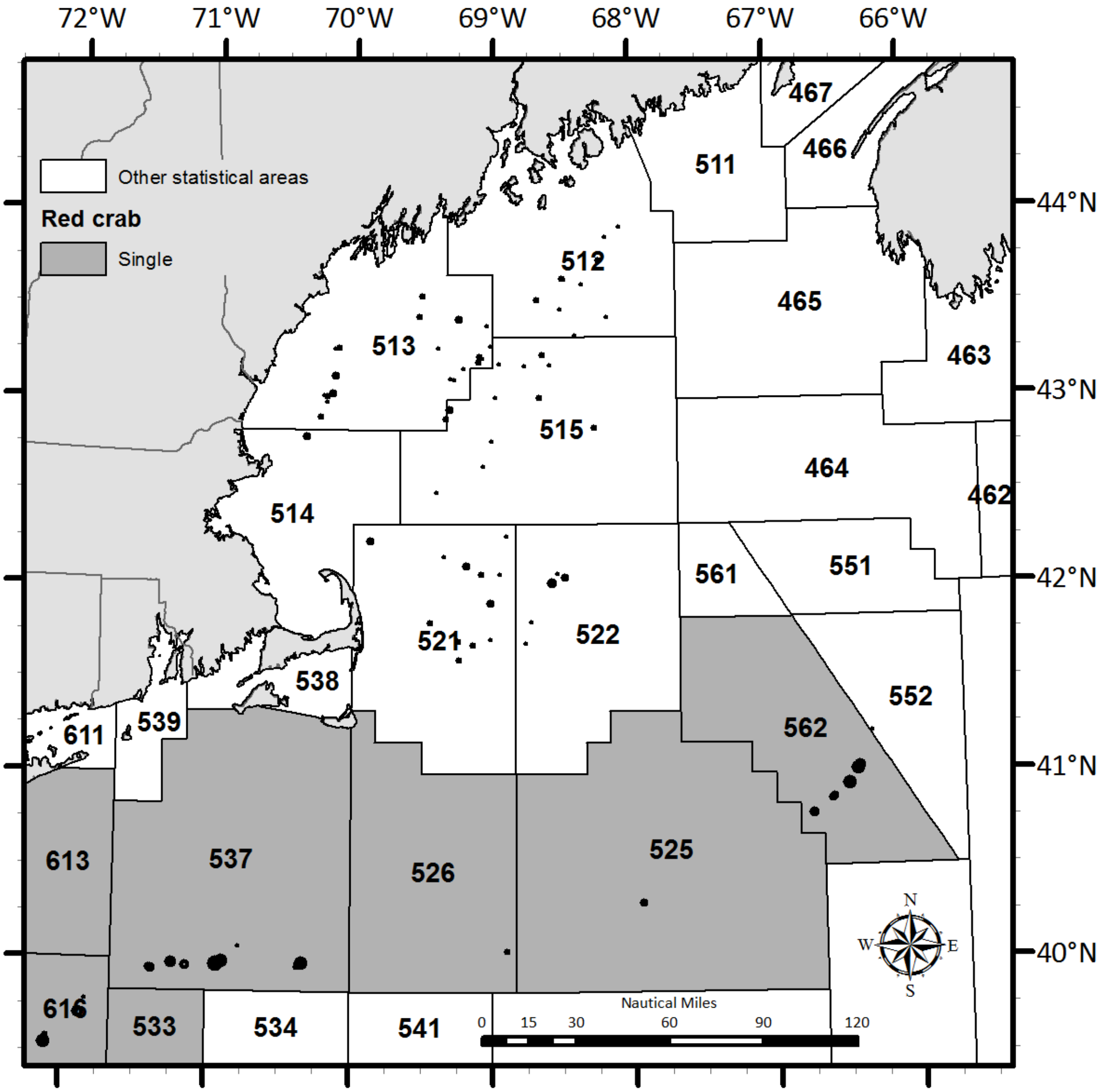
In US waters, deep-sea red crab (*Chaceon quinquidens*) occur in the Gulf of Maine, along the continental slope from Georges Bank to the Gulf of Mexico, and on the seamounts.

There is limited information about red crab spawning locations and times. Erdman et al. (1991) suggested that the egg brooding period may be about nine months, at least for the Gulf of Mexico population, and larvae are hatched in the early spring there. There is no evidence of any restricted seasonality in spawning activity in any geographic region of the population, although a mid-winter peak is suggested as larval releases are reported to extend from January to June (Wigley et al. 1975; Haefner 1978; Lux et al. 1982; Erdman et al. 1991; Biesiot and Perry 1995).

Based on laboratory observations, larvae probably consume zooplankton. Juveniles and adults are opportunistic feeders. Post-larval, benthic red crabs eat a wide variety of infaunal and epifaunal benthic invertebrates (e.g. bivalves) that they find in the silty sediment or pick off the seabed surface. Smaller red crabs eat sponges, hydroids, mollusks (gastropods and scaphopods), small polychaetes and crustaceans, and possibly tunicates. Larger crabs eat similar small benthic fauna and larger prey, such as demersal and mid-water fish (*Nezumia* and myctophids), squid, and the relatively large, epibenthic, quill worm (*Hyalinoecia artifex*).They can also scavenge deadfalls (e.g., trawl discards) of fish and squid, as they are readily caught in traps with these as bait and eat them when held in aquaria.

Deep-sea red crab is considered a data poor stock since they inhabit deep water, are rarely caught in the trawl survey, and there is little information about their life history. Males only are landed in the trap fishery, which is managed via the Atlantic Deep-Sea Red Crab FMP, implemented in 2002. The species is managed as a single stock (Map 63), and red crabs in the Gulf of Maine are not included in reference point, biomass, or management calculations. Additional details are provided in the 2008 Data Poor Stocks Working Group Report (NEFSC 2009), which found that as of 2008, the stock status was unknown.

Map 63 – Red crab stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



4.2.1.7 Surfclam and ocean quahog

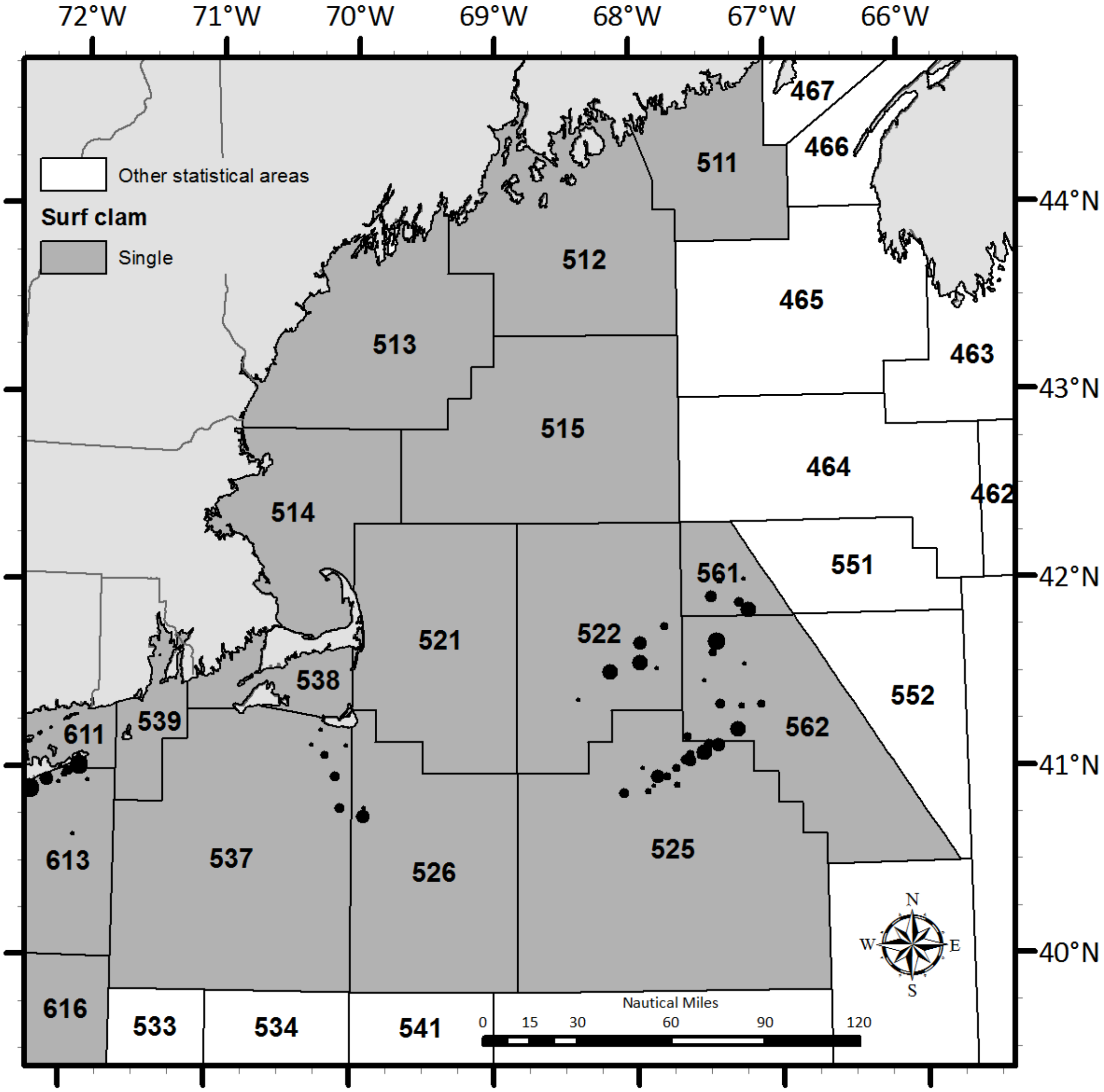
Surfclams (*Spisula solidissima*) and ocean quahogs (*Arctica islandica*) are bivalve mollusks that are found in continental shelf waters from Cape Hatteras, NC, north to the Gulf of St. Lawrence/Newfoundland. Major concentrations of surfclams are found on Georges Bank, south of Cape Cod, off Long Island, southern New Jersey, and the Delmarva Peninsula. The greatest concentrations of ocean quahogs are fished in offshore waters south of Nantucket to the

Delmarva Peninsula. Ocean quahogs are referred to mahogany quahogs in Maine, as they are harvested at smaller sizes when they tend to have a more brownish coloration. Ocean quahogs should not be confused with the species *Mercenaria mercenaria*, which is also commonly referred to as a quahog.

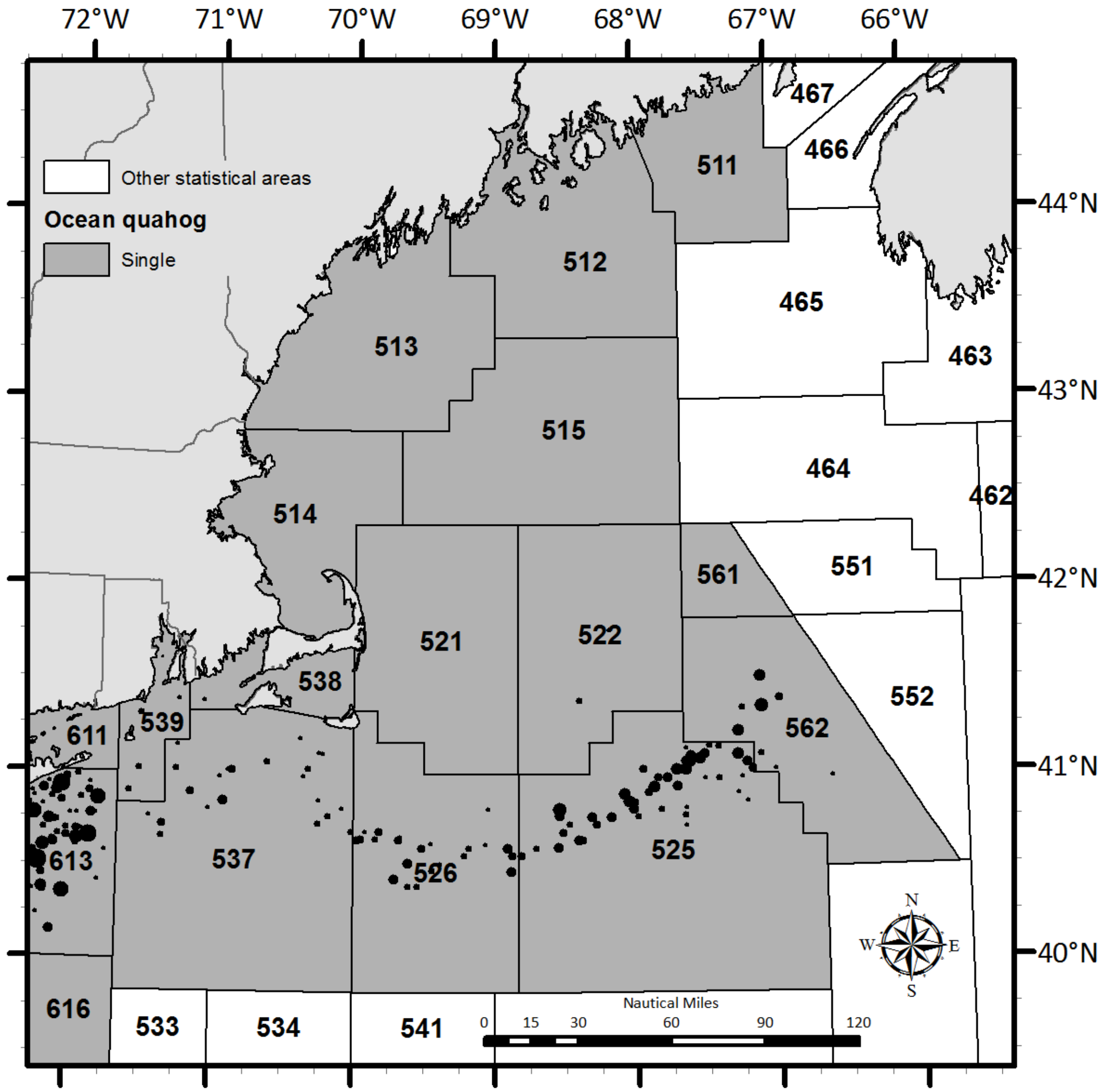
In general, surfclams are found in shallower depths than quahogs (most common at 10-40 meters as compared to 40-80 m), although quahogs are found in shallower waters along the Maine coast and support a fishery in that region. The greatest concentrations of surfclams are usually found in well-sorted, medium sand, but they may also occur in fine sand and silty fine sand. Adult ocean quahogs are usually found in dense beds over level bottoms, just below the surface of the sediment which ranges from medium to fine grain sand. Both species live in the sediment and are therefore not vulnerable to most types of fishing gears.

Ocean quahogs are an extremely slow-growing, long-lived species that can reach 100 years of age under normal conditions. Surfclams can live to over 30 years of age and 15-20 year old clams are common. The assessments for both stocks were updated during 2013 and neither is overfished, nor is overfishing occurring (NEFSC 2013). The assessment estimated low fishing mortality rates for both stocks during 2011: $F=0.007\ y^{-1}$ for ocean quahogs and $F=0.027\ y^{-1}$ for surfclams.

Map 64 – Surf clam stock boundary and catch/tow from the clam dredge surveys (2002, 2005, 2008, 2011, 2012).



Map 65 – Ocean quahog stock boundary and catch/tow from the clam dredge surveys (2002, 2005, 2008, 2011, 2012).



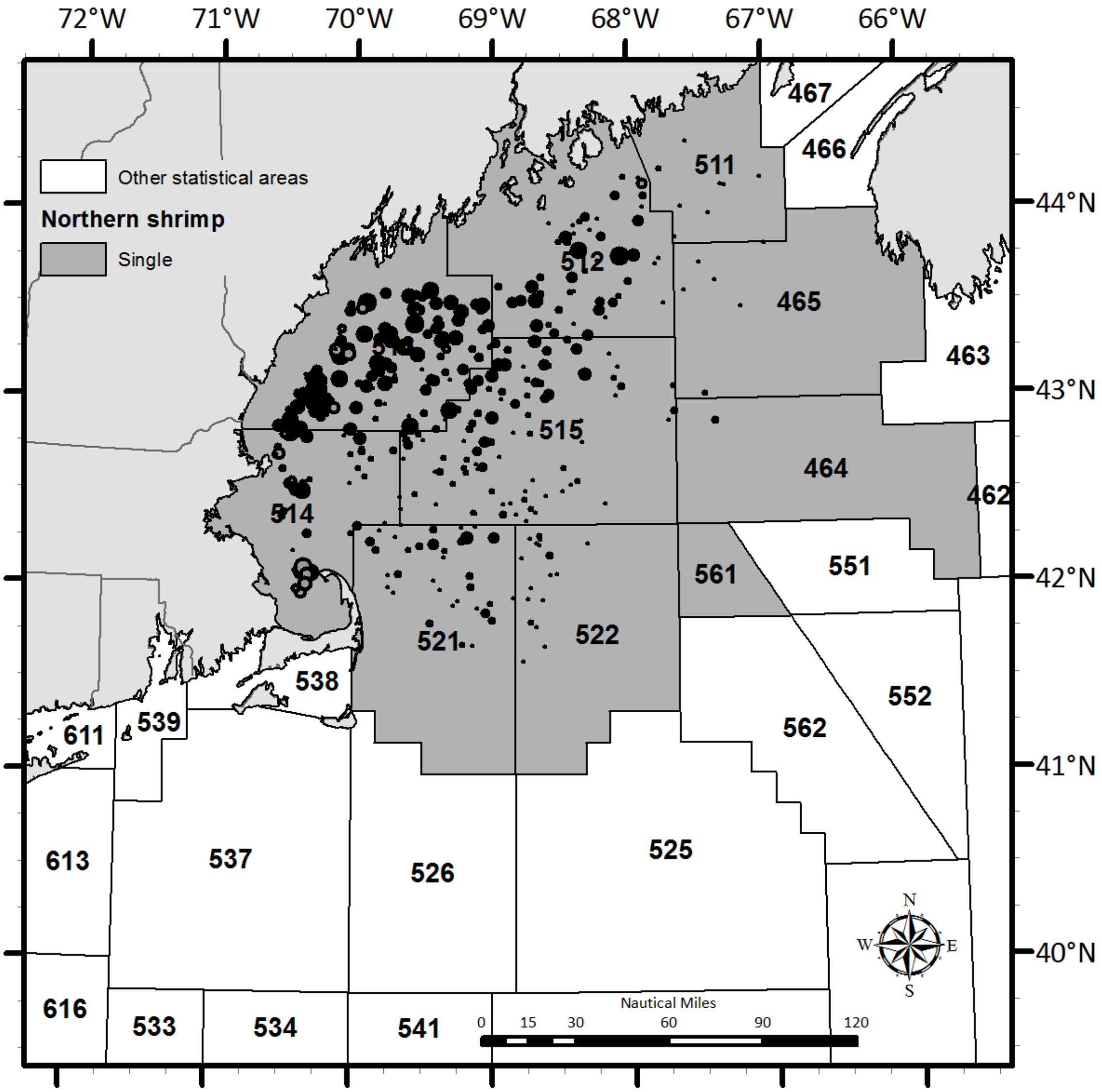
4.2.1.8 Northern shrimp

Northern shrimp (*Pandalus borealis*) are found in US waters off Maine, New Hampshire, and Massachusetts and also in Atlantic Canada. They mature first as males and then transform into females at around age 3.5 years; females live until about age 5. Growth rate, size at age, and age of male-female transition can vary with environmental parameters and by stock density. The shrimp spawn offshore in the late summer and the egg-bearing females move inshore in late fall and winter. The juveniles then remain inshore for a year or more before moving offshore.

The northern shrimp stock is assessed annually by the ASMFC's Northern Shrimp Technical Committee; the most recent assessment report was released in November 2013 (ASFMC Northern Shrimp Technical Committee 2013). Various surveys inform this assessment, including an annual summer shrimp survey, the fall NEFSC trawl survey, the spring ME/NH trawl survey, and historical surveys by the state of Maine. The most recent stock assessment report provides a summary of the biology and status the species.

The 2013 assessment indicated that the stock has collapsed. Biomass peaked in around 2007 and has declined since to an estimated 500 mt in the terminal year of the model, which is a very low biomass relative to values typically estimated since the mid-1980s, and future does not look promising. The female population in 2013 consists of the 2008 and 2009 year classes, and although these year classes were above average in size when first observed in the surveys, they have since declined to low levels. In 2011 recruitment was poor, and the 2012 recruitment index was even lower. Relatively higher temperatures in the Gulf of Maine suggest "an increasingly inhospitable environment for northern shrimp" (ASMFC 2012, page 23). A benchmark assessment will be conducted in early 2014.

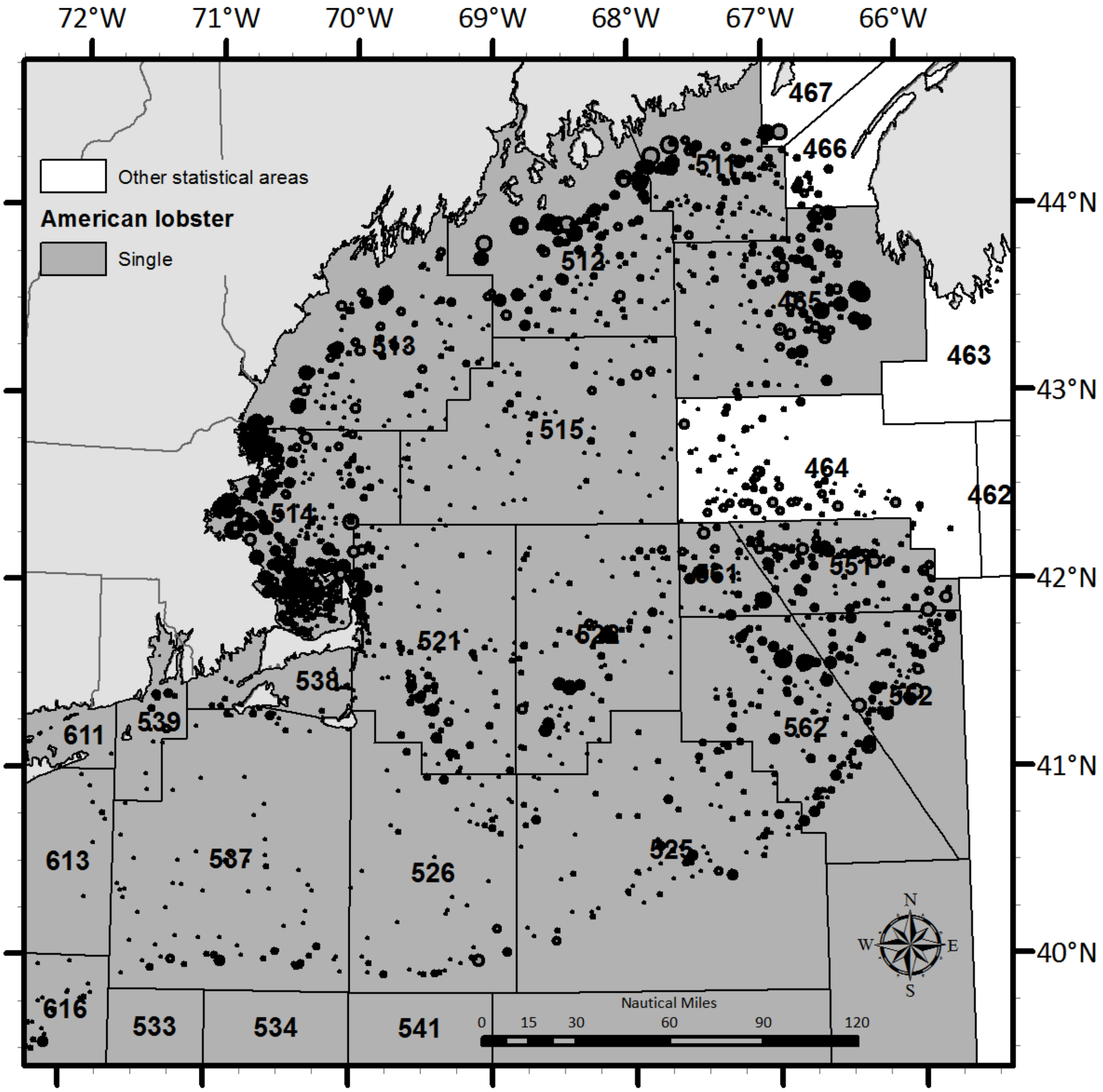
Map 66 – Northern shrimp stock boundary and catch/tow from NMFS shrimp survey, spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



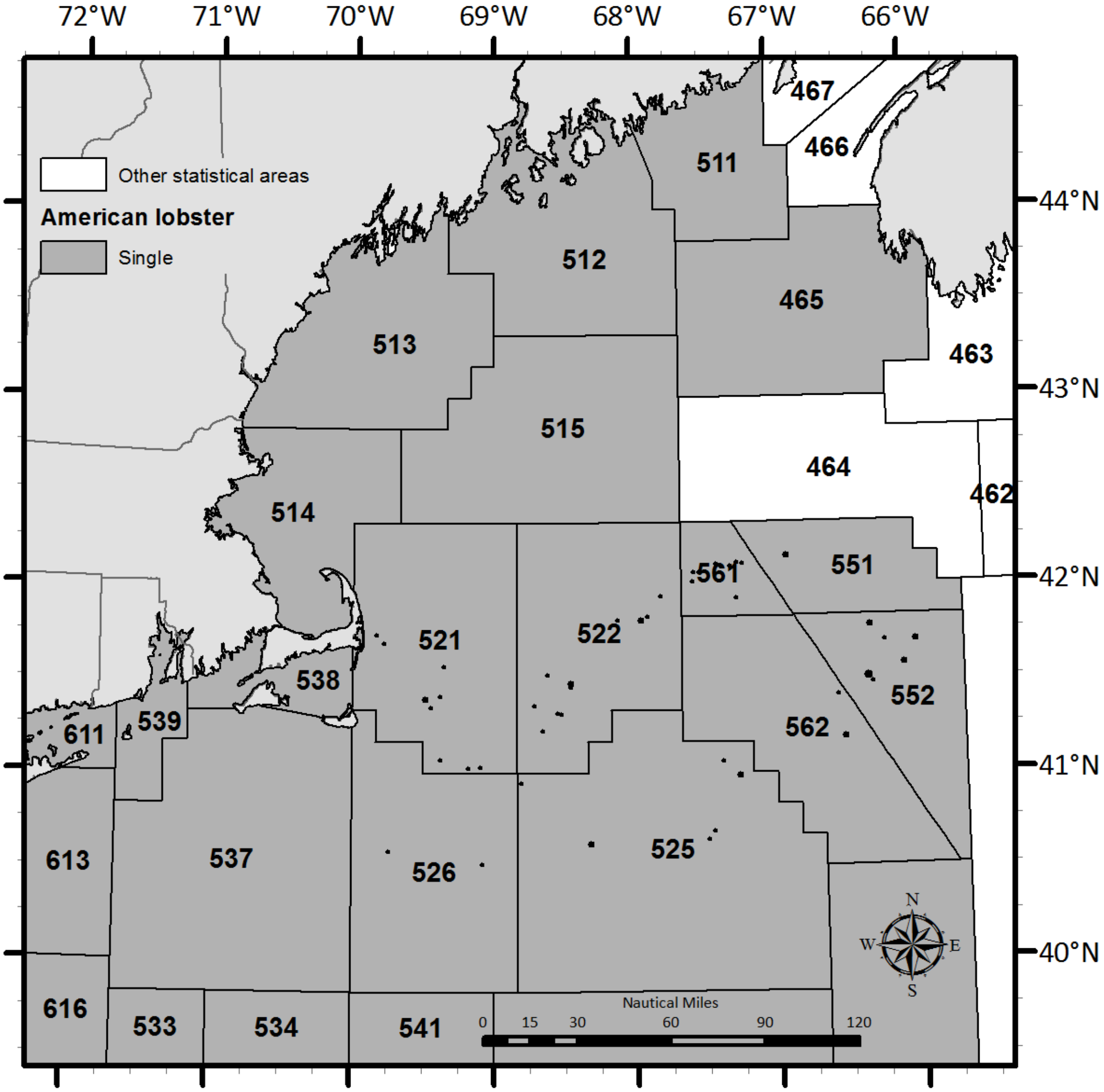
4.2.1.9 American lobster

American lobsters (*Homarus americanus*) are benthic crustaceans that are found in US waters from Maine to New Jersey inshore and Maine to North Carolina offshore. Lobsters tend to be solitary, territorial, and exhibit a relatively small home range of 5-10 square kilometers, although large mature lobsters living in offshore areas may migrate inshore seasonally to reproduce, and southern inshore lobsters may move to deeper areas to seek cooler temperatures on a seasonal or permanent basis. Lobsters are assessed in three stock units, Gulf of Maine, Georges Bank, and Southern New England. The 2009 assessment indicated that none of the stocks is experiencing overfishing, but the Southern New England stock is overfished (ASMFC American Lobster Stock Assessment Subcommittee 2009). A new assessment will be completed soon.

Map 67 – American lobster stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



Map 68 – American lobster stock boundaries and catch/tow from summer NMFS scallop dredge survey, 2002-2013. All survey values are shaded black.

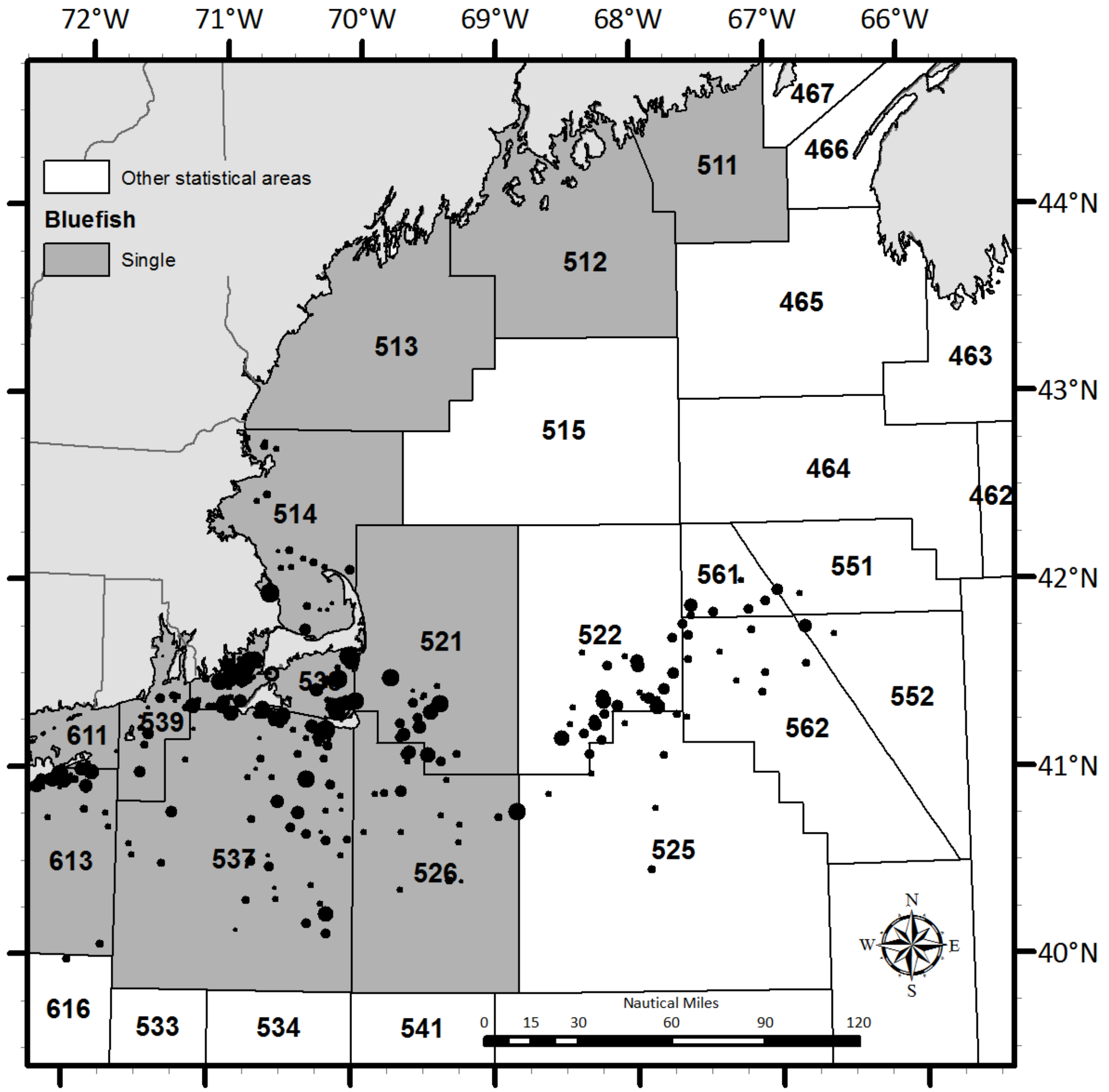


4.2.1.10 Atlantic bluefish

Bluefish (*Pomatomus saltatrix*) is a migratory pelagic species found in most temperate and tropical marine waters throughout the world. Along the U.S. Atlantic coast, bluefish commonly are found in estuarine and continental shelf waters. Bluefish are a schooling species that migrate in response to seasonal changes, moving north and inshore during spring and south and offshore in the late autumn.

The Atlantic bluefish fishery exploits what is considered to be a single stock of fish. The stock assessment was updated in July 2013 and while results are still preliminary, it appears that the stock was not overfished and overfishing was not occurring in 2012. 2013 projections indicate that the fishing mortality rate has been below the threshold F_{MSY} since the late 1990s. With the exception of 2007, the Council's recommended harvest limit has never been exceeded. According to the 2012 assessment update, the stock was above the threshold of ½ B_{MSY} during 2011, so it was not overfished during 2011.

Map 69 – Bluefish stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



4.2.1.11 Atlantic mackerel, squid, and butterfish

Mackerel (*Scomber scombrus*), butterfish (*Peprilus triacanthus*), and squid are schooling pelagic species that range from at least the Gulf of St. Lawrence south to at least Cape Lookout, NC. Two squid species are managed, shortfin squid (*Illex* sp.) and longfin inshore squid (*Doryteuthis*

(Amerigo) pealeii), which until recently was referred to as *Loligo pealeii*. They follow seasonal migration patterns based largely on water temperature. *Illex* move offshore in spring, and inshore in the summer and fall. In contrast, longfin squid move offshore in the fall, and overwinter along the shelfbreak, returning inshore in spring.

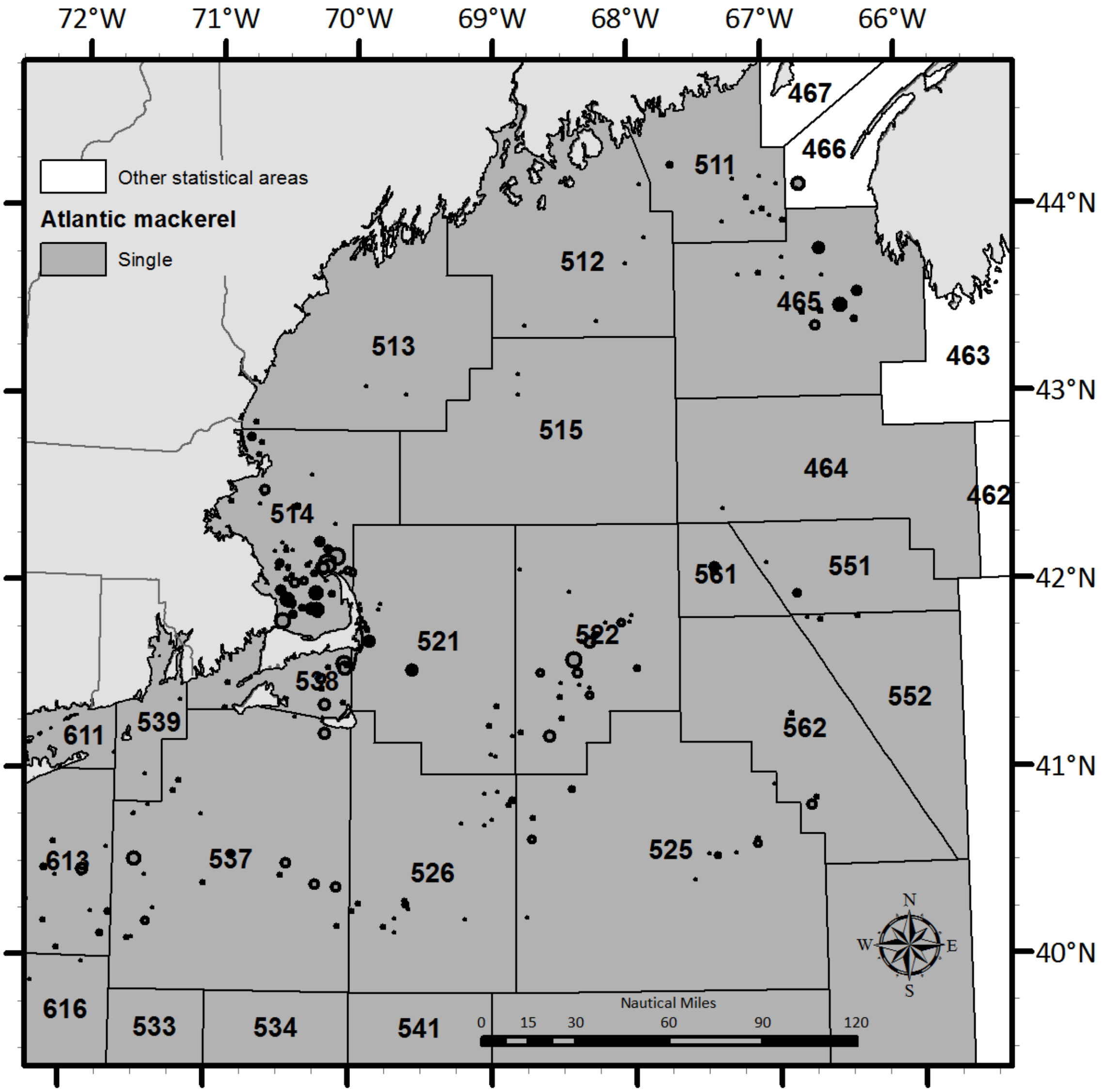
Squid are fast-growing, short-lived species, living about a year, while Atlantic mackerel grows more slowly with a maximum observed age of 17 years, with all fish reaching sexual maturity at age 3. Butterfish are intermediate in lifespan and growth rate, maturing at age 1 and typically living to age 3 years, rarely to 6 years. All are important prey species for other managed resources.

In general assessment of all four species has proven challenging and status determinations are often unknown or highly uncertain. Mackerel are managed as a single stock, and although technically classified as not overfished and overfishing not occurring, there was substantial uncertainty associated with the most recent assessment, conducted in 2010 by the Transboundary Resource Assessment Committee. The TRAC recommended management based on recent landings history, rather than on the basis of short term projections and characterization of the stock relative to specific reference points.

Butterfish are also managed as a single stock. The most recent assessment in 2010 questioned the 2004 reference points, and while it was agreed that overfishing was not likely to be occurring, the overfished status of butterfish was classified as unknown. A benchmark assessment of the stock is ongoing.

A determination of overfished/overfishing status in *Illex* was not possible during the last assessment, which occurred in 2006. However, data updates provided by NEFSC indicate that catch indices and landings are within their typical ranges. Loligo were assessed a bit more recently, and based on a new reference point, the stock was not overfished in 2009. An overfishing threshold was not recommended during this assessment, so an overfishing determination is not possible.

Map 70 – Atlantic mackerel stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.

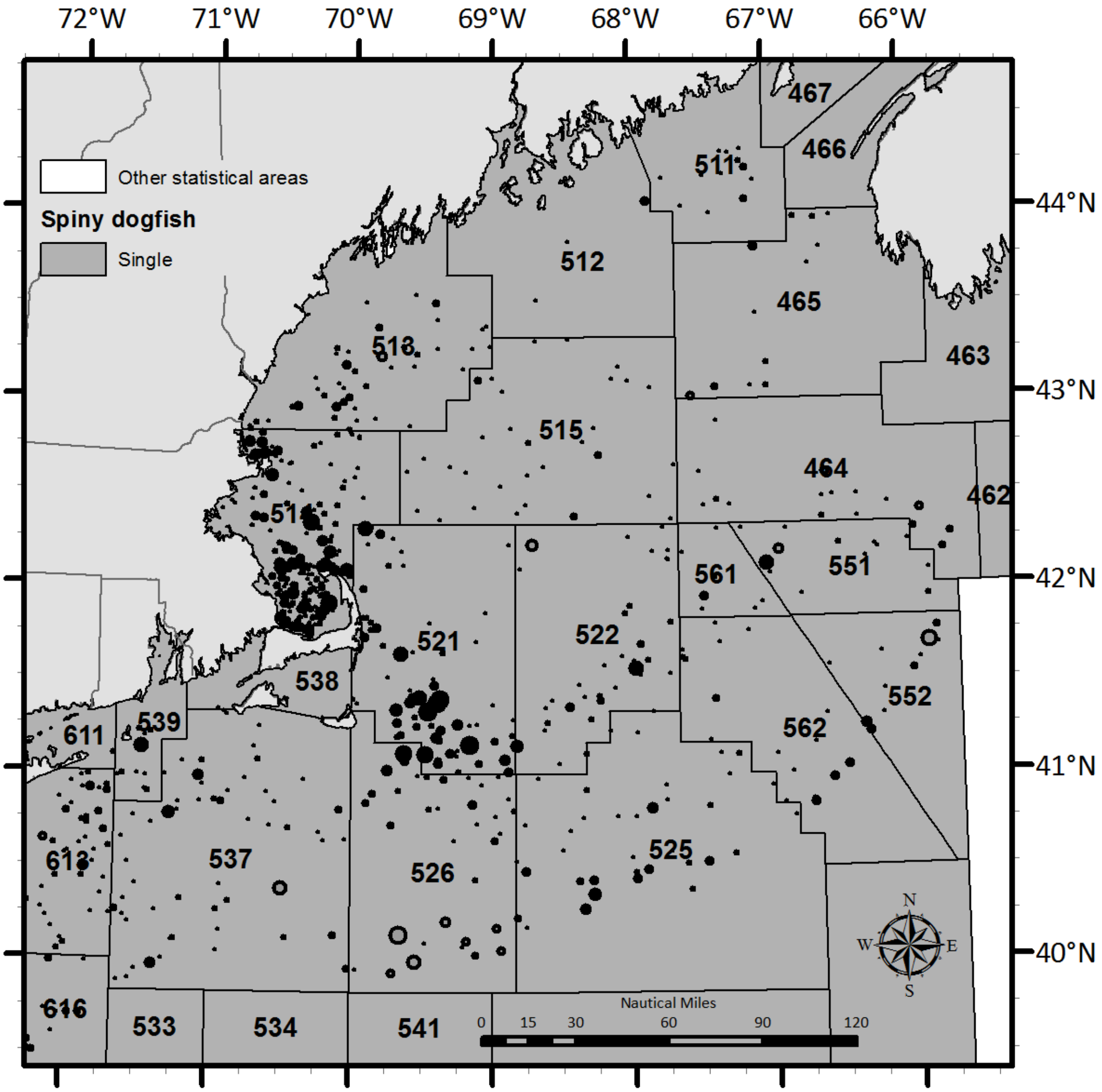


4.2.1.12 Spiny dogfish

Spiny dogfish (*Squalus acanthias*) are the most abundant sharks in the western North Atlantic, and range from Labrador to Florida, although they are most abundant from Nova Scotia to Cape Hatteras, North Carolina. Spiny dogfish are highly migratory, often traveling in large troops, and they move northward in the spring and summer and southward in the fall and winter. Spiny dogfish are known to be opportunistic predators, consuming whatever prey are readily abundant in their environment, including pelagic and benthic invertebrates and fishes. Although dogfish have a varied diet, most of what they eat are invertebrates (ctenophores in particular) and a recent study of 40,000 stomachs found that less than 1 percent of their diet was composed of principal groundfish species (Link et al. 2002).

In spite of their large numbers and opportunistic feeding, spiny dogfish, like many elasmobranches, suffer from several reproductive constraints. Females may take 7-12 years to reach maturity, growing more than one-third larger than their mature male counterparts before becoming sexually mature. Fertilization and egg development are internal, and gestation takes roughly 2 years, resulting in litters that usually average 6-7 dogfish. As a result of these factors, spiny dogfish are vulnerable to overfishing, particularly if fishing activities focus on the largest individuals, which are almost all mature females. As a result of increased fishing pressure, spiny dogfish were classified as overfished in 1998. In 2010, the stock was declared rebuilt, and in 2012, the stock was about 35% above its biomass reference point and the fishing mortality rate of F=0.148 was well below the MSY reference point of F=0.2439.

Map 71 – Spiny dogfish stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



4.2.1.13 Summer flounder, scup, and black sea bass

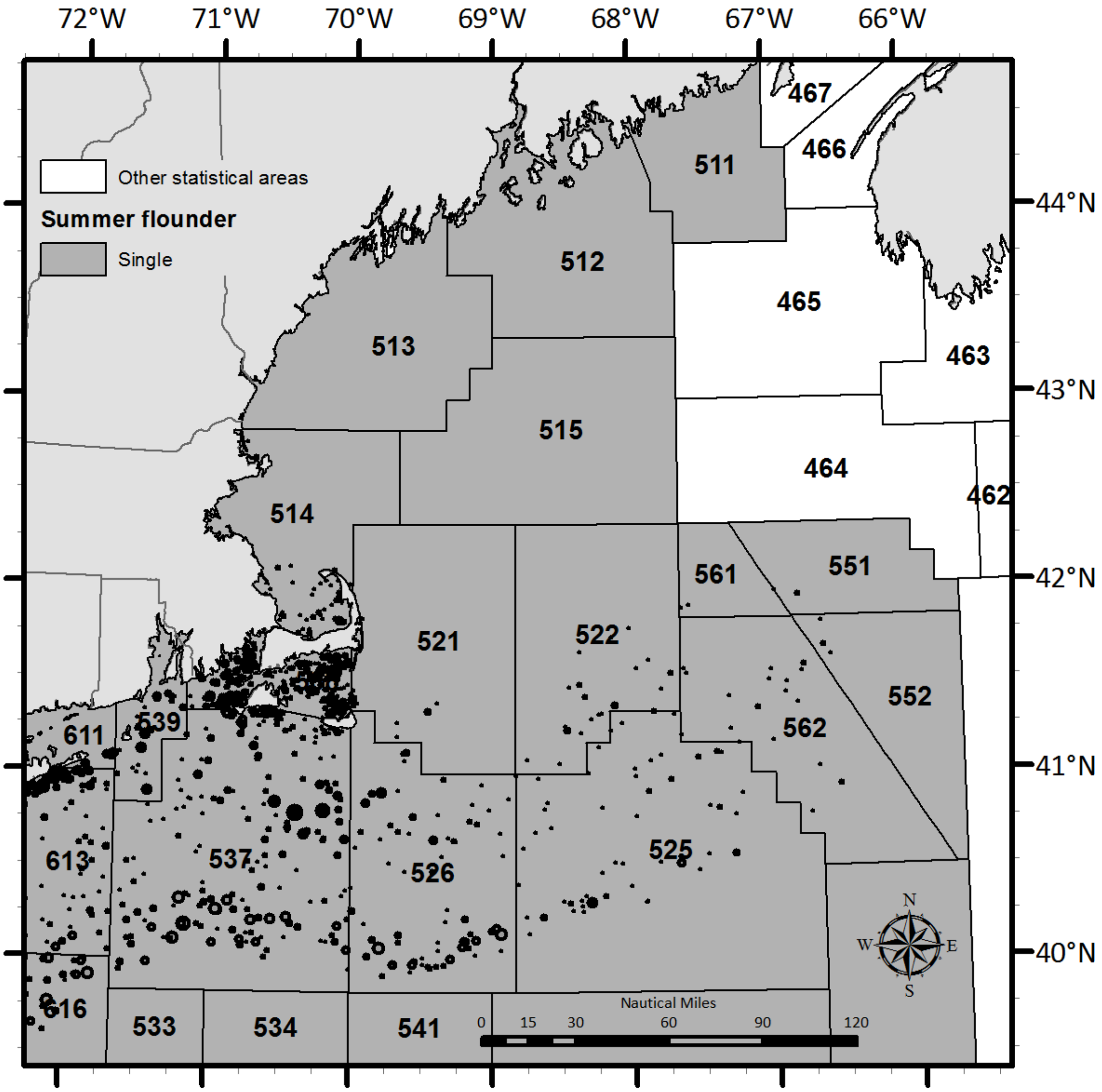
Summer flounder (*Paralichthys dentatus*), scup (*Stenotomus chrysops*), and black sea bass (*Centropristis striata*) are three demersal finfish species that occur primarily in the Middle Atlantic Bight from Cape Cod, MA, to Cape Hatteras, NC. All three species exhibit seasonal movement or migration patterns. Summer flounder move inshore to shallow coastal and estuarine waters during warmer months and move offshore during colder months. Scup is a schooling species that undertakes extensive migrations between the coastal waters in the summer and outer continental shelf waters in the winter. Black sea bass are most often found in association with structured habitats, and they migrate offshore and to the south as waters cool in the fall, returning north and inshore to coastal areas and bays as waters warm in the spring.

All three species are managed as single stocks throughout their ranges. In 2011, summer flounder was declared rebuilt. Fishing mortality has been fluctuating around the threshold value since the mid-2000s, and currently the rate is below the threshold so overfishing is not occurring.

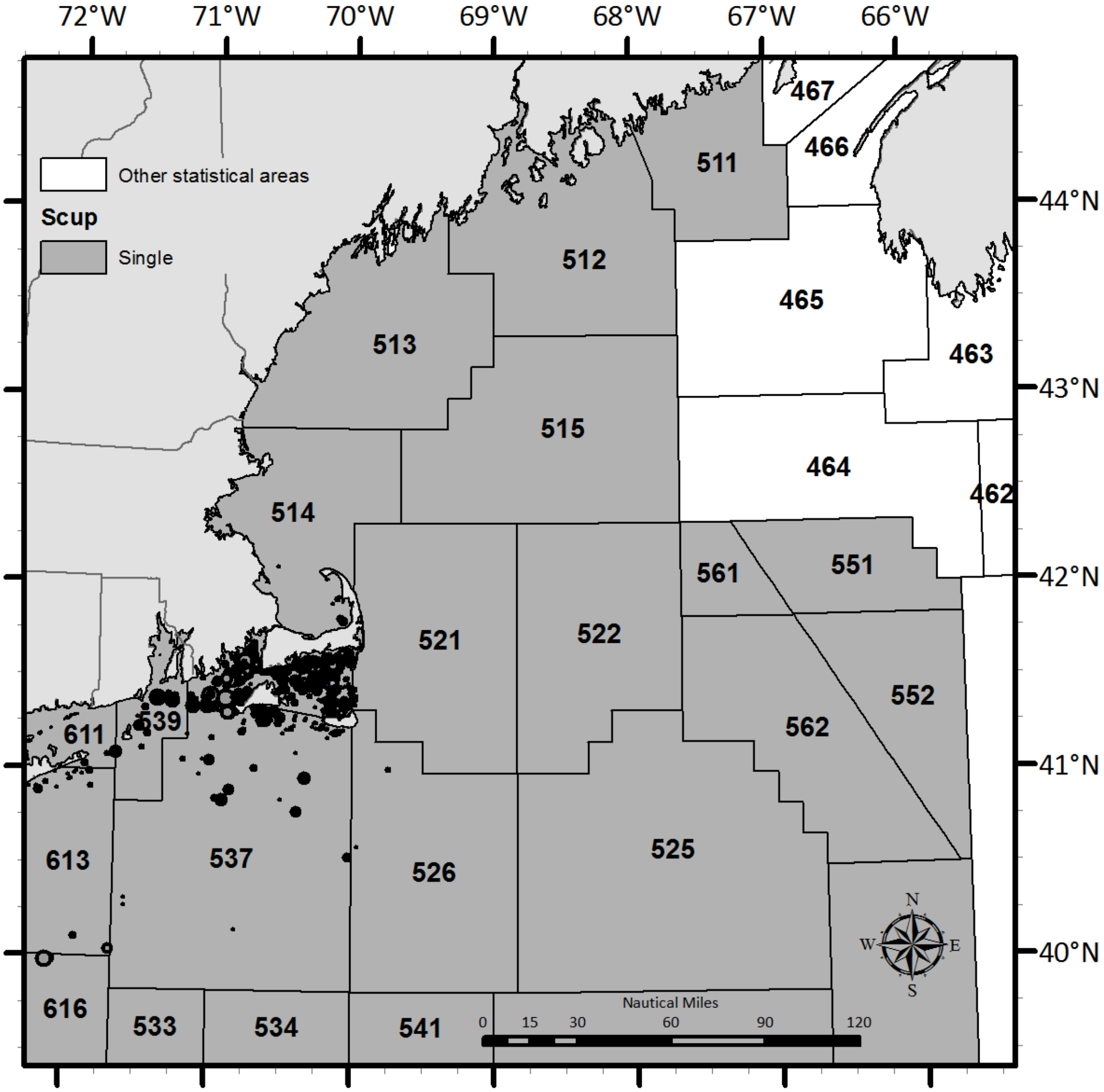
Scup spawning stock biomass has been increasing since the late 1990s, and is now more than double the reference spawning stock biomass at MSY reference point. Fishing mortality on scup has been below the threshold since the early 2000s.

The most recent accepted benchmark assessment of black sea bass occurred in 2008. The 2012 update indicated that the stock was not overfishing and overfishing was not occurring in 2011. In 2011, the stock size was roughly equal to the biomass at MSY reference point, and fishing mortality rate was about half the threshold rate.

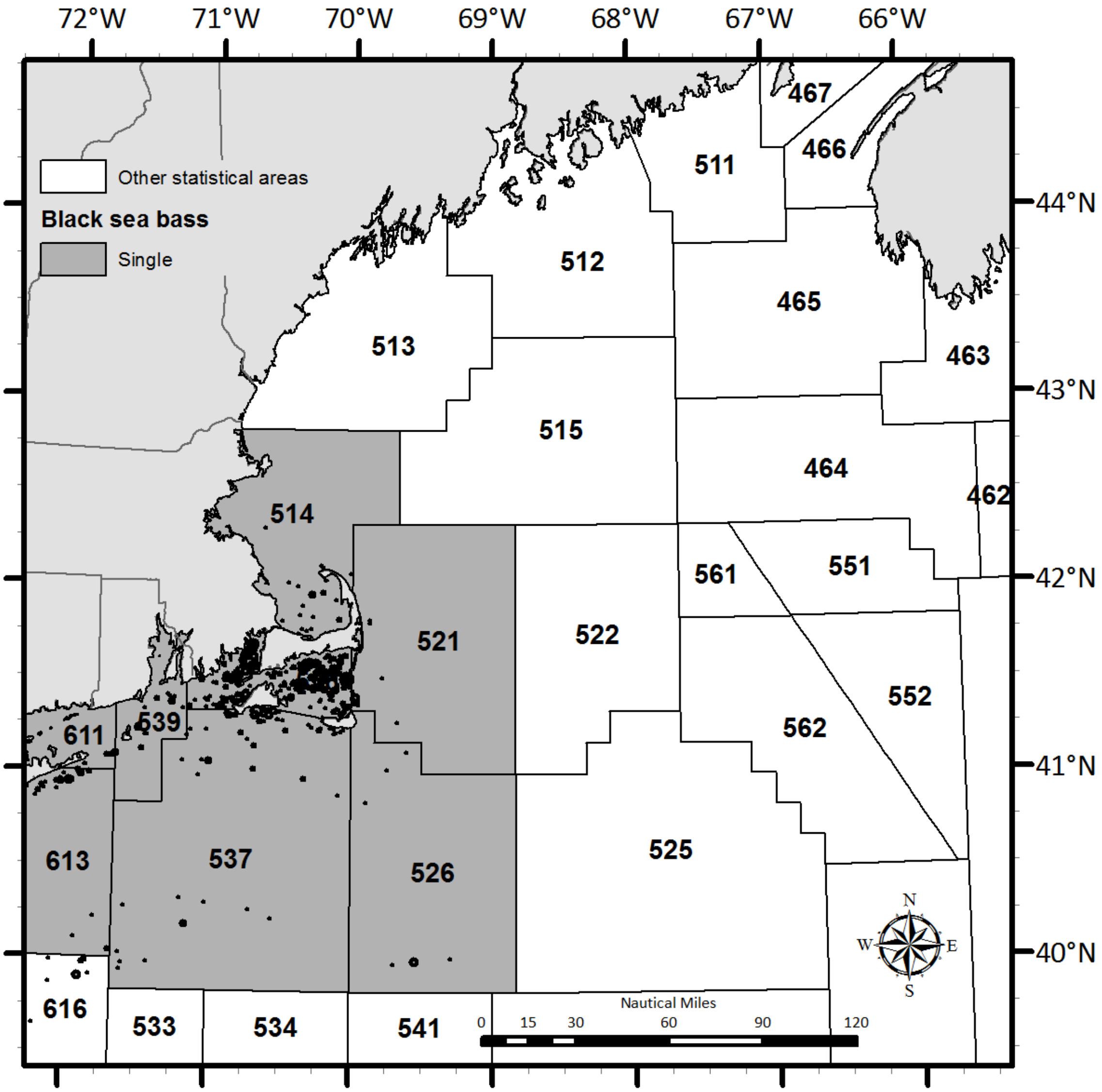
Map 72 – Summer flounder stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



Map 73 – Scup stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



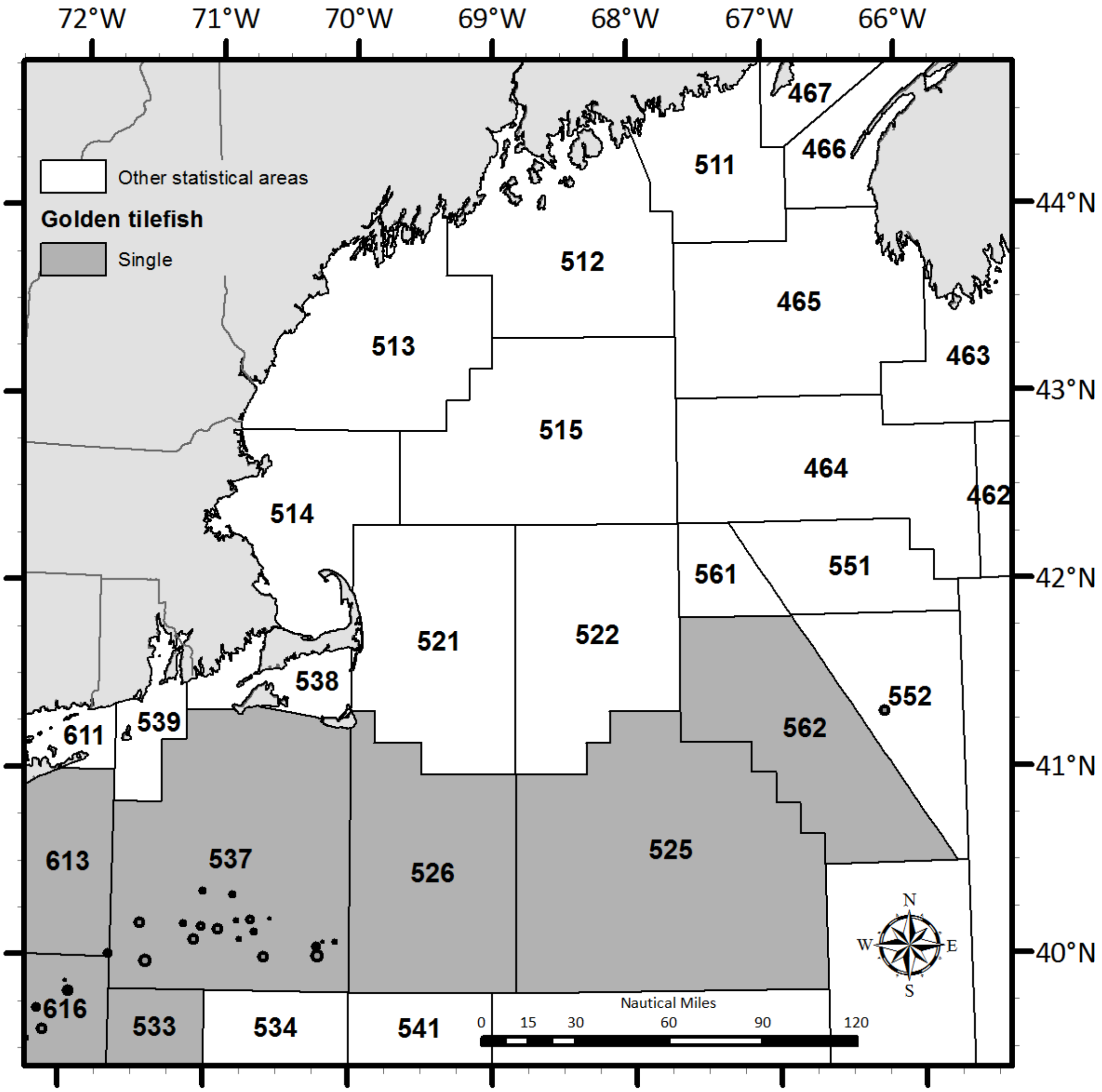
Map 74 – Black sea bass stock boundaries and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



4.2.1.14 Golden tilefish

The golden tilefish (*Lopholatilus chamaeleonticeps*) is the largest and longest lived of all the tilefish species, and in U.S. waters ranges from Georges Bank to Key West, FL, and throughout the Gulf of Mexico. Golden tilefish occupy a fairly restrictive band along the outer continental shelf and are most abundant in depths of 100-240 meters. Temperature may also constrain their range, as they are most abundant near the 15° C isotherm. Although this species occupies a variety of habitats, it is somewhat unique in that they create and modify existing vertical burrows in the sediment as their dominant habitat in U.S. waters.

Map 75 – Golden tilefish stock boundary and catch/tow from spring and fall NMFS, MADMF, and ME/NH surveys, 2002-2013. Spring survey values shaded grey may obscure fall survey values shaded black.



4.2.2 Groundfish distribution analysis

In addition to goals and objectives to reduce adverse impacts of fishing on EFH, the Council decided to focus on conservation of important groundfish stocks and integrate a re-evaluation of existing groundfish seasonal and year round closed areas into the EFH amendment. In late 2012, the Council added two goals to enhance groundfish fishery productivity and maximize societal net benefits from the groundfish stocks while addressing current management needs (see Section 3.2). Four objectives were also added to improve groundfish spawning protection, including protection of localized spawning contingents or sub-populations of stocks; improve protection of critical groundfish habitats; improve refuge for critical live history stages; and improve access to both the non-use benefits arising from closed area management across gear types, fisheries, and groups.

It is notable that these objectives seek improvements relative to the status quo set of seasonal and year round closed areas, so that to meet these objectives, alternative spatial management of fishing should either improve conservation by considering practicable alternatives, or by maintaining the existing level of conservation while reducing the effects on the groundfish fishery.

The Council developed the Swept Area Seabed Impact (SASI) approach to evaluate the potential for mitigating the adverse effects of fishing on EFH, by area and gear type. The fundamental basis of this modeled approach is to evaluate the vulnerability of seabed substrates to adverse effects of various bottom-tending gears currently in use by fisheries in the Northeast region. The SASI model approach was peer-reviewed by the Council's SSC and approved to use as the basis for identification of areas where mobile bottom tending gears (MBTG) would adversely affect EFH.

The SASI model considers the type of substrate in an area, the geological and biological structures associated with that substrate, and the degree to which those features would be affected by various MBTG, including otter trawls, clam dredges, and New Bedford-style scallop dredges. The assessment accounted for the propensity for alteration by natural disturbances such as currents and storms. In general, areas dominated by cobble and boulder substrates and associated structures were identified as having characteristics that would be adversely affected by MTBG fishing, especially when these habitat types occur in low energy areas not routinely disturbed by currents and storms. The results of the model were used to identify a range of potential habitat management areas designed to minimize the adverse effectcs of fishing on EFH.

However, the SASI model does not specifically identify which species would benefit from habitat protections, or how reductions in impacts would lead to long term improvements in groundfish productivity. Thus, as a complement to the SASI approach, the Council developed a groundfish-focused analysis to evaluate and identify management areas designed to meet the groundfish-related goals and objectives specified above. The scientific literature does identify species associations by habitat types (see descriptions by species in section 4.2.1, particularly groundfish species in section 4.2.1.1), including vulnerable cobble- and boulder-dominated habitats. In theory, species that are associated with hard, stable habitats derive protection from predators and food from animals that live in these locations. Thus protection of these habitats is expected to improve survival and growth. Focusing on the most critical groundfish lifestages, the Council evaluated the distribution of age 0 and 1 groundfish.[1] These small fish tend to be most closely associated with complex substrates and therefore likely to derive benefit from the protection that it provides. Several sources of data were considered, including observed catches on commercial fishing boats and various periodic fish surveys conducted by NMFS, various coastal states, and others.

---

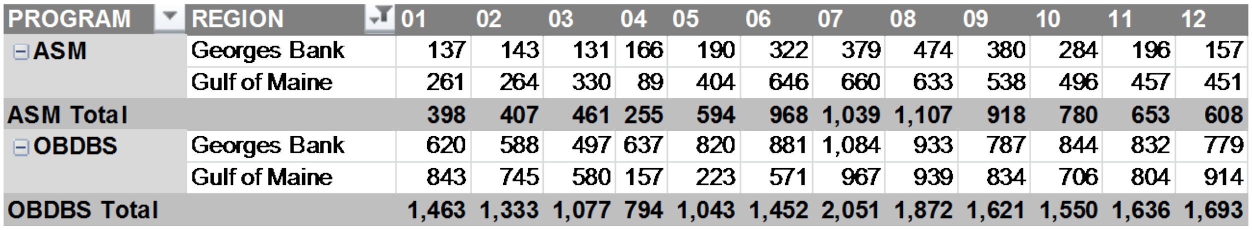
[1] Note that this is a narrower focus than the juvenile groundfish EFH designations, which are based on the distribution of groundfish below the size at 50% maturity.

The advantage of observed catches on commercial boats is the sheer amount of data in recent years since 1989 and continuous sampling throughout the year, with over 1,500 Georges Bank and 2,000 Gulf of Maine observed trips each year since 2010 (Table 16). Although there is some seasonality in the At-Sea Monitoring (ASM) observed trips, sampling occurs throughout the year (Table 17). There are two major deficiencies in the observed data that make it unsuitable for examining the distribution of age 0 and 1 groundfish, however. One is that fishing locations are of course influenced by a variety of factors, the most problematic being they naturally exclude observations in closed areas which in this case are very important to the analysis (particularly if the No Action closed areas are having a positive effect on protection of juvenile groundfish). Fishermen of course also target areas having high catches and other areas are therefore undersampled. The second problem is that due to minimum mesh size and other factors, commercial fishing gears catch a relatively low fraction of small fish.

Table 16 – Number of observed trips for all gears by the At-sea Monitoring and Observer programs on Georges Bank (statistical areas 521-543) and in the Gulf of Maine (statistical areas 464-515).

	Georges Bank		Georges Bank Total	Gulf of Maine		Gulf of Maine Total
YEAR	ASM	OBDBS		ASM	OBDBS	
1989		124	**124**		191	**191**
1990		86	**86**		186	**186**
1991		291	**291**		939	**939**
1992		407	**407**		1,064	**1,064**
1993		288	**288**		676	**676**
1994		177	**177**		195	**195**
1995		185	**185**		223	**223**
1996		108	**108**		154	**154**
1997		102	**102**		74	**74**
1998		93	**93**		93	**93**
1999		121	**121**		119	**119**
2000		309	**309**		207	**207**
2001		141	**141**		193	**193**
2002		206	**206**		318	**318**
2003		427	**427**		642	**642**
2004		879	**879**		1,299	**1,299**
2005		1,746	**1,746**		1,481	**1,481**
2006		779	**779**		440	**440**
2007		937	**937**		455	**455**
2008		1,009	**1,009**		528	**528**
2009		997	**997**		861	**861**
2010	900	788	**1,688**	1,532	594	**2,126**
2011	1,095	749	**1,844**	1,978	781	**2,759**
2012	964	785	**1,749**	1,719	884	**2,603**
2013	588	426	**1,014**	733	249	**982**

Table 17 – Number of observed trips by program, month, and region from 2002-2012.



PROGRAM	REGION	01	02	03	04	05	06	07	08	09	10	11	12
⊟ASM	Georges Bank	137	143	131	166	190	322	379	474	380	284	196	157
	Gulf of Maine	261	264	330	89	404	646	660	633	538	496	457	451
ASM Total		398	407	461	255	594	968	1,039	1,107	918	780	653	608
⊟OBDBS	Georges Bank	620	588	497	637	820	881	1,084	933	787	844	832	779
	Gulf of Maine	843	745	580	157	223	571	967	939	834	706	804	914
OBDBS Total		1,463	1,333	1,077	794	1,043	1,452	2,051	1,872	1,621	1,550	1,636	1,693

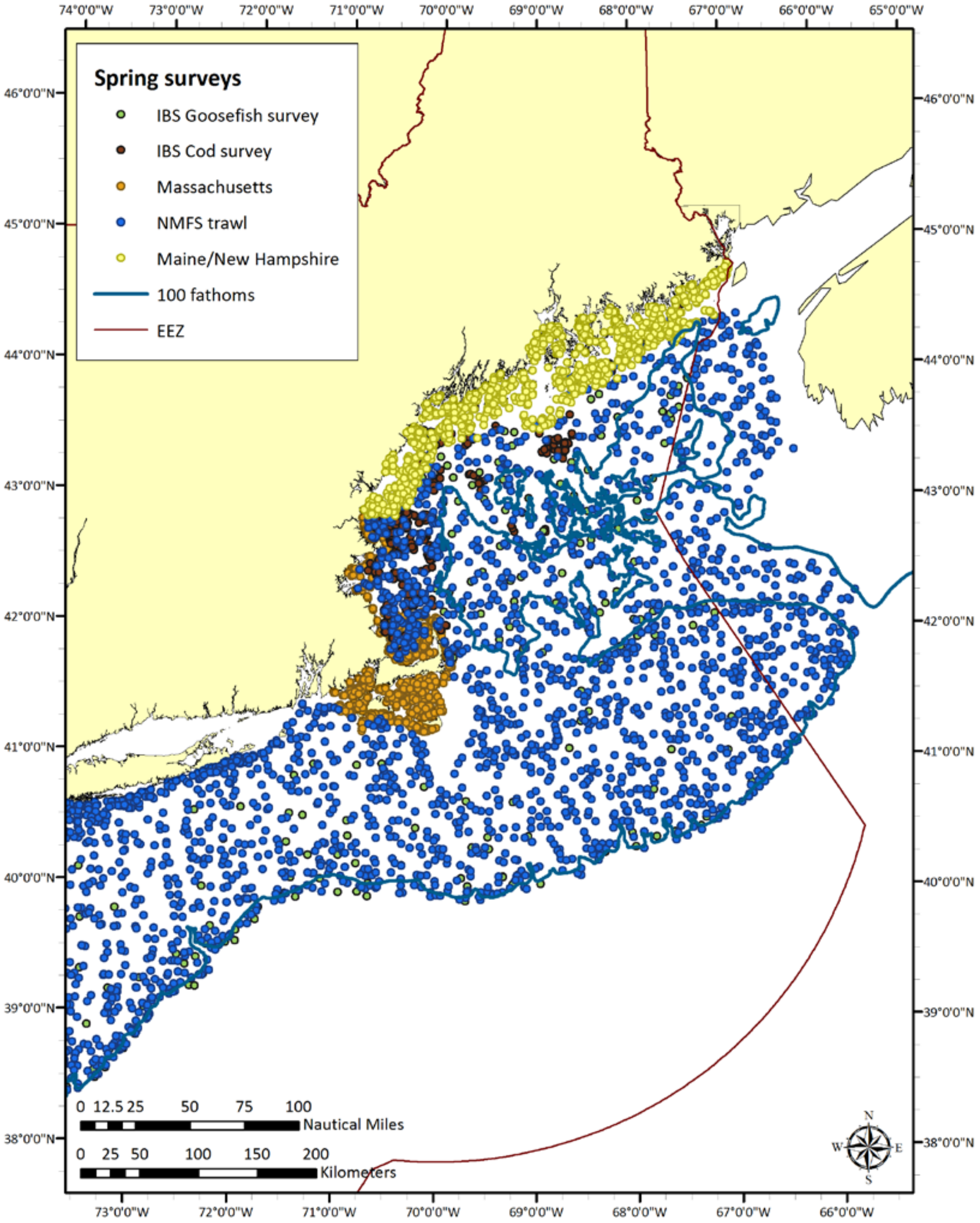
In contrast, surveys have some major advantages that observed commercial catches don't have. First, they catch a relatively large proportion of age 0 and 1 groundfish because mesh liners are used. The surveys are designed to catch small fish and detect incoming year classes. Second, the tows sample randomly from each stratum (Map 76-Map 79), regardless of management status of the area being sampled, bottom type, or availability of fish. One disadvantage is that although there are seasonal surveys (primarily spring and fall), the surveys occur during specific periods and the resulting fish distribution data reflect what occurs only during that time period. Fish distribution during the late spring and early summer (late April to June, for example) is unobserved in these data (Table 18). A less problematic issue is that the survey tow locations sometimes avoid certain areas, such as very shallow depths and extra hard bottom, the latter causing gear damage. Thus, certain areas such as the center of Cashes Ledge, Fippennies Ledge, and Nantucket Shoals are not sampled (Map 81).

Using the survey data, the Council applied scientifically-accepted methods to identify locations of well above average survey catches of age 0 and 1 groundfish, often called a "hotspot analysis". A hotspot in this analysis was identified when there was a cluster of significantly above average catches ($p>0.05$) for each survey over the 10-year period (2002-2011 in the fall and summer surveys; 2003-2012 for the spring surveys). A single catch that was significantly above the survey mean was not deemed to represent a hotspot, nor was a cluster of above average catches that none were significantly above average.

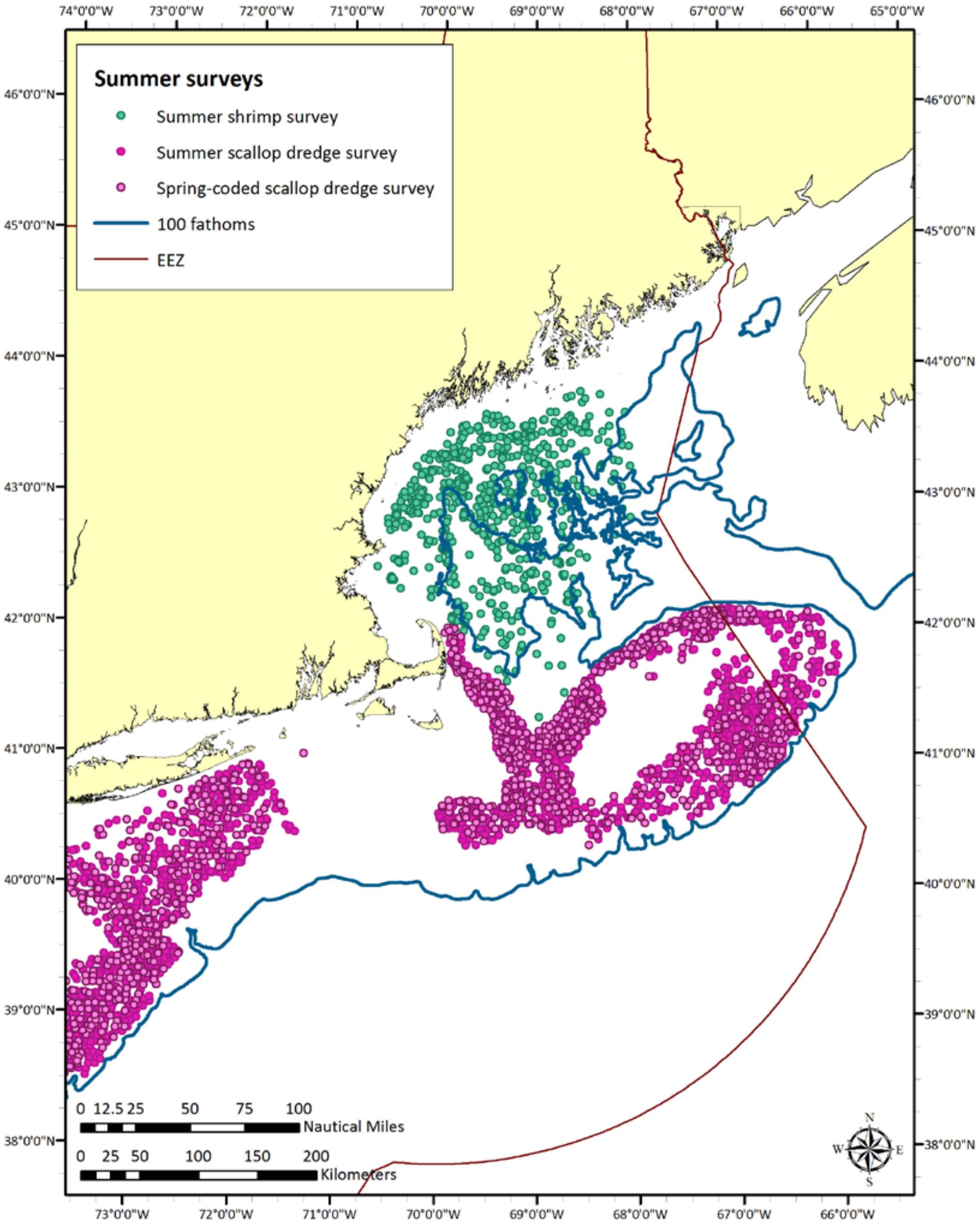
A matrix of weightings was developed to focus the analysis and provide greater emphasis to stocks having low biomass (i.e overfished), existence of sub-populations, a high degree of residency, and high substrate affinity. The weighted hotspot results were used to identify critical habitat areas for juvenile groundfish. The weights associated with these factors and applied to the number of hotspots in each 100 km^2 grid are listed in Table 19.

Like the SASI model approach, the hotspot analyses were peer-reviewed by the Council's SSC, which concluded that "the analyses, results, and hotspot summaries used by the [Closed Area Technical Team] are appropriate for developing management alternatives". More details and an example of what was considered to be a hotspot for this analysis are provided Appendix E, which was adapted from the report provided for the SSC review.

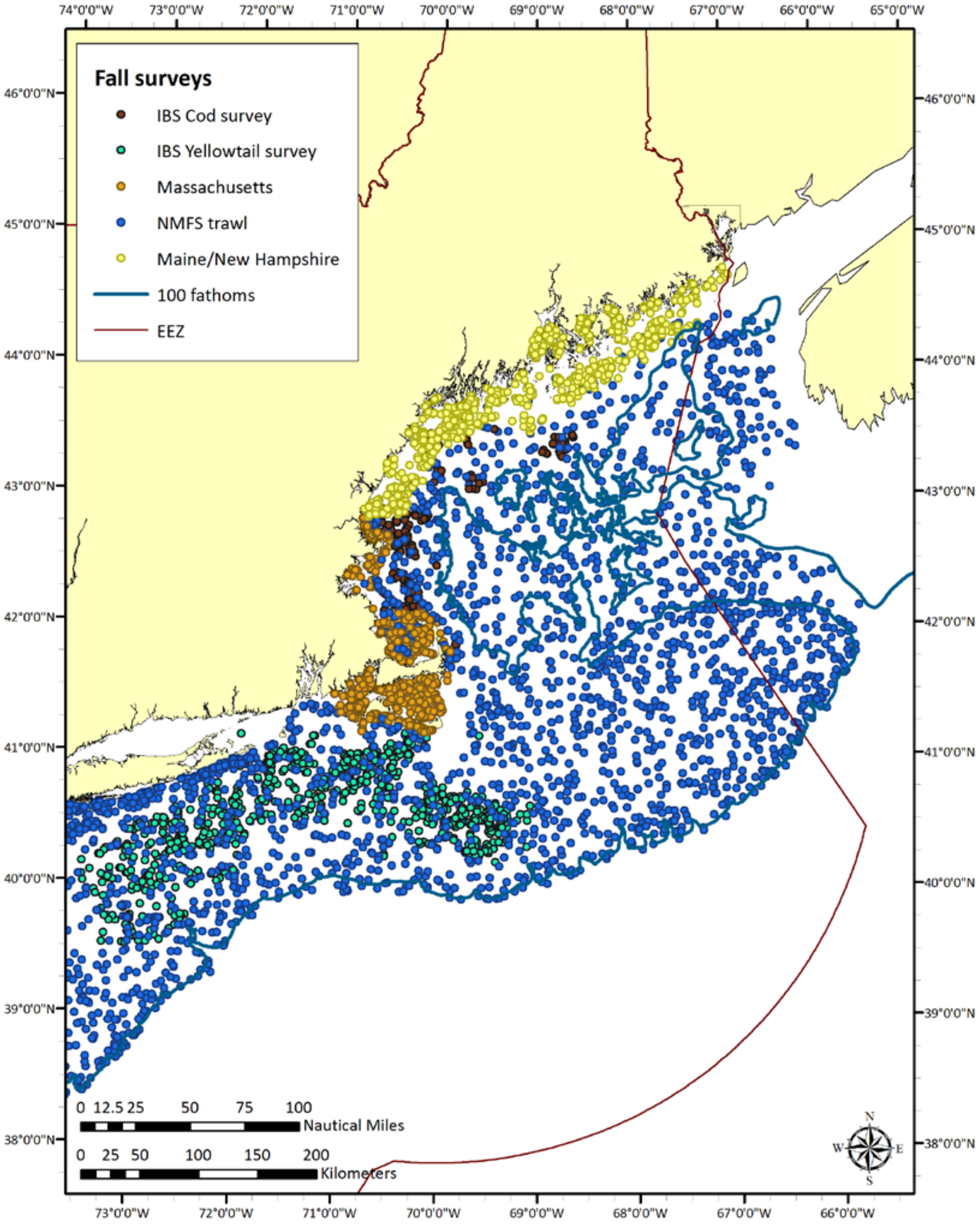
Map 76 – Domain of spring survey tows used for the hotspot analysis, by survey type. Tows used in analysis were made between fall 2002 and spring 2012.



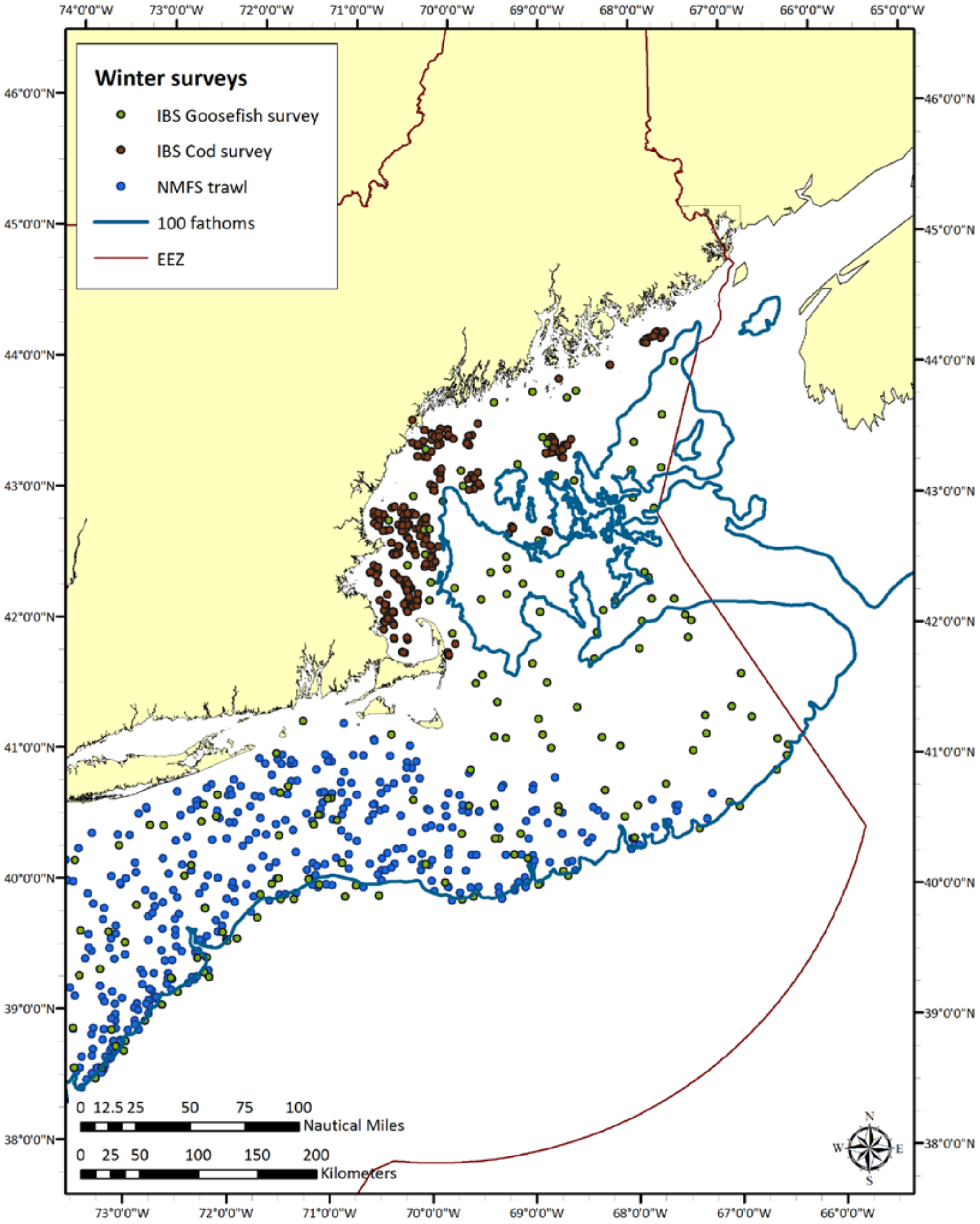
Map 77 – Domain of summer survey tows used for the hotspot analysis, by survey type. Tows used in analysis were made between fall 2002 and spring 2012.



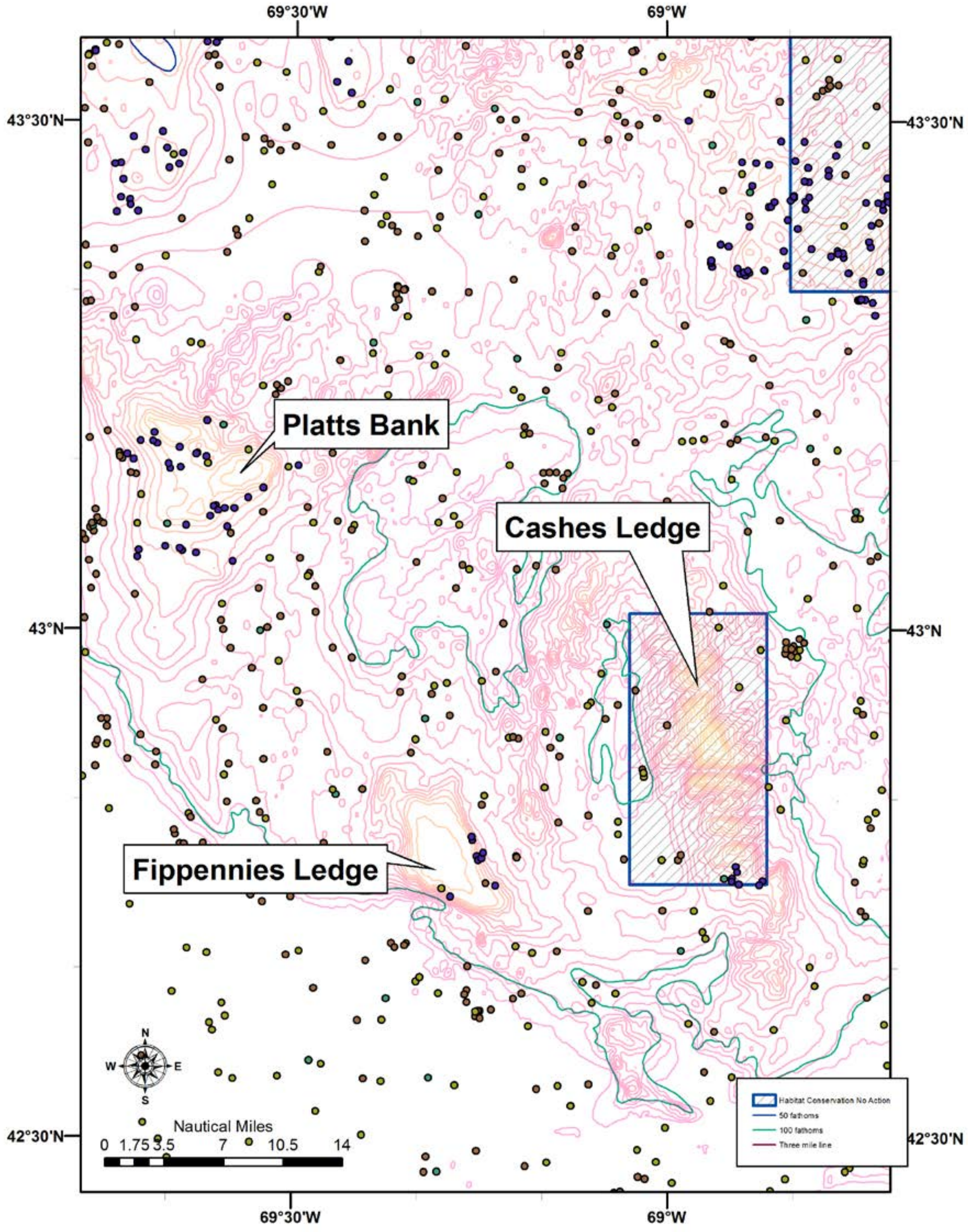
Map 78 – Domain of fall survey tows used for the hotspot analysis, by survey type. Tows used in analysis were made between fall 2002 and spring 2012.



Map 79 – Domain of winter survey tows used for the hotspot analysis, by survey type. Tows used in analysis were made between fall 2002 and spring 2012.



Map 80 – Survey tows taken by NMFS trawl surveys in the vicinity of Platts Bank, Fippennies Ledge, Cashes Ledge during Fall 2002 to Spring 2012.



Map 81 – Survey tows taken by NMFS trawl and MADMF trawl surveys in the vicinity of Nantucket Shoals during Fall 2002 to Spring 2012.

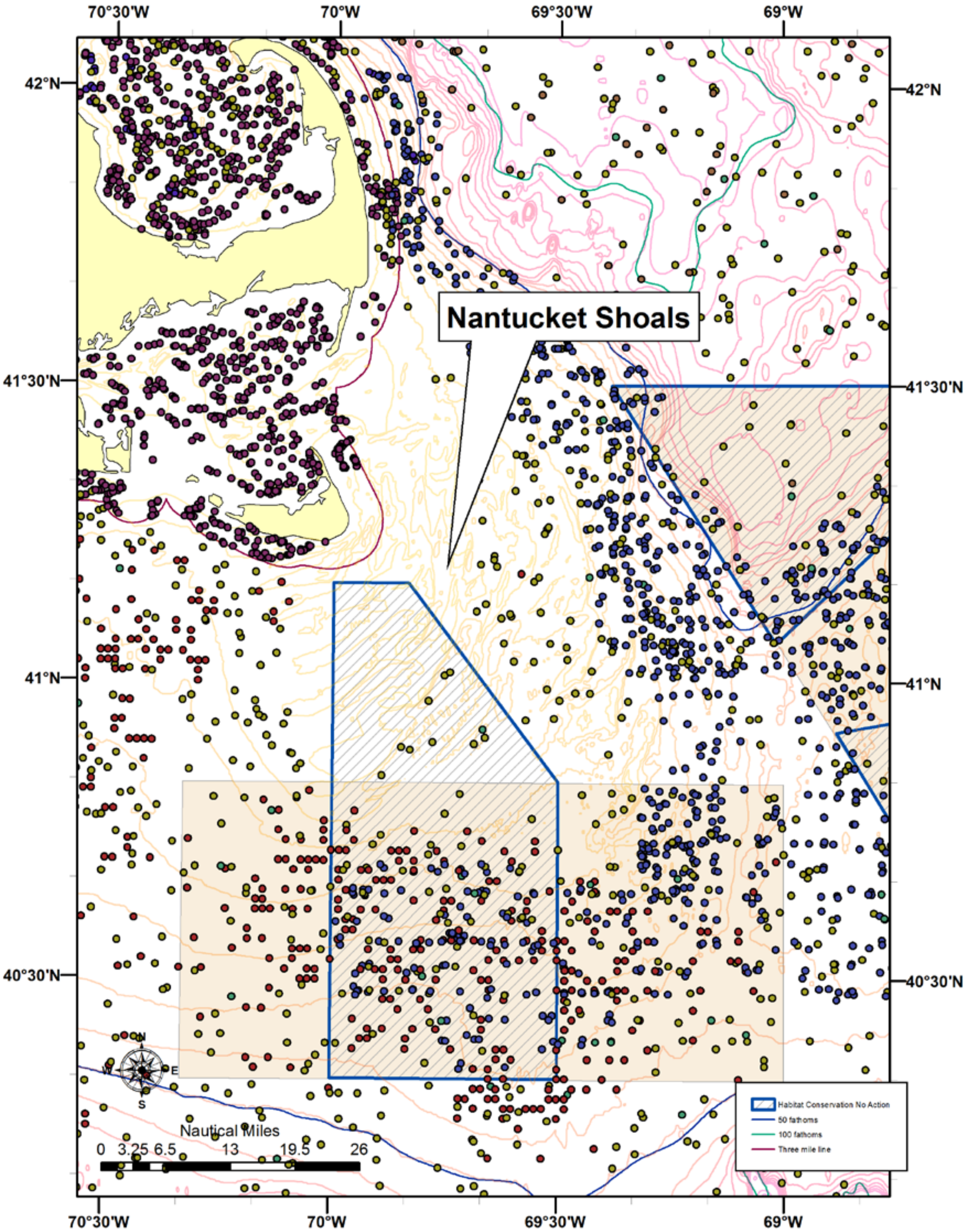
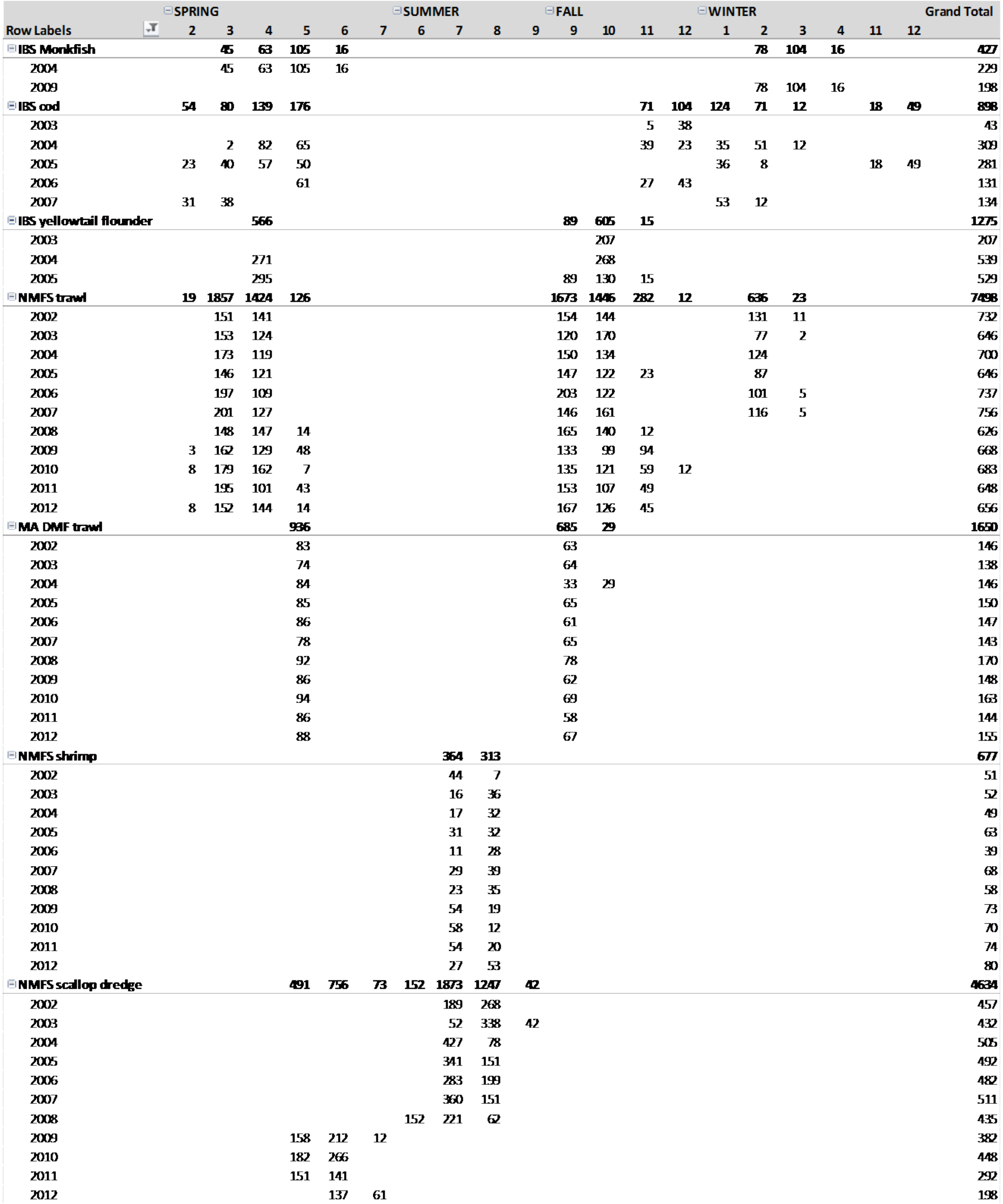


Table 18 – Number of random and non-random survey tows used in age 0 and 1 and large spawner groundfish hotspot analysis by survey type, season, and month of sampling.



	SPRING						SUMMER				FALL				WINTER						Grand Total
Row Labels	2	3	4	5	6	7	6	7	8	9	9	10	11	12	1	2	3	4	11	12	
IBS Monkfish		**45**	**63**	**105**	**16**											**78**	**104**	**16**			**427**
2004		45	63	105	16																229
2009																78	104	16			198
IBS cod	**54**	**80**	**139**	**176**									**71**	**104**	**124**	**71**	**12**		**18**	**49**	**898**
2003													5	38							43
2004		2	82	65									39	23	35	51	12				309
2005	23	40	57	50											36	8			18	49	281
2006				61									27	43							131
2007	31	38													53	12					134
IBS yellowtail flounder			**566**								**89**	**605**	**15**								**1275**
2003												207									207
2004			271									268									539
2005			295								89	130	15								529
NMFS trawl	**19**	**1857**	**1424**	**126**							**1673**	**1446**	**282**	**12**		**636**	**23**				**7498**
2002		151	141								154	144				131	11				732
2003		153	124								120	170				77	2				646
2004		173	119								150	134				124					700
2005		146	121								147	122	23			87					646
2006		197	109								203	122				101	5				737
2007		201	127								146	161				116	5				756
2008		148	147	14							165	140	12								626
2009	3	162	129	48							133	99	94								668
2010	8	179	162	7							135	121	59	12							683
2011		195	101	43							153	107	49								648
2012	8	152	144	14							167	126	45								656
MA DMF trawl				**936**							**685**	**29**									**1650**
2002				83							63										146
2003				74							64										138
2004				84							33	29									146
2005				85							65										150
2006				86							61										147
2007				78							65										143
2008				92							78										170
2009				86							62										148
2010				94							69										163
2011				86							58										144
2012				88							67										155
NMFS shrimp								**364**	**313**												**677**
2002								44	7												51
2003								16	36												52
2004								17	32												49
2005								31	32												63
2006								11	28												39
2007								29	39												68
2008								23	35												58
2009								54	19												73
2010								58	12												70
2011								54	20												74
2012								27	53												80
NMFS scallop dredge				**491**	**756**	**73**	**152**	**1873**	**1247**	**42**											**4634**
2002								189	268												457
2003								52	338	42											432
2004								427	78												505
2005								341	151												492
2006								283	199												482
2007								360	151												511
2008							152	221	62												435
2009				158	212	12															382
2010				182	266																448
2011				151	141																292
2012					137	61															198

Table 19 – Weighting factors applied to juvenile groundfish hotspot data to sum hotspots across species and develop area management options. The final weighting sum was applied to the gridded hotspots for species shaded in red. Grey shaded rows designate species not managed by catch shares.

Stock (Red cells indicate selected stocks for Option 3)	Juvenile size threshold Age 0 and 1 length (90th %ile, cm)	Length at 20% female maturity (cm) re-estimated by CATT	Vulnera-bility of species (Bmsy/B)[1]	Sub-populations[2]	Residency[3]	Substrate[4]	Final Weighting Sum
GB cod	24 (Sp), 34 (Fa)	36	14.11	2	1	3	20.11
GOM cod	24 (Sp), 34 (Fa)	36	5.53	3	1	3	12.53
GB yellowtail flounder	13 (Sp), 15 (Fa)	25	9.39	1	2	1	13.39
CC/GOM yellowtail flounder	13 (Sp), 15 (Fa)	25	4.21	1	2	1	8.21
SNE/MA yellowtail flounder	13 (Sp), 15 (Fa)	25	0.77	1	2	1	4.77
GOM winter flounder	18 (Sp), 28 (Fa)	27	UNK	UNK	2	1	10.04
GB winter flounder	18 (Sp), 28 (Fa)	27	1.22	3	2	1	7.22
SNE/MA winter flounder	18 (Sp), 28 (Fa)	27	6.17	3	2	1	12.17
White hake	34 (Sp), 39 (Fa)	25	1.21	UNK	2	1	6.04
GOM haddock	24 (Sp), 34 (Fa)	28	1.71	1	1	3	6.71
GB haddock	24 (Sp), 34 (Fa)	28	0.75	1	1	3	5.75
Witch flounder	20 (Sp), 19 (Fa)	28	2.45	3	2	1	8.45
American plaice	12 (Sp), 18 (Fa)	24	1.70	UNK	1	1	5.54
Pollock	23 (Sp), 32 (Fa)	39	0.46	2	2	2	6.46
Acadian redfish	14 (Sp), 13 (Fa)	19	0.76	1	2	3	6.76
Atlantic halibut	see winter fl.	NA	28.82	UNK	2	2	34.66
Ocean pout	29	29[6]	12.05	UNK	1	2	16.88
N. windowpane	see yellowtail	18	3.48	UNK	2	1	8.31
S. windowpane	see yellowtail	18	0.69	UNK	2	1	5.52
Atlantic wolffish	47	47[7]	3.48	UNK	UNK	2	8.99
Sum							208.52
Mean			**5.21**	**1.83**	**1.68**	**1.70**	**10.43**

1 Either SSBmsy/SSB or Bmsy/B used depending on what is reported in the assessment

2 Derived from Table 81 in Framework 48 or from NEFSC biological data. 1=no subpopulations, 2=some evidence, 3=known subpopulations

3 Based on information in literature. 1=less resident, more migratory; 2=more resident, less migratory

4 Based on information in literature. 1=almost exclusively in mud or sand substrates, 2=occur in a variety of substrates including gravels, 3=strong affinity for coarse or hard substrates

5 Sums include a mean value for unknowns

6 From O'Brien et al. (1993)

7 From Templeman (1986)

The various surveys occurred during various periods, the longest being the fall NMFS trawls survey which has been conducted annually since 1963. Data for all of the regular surveys, including the ME/NH trawl survey was available during 2002-2012. The Council analyzed age 0/1 groundfish distribution data during the fall 2002 to spring 2012 period because it was more likely than earlier data to represent current and potentially future conditions. Data before 2002 is probably reflective of differing conditions that affect geographical distributions, including changing temperature and stock abundance. Survey data from Industry Based Surveys (IBS) for monkfish, cod, and yellowtail flounder were included in the hotspot analysis, even though a proportion of survey tows were directed by fishermen specifically to target spawning cod[2]. Summer (primarily the shrimp and scallop surveys) and winter (primarily the NMFS trawl survey that terminated in 2007) only partially covered the range of species included in this analysis. Obviously hotspots during these seasons were undetectable in unsurveyed areas not covered by these surveys.

Species included in the hotspot analysis were Acadian redfish, Alewife, American plaice, Atlantic halibut, Atlantic herring, cod, goosefish (monkfish), haddock, ocean pout, pollock, red hake, silver hake, white hake, windowpane flounder, winter flounder, witch flounder, and yellowtail flounder.

Hotspot analyses were conducted for the entire range for each species in the survey data, but were given differing weights by stock area to account primarily for differences in stock abundance relative to each stock's B_{msy} target. Since the purpose of the analysis was to identify areas that were vulnerable bottom habitat, only stocks that either "occur in a variety of substrates including gravels" or had "strong affinity for course or hard substrates" were given non-zero weights.

The species that were therefore given non-zero weights in the composite scoring to identify habitat areas included cod, haddock, pollock, redfish, halibut, pout, and wolfish (

---

[2] A sensitivity analysis conducted by the Council's Closed Area Technical Team showed that clustering of data did not affect the results, unless areas of high concentration went unsampled or were not surrounded by other samples.

Table 19). Wolffish catches were relatively sparse and no hotspots were identified. Suitable data for skates were compiled but were not analyzed for hotspots.

Although the entire range of survey data for a species was analyzed, this amendment focuses on specific areas for habitat protection, for dedicated habitat research, and for spawning. Therefore a summary of hotspots in areas included for the various alternatives is given below.

4.2.2.1 Age 0/1 groundfish hotspot and GAMs analyses

As mentioned in the section above, management-weighted and unweighted hotspots were summarized for existing EFH closed areas (No Action) and for various areas under consideration for habitat management (via gear modification or closure) in this amendment. Gridded (1 km resolution) hotspot summaries by season and species for age 0 and 1 fish are presented below, along with these management area summaries. The number of hotspots in specific areas vary by season due to seasonal variations in geographic distribution as well as the amount and extent of surveys conducted during each season (see sampling summary in the above section). Therefore no attempt was made to rank or grade areas by summing weighted or unweighted hotspots across seasons.

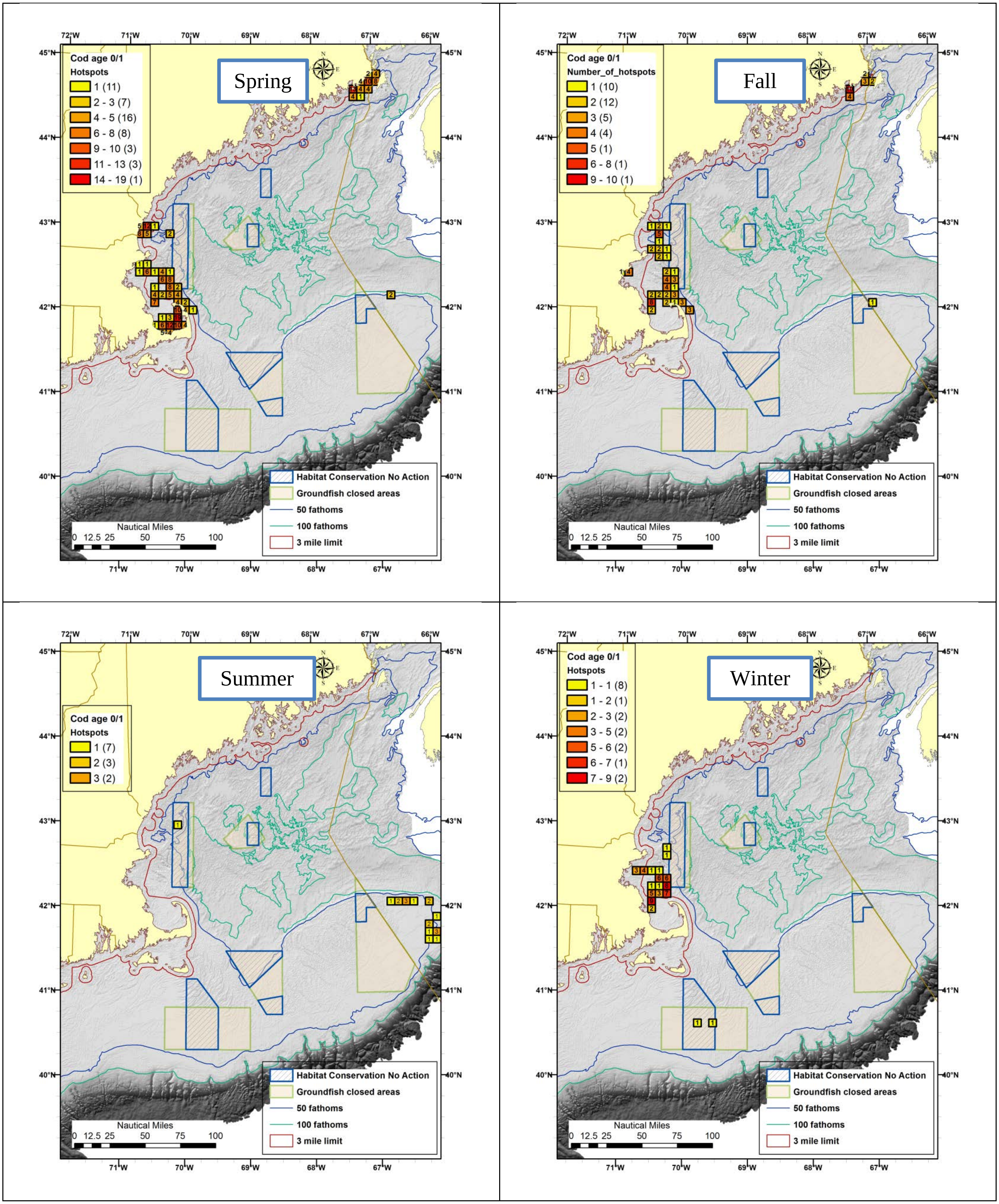
4.2.2.1.1 By species

Hotspots (i.e. concentrations of significantly above average survey catches from 2002-2012) for individual groundfish stocks are shown in Map 82 to Map 103. Hotspot distribution maps for age 0/1 or small juvenile fish are summarized below for the large mesh groundfish, small mesh groundfish, and other associated species that are common in the Gulf of Maine and on Georges Bank.

Cod

Cod are caught throughout the region, including the Gulf of Maine, Georges Bank, and Southern New England. Two stocks are recognized, Gulf of Maine and Georges Bank/Southern New England (Map 82). Using survey age-length keys, age 0 and 1 cod are less than 24 cm in the spring and 34 cm in the fall, rounded up to 25 and 35 cm respectively for the hotspot analysis. Hotspots of age 0/1 cod were identified mainly in the western Gulf of Maine in the spring and fall surveys (Map 82), mostly in Massachusetts Bay, inshore of Stellwagen Bank and in the southern portion of the Bigelow Bight, north of Cape Ann, MA. The summer surveys for shrimp and scallops did not cover areas where there were concentrations of abundant age 0/1 cod. The winter trawl and IBS cod surveys found concentrations of age 0/1 cod in Massachusetts Bay, partly overlapping the Stellwagen Bank area, but inshore of the Western Gulf of Maine year round groundfish closed area (Map 82). Close examination of the age 0/1 cod survey catch distributions and the identified hotspots indicate that small juvenile cod are more abundant in habitat areas west and south (i.e. inshore) of Stellwagen Bank in the spring, and offshore of it in the fall, but in either season mostly inshore of the Western Gulf of Maine year round groundfish closed area. During the summer scallop dredge survey, it is common to find clusters of high abundances of age 0/1 cod on the far eastern portion of Georges Bank, in Canadian waters.

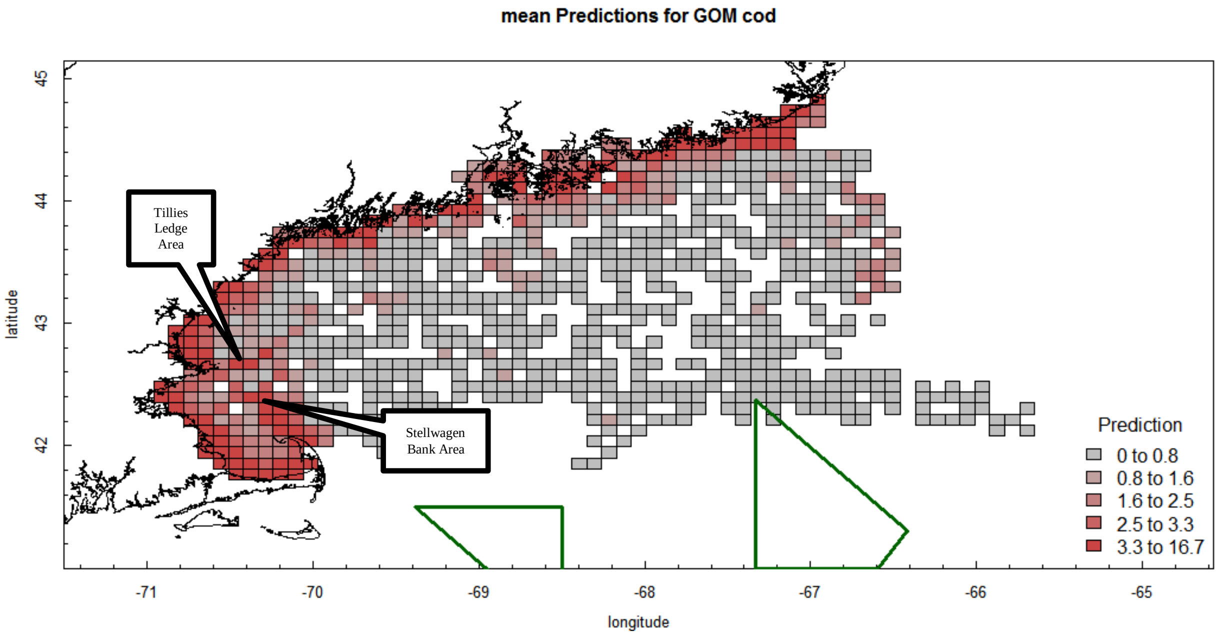
Map 82 – Seasonal distribution of age 0-1 cod hotspots from 2002-2012 survey abundance.



The above cod hotspots are consistent with a habitat suitability model developed for the Council by Mr. Truesdell, a PhD candidate at the University of Maine, Orono ("Modeling Juvenile Atlantic cod and yellowtail flounder abundance on Georges Bank and in the Gulf of Maine using 2-stage generalized additive models" by Samuel Truesdell, 2013, Appendix G???). A two-stage General Additive Model (GAMs) was developed using analytical methods previously used in a lobster habitat suitability model (Chang et al. 2010 ???). The cod model estimated the association of age 0/1 cod with various environmental factors that included seabed form, sediment type, depth, and temperature. Control variables included in the model included season, survey (accounting for differences in catchability between surveys), and zenith angle (accounting for diel variations in catchability).

According to the model results, the habitat and oceanic conditions most suitable to small juvenile cod, independent of stock size and fishing, were located along the shallower inshore portions of the Gulf of Maine, from Cape Cod to northern Maine (Map 83). The grids with the highest predicted cod abundance in the Western Gulf of Maine were well inshore of the Western Gulf of Maine year round groundfish closed area and the Western Gulf of Maine EFH closure. The model also predicts high age 0/1 cod abundance for areas north of Cape Cod, MAStellwagen Bank and off Cape Ann, MA on Tillies Ledge, both partly overlapping the Western Gulf of Maine EFH closure area. There also appear to be above average predicted abundance for some of the higher relief features in the central Gulf of Maine, such as Platts Bank, Cashes Ledge, and Jeffries Bank.

Map 83 – Mean predicted age 0/1 cod abundance in the Gulf of Maine.

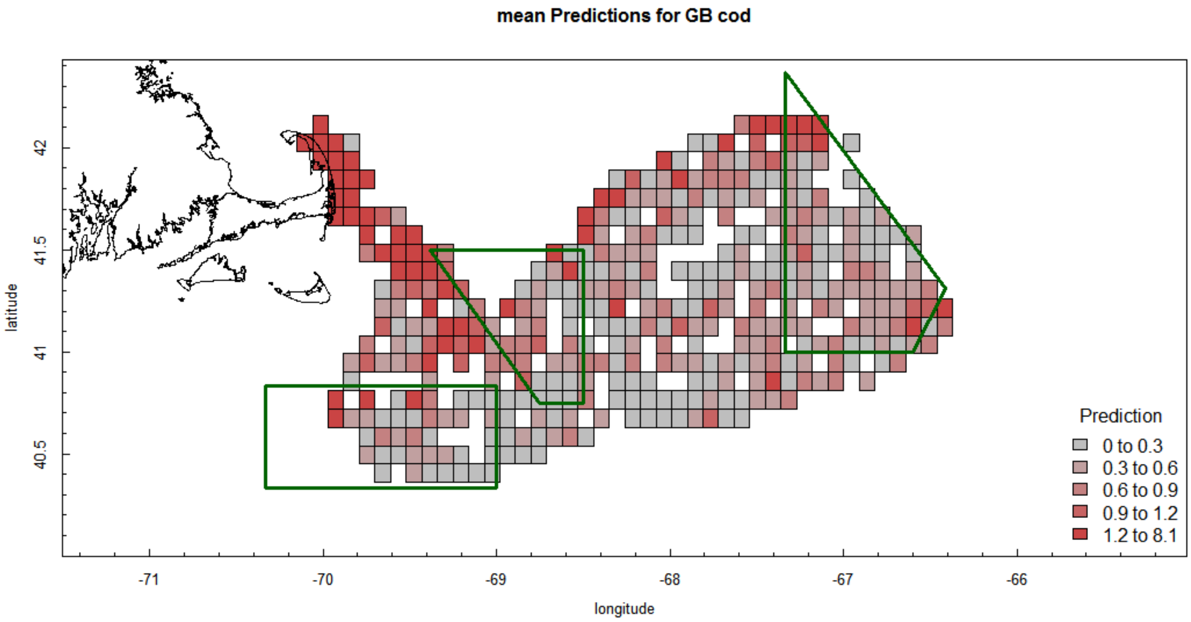


A GAMs model was also developed for Georges Bank cod, which estimated the association of age 0/1 cod with various habitat and oceanographic variables, including seabed form, dominant sediment, sediment coarseness, sheer stress (a measure of wave and current energy), temperature, and depth. Control variables included in the analysis were season, survey type, and zenith angle.

Based on habitat and oceanographic conditions, the GAMs analysis predicted high abundance along the Great South Channel from off Cape Cod, MA and past the western edge of Closed Area I, with notable predictions of high abundance in the center and northern portions of the Nantucket Lightship Area, which also overlaps the Nantucket Lightship Area EFH closure (Map 84). It is important to recognize that high juvenile cod abundance was predicted in these areas yet cod catches from the 2002-2012 surveys was not above average and no age 0/1 cod hotspots were detected in this area. Over a longer 1963-2008 period, this area was very important for cod and had high abundance of age 0/1 cod (Lough 2010???). The implication is that conditions are good for juvenile cod, but recent abundance is low and there were few hotspots identified in this area due to other factors including fishing.

High cod abundance was also predicted along the northern margin of Georges Bank through the Northern Edge in Closed Area II. Unlike the Perry and Smith (1994) results for the Scotian Shelf, the Georges Bank GAMs analysis indicated suitable habitat on the shallower areas of Georges Bank, including near an area called Little Georges Bank, east of Closed Area I. Age 0/1 cod were predicted to have high abundance in the shallower areas of the Bank during the spring and along the deeper margins of Georges Bank in the fall.

Map 84 – Mean predicted age 0/1 cod abundance for Georges Bank and the Great South Channel.



Yellowtail flounder

Catches of age 0/1 yellowtail flounder appear to be more broadly dispersed and not as concentrated as are cod. Fewer hotspots were detected in any season (Map 85). Yellowtail flounder hotspots in the spring were located mainly in the shallower portions of Massachusetts Bay, much of them from the MADMF survey in state waters. These hotspot results are not surprising, since yellowtail flounder are less concentrated and more strongly associated with sand and mud substrates. A few scattered hotspots of age 0/1 yellowtail flounder were found in the summer and fall survey catches, but no hotspots were detected in the winter survey (which was designed to sample flatfish).

Age 0/1 yellowtail flounder hotspots were less numerous than they were for cod. Since yellowtail flounder occupy more widely dispersed sandy habitats, this result is unsurprising. Another factor that might influence the outcome is stock size. Depending on how species respond to changes in stock abundance, density can remain constant across space or increase as a proportion of the total abundance. For total abundance, Periera et al. 2012 found that yellowtail flounder densities are consistent with the constant density and basin models. Their results were based on total catch per tow of all sizes. Based on the Periera et al. 2012 results, hotspots should be more prevalent at low stock size as they are now[3]. The hotspot analysis, however, focuses on age 0/1 flounder. Fish of this size range may respond differently to density dependent factors than large and adult fish, particularly if there is age truncation due to high fishing mortality.

In the spring, hotspots were identified in Ipswich, Massachusetts, and Cape Cod Bays in the Western Gulf of Maine. These hotspots are in the Cape Cod yellowtail flounder stock area. During the Summer and fall, sporadic hotspots were identified in the Great South Channel and on Georges Bank. Despite the type of survey gear that is designed to catch flatfish in the winter trawl survey, no yellowtail flounder hotspots were identified from the 2002-2007 data.

A GAMs model for Georges Bank yellowtail flounder estimated the association of age 0/1 yellowtail flounder with various habitat and oceanographic variables, including seabed form, dominant sediment, sediment coarseness, sheer stress (a measure of wave and current energy), temperature, and depth. Control variables included in the analysis were season, survey type, and zenith angle.

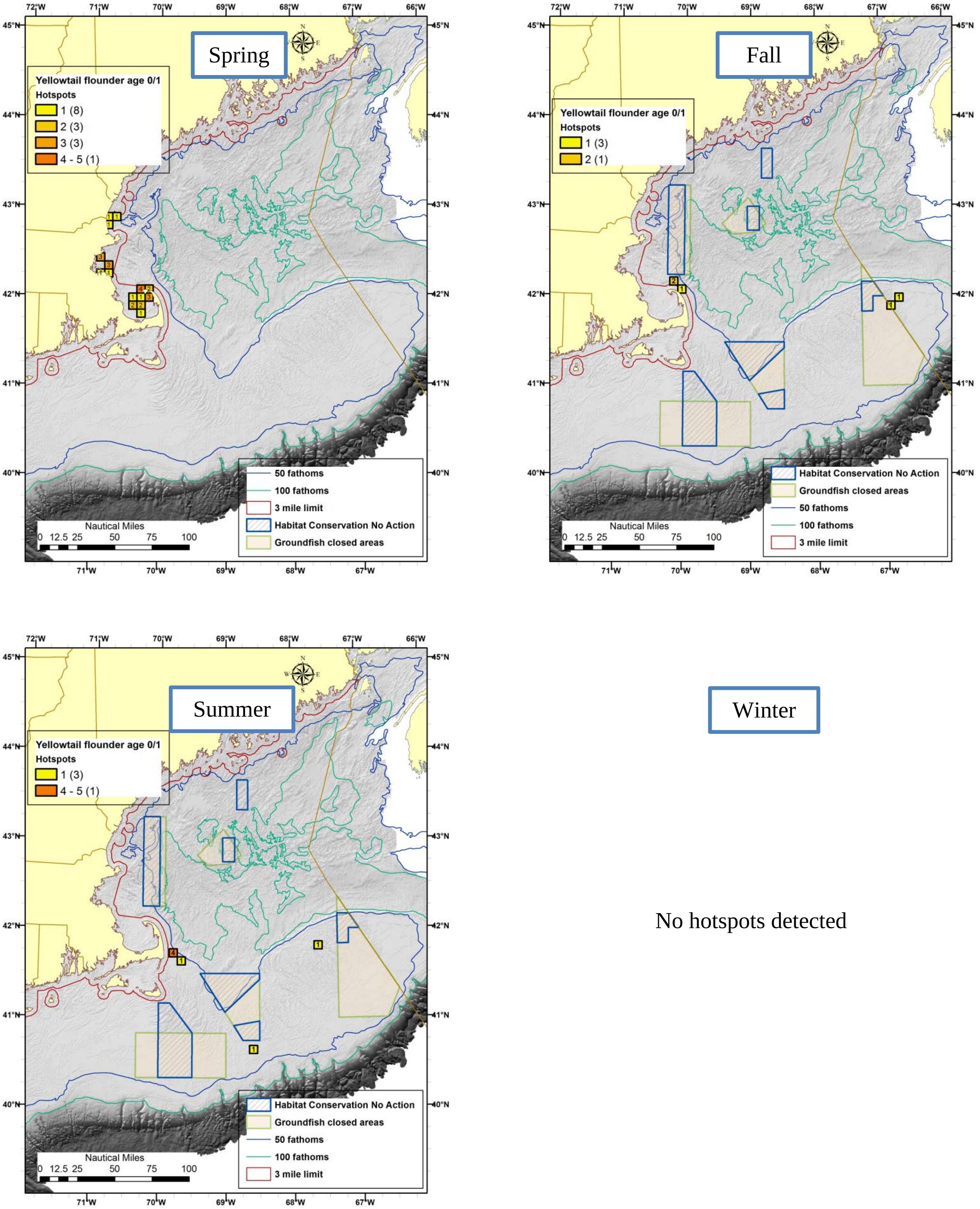
The predicted abundance is shown in Map 86. Clusters of high abundance based on the GAMs analysis are generally in the Nantucket Lightship Area and on Eastern Georges Bank, mostly visible in the spring but more random in the fall. Clusters of high abundance elsewhere are more scattered through the Great South Channel and western Georges Bank.

The higher predicted juvenile abundance in the Nantucket Lightship Area suggests that it may play an important role for a yellowtail flounder nursery area. The Nantucket Lightship Area may however play a less important role for adult yellowtail flounder since it was not found to contribute to yellowtail flounder biomass rebuilding (DeCelles et al. 2012; Kerr et al. 2012???).

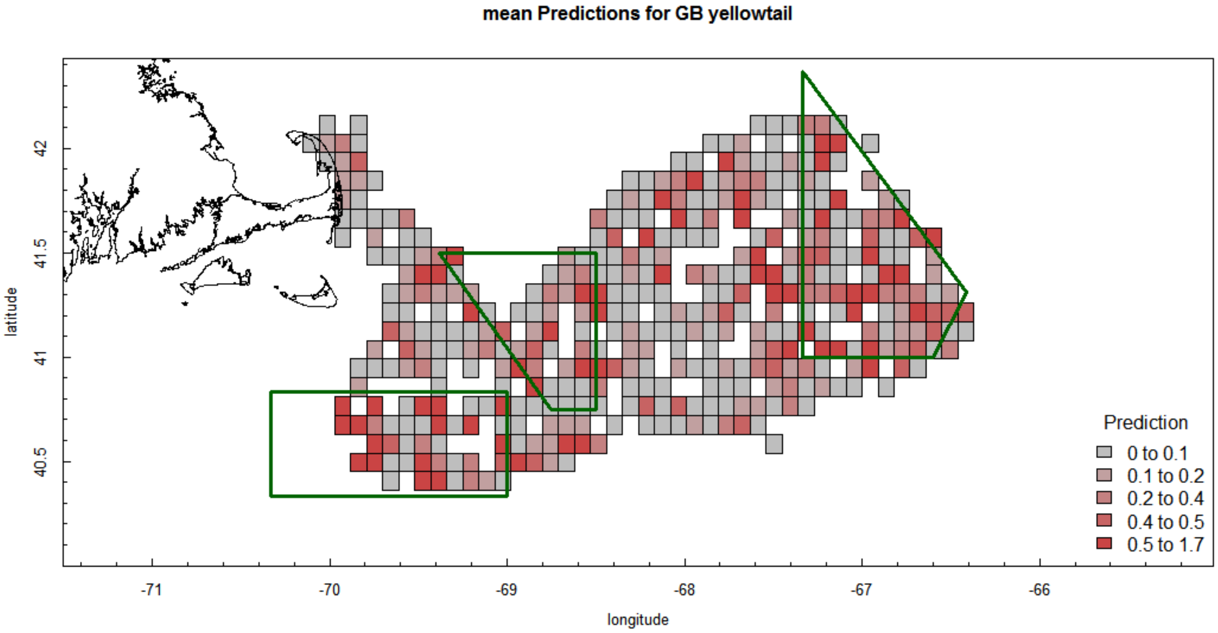
---

[3] The ratio of B_{MSY} to current biomass is 9.39 for Georges Bank yellowtail flounder and 4.21 for Cape Cod yellowtail flounder.

Map 85 – Seasonal distribution of age 0-1 yellowtail hotspots from 2002-2012 survey abundance.



Map 86 – Mean predicted age 0/1 yellowtail flounder abundance for Georges Bank and the Great South Channel.



Winter flounder

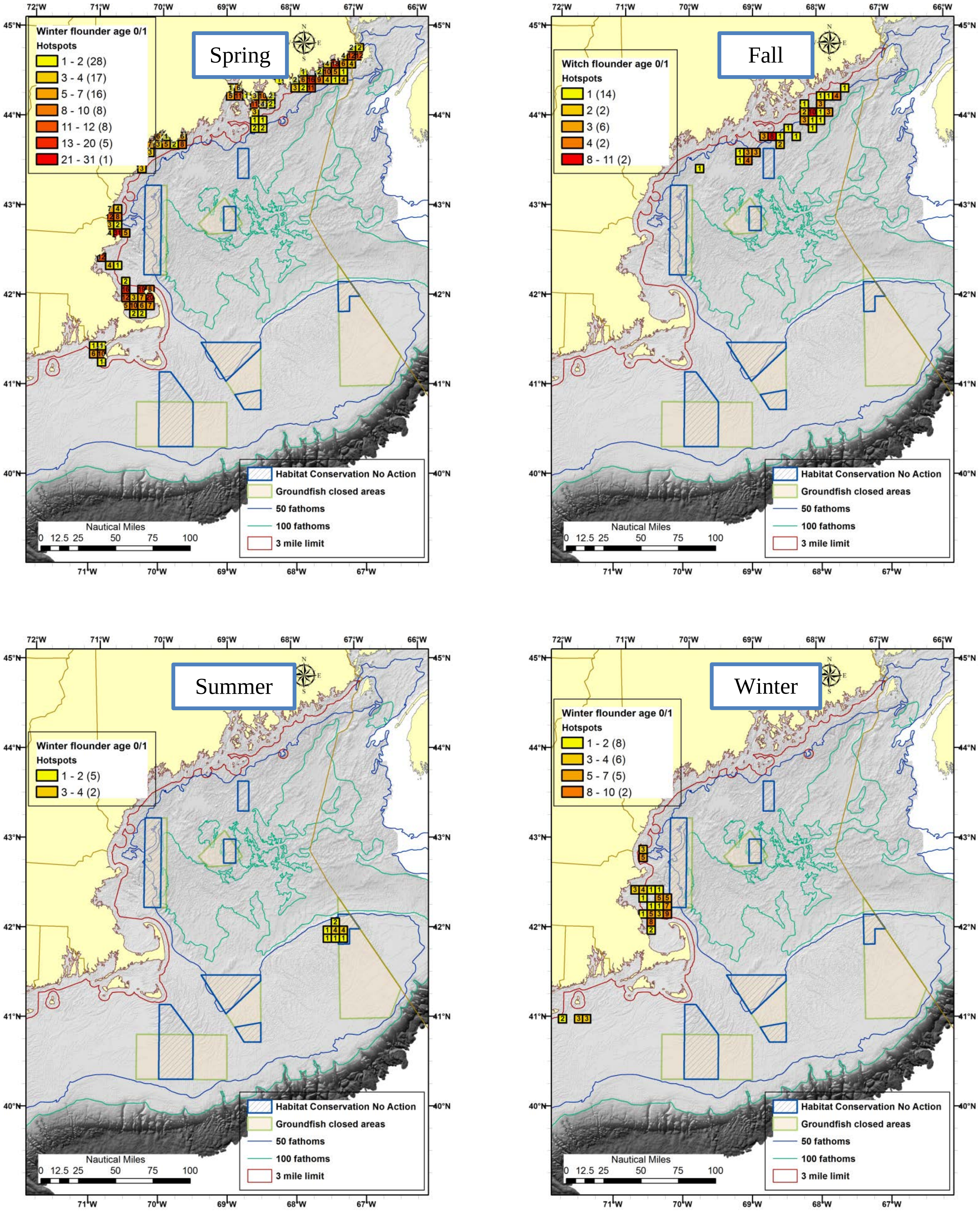
Age 0/1 hotspots for winter flounder were detected along the coastline from Southern New England to northern Maine in the spring. The hotspot analysis for age 0/1 winter flounder revealed several important areas with clusters of high winter flounder abundance in the spring, ranging from the shallow coastal areas in Rhode Island Sound, Cape Cod Bay, Massachusetts Bay, Ipswich Bay, Casco Bay, off Mt. Desert Island, ME, and in Northern ME, near Machias (Map 87). In the fall, hotspots were identified in a little deeper water off central and northern ME, but not in the Massachusetts Bay area. In winter, clusters of hotspots of age 0/1 winter flounder appear in Massachusetts Bay and overlap Stellwagen Bank, but are inshore of the Western Gulf of Maine closed area. A few hotspots are located inshore in Ipswich Bay as well. No hotspots were identified in the summer shrimp survey data, but occur in the summer scallop dredge survey on the Northern Edge of Georges Bank, west of the Cod HAPC.

Although DeCelles and Cadrin (2010) focused on the distribution and movement of adult winter flounder in coastal and estuarine waters of the southern Gulf of Maine, these hotspots results are adjacent to the identified spawning locations and may show areas that serve as important nursery areas.

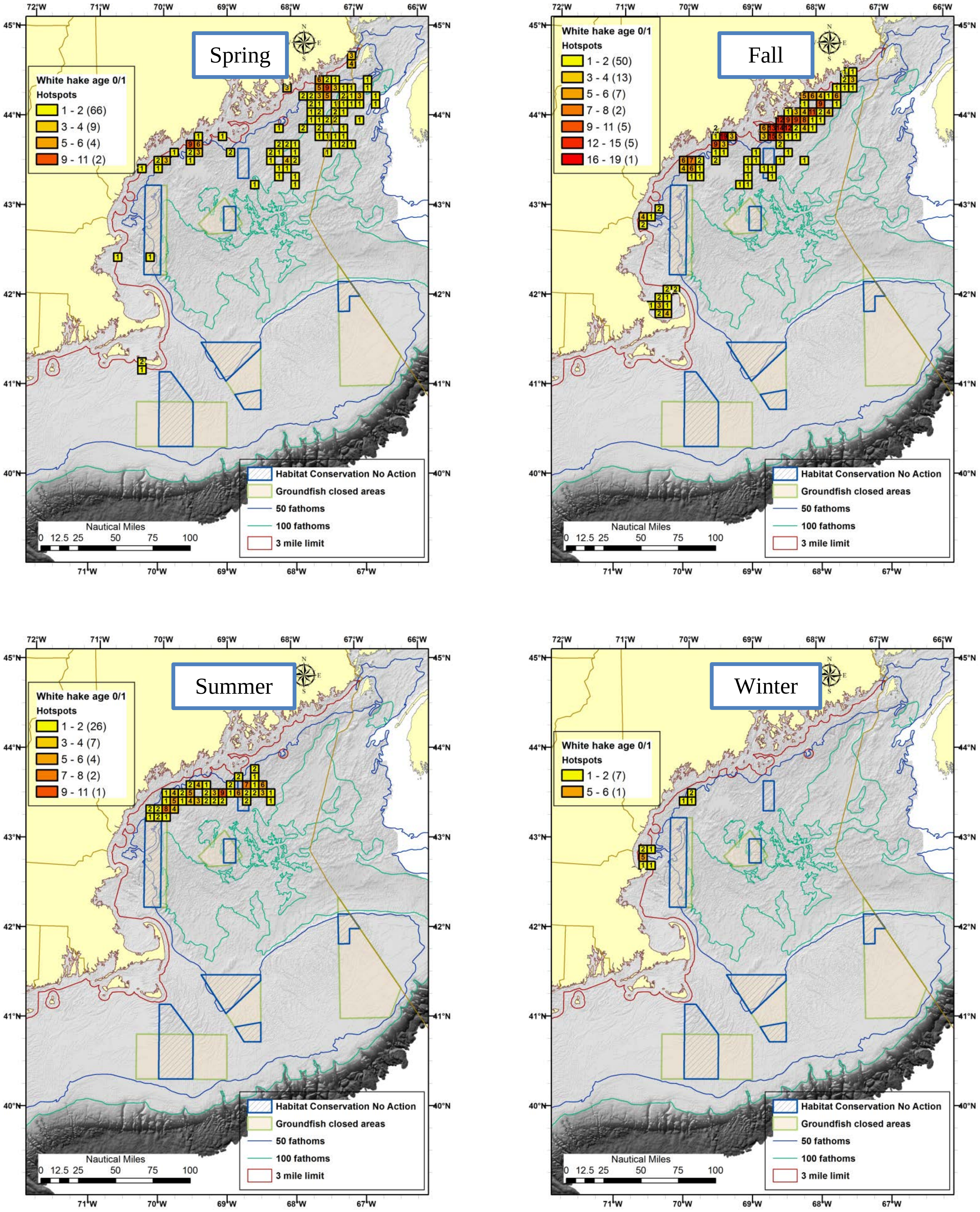
White hake

Less is known about the distribution of juvenile white hake in relation to oceanographic features in the Gulf of Maine than information on cod, haddock, and winter flounder. The hotspot analysis of the distribution of age 0/1 white hake identified hotspots, or clusters of significantly above average catch, scattered mostly in the northern Gulf of Maine in the spring, from moderate depths along the coast to deeper depths in the eastern Gulf of Maine (Map 88). In the summer shrimp trawl survey, age 0/1 white hake hotspots were distributed broadly in moderate depths off central and southern ME, and on both sides of the Jeffries Bank EFH closed area. Hotspots further east might be found in the summery, but it is outside the sampling range of this survey. Hotspots for age 0/1 white hake were also found in the IBS cod survey data, clustered in Ipswich Bay and off Casco Bay. This survey has a restricted sampling region, however, and age 0/1 winter flounder hotspots may occur elsewhere in the inshore portions of the Gulf of Maine.

Map 87 – Seasonal distribution of age 0-1 winter flounder hotspots from 2002-2012 survey abundance.



Map 88 – Seasonal distribution of age 0-1 white hake hotspots from 2002-2012 survey abundance.



Haddock

Hotspots for age 0/1 haddock catches in spring surveys were scattered broadly across southern Georges Bank, both inside and outside of Closed Area II (Map 89). No hotspots were detected on the Northern Edge during the spring surveys. Clusters of hotspots were however identified in the Western Gulf of Maine, immediately north of Cape Cod, in the deeper waters of Ipswich Bay, and offshore of Cape Elizabeth, ME. Another cluster of hotspots occurred in Northern ME, near Machias. A few hotspots appeared near Cashes Ledge.

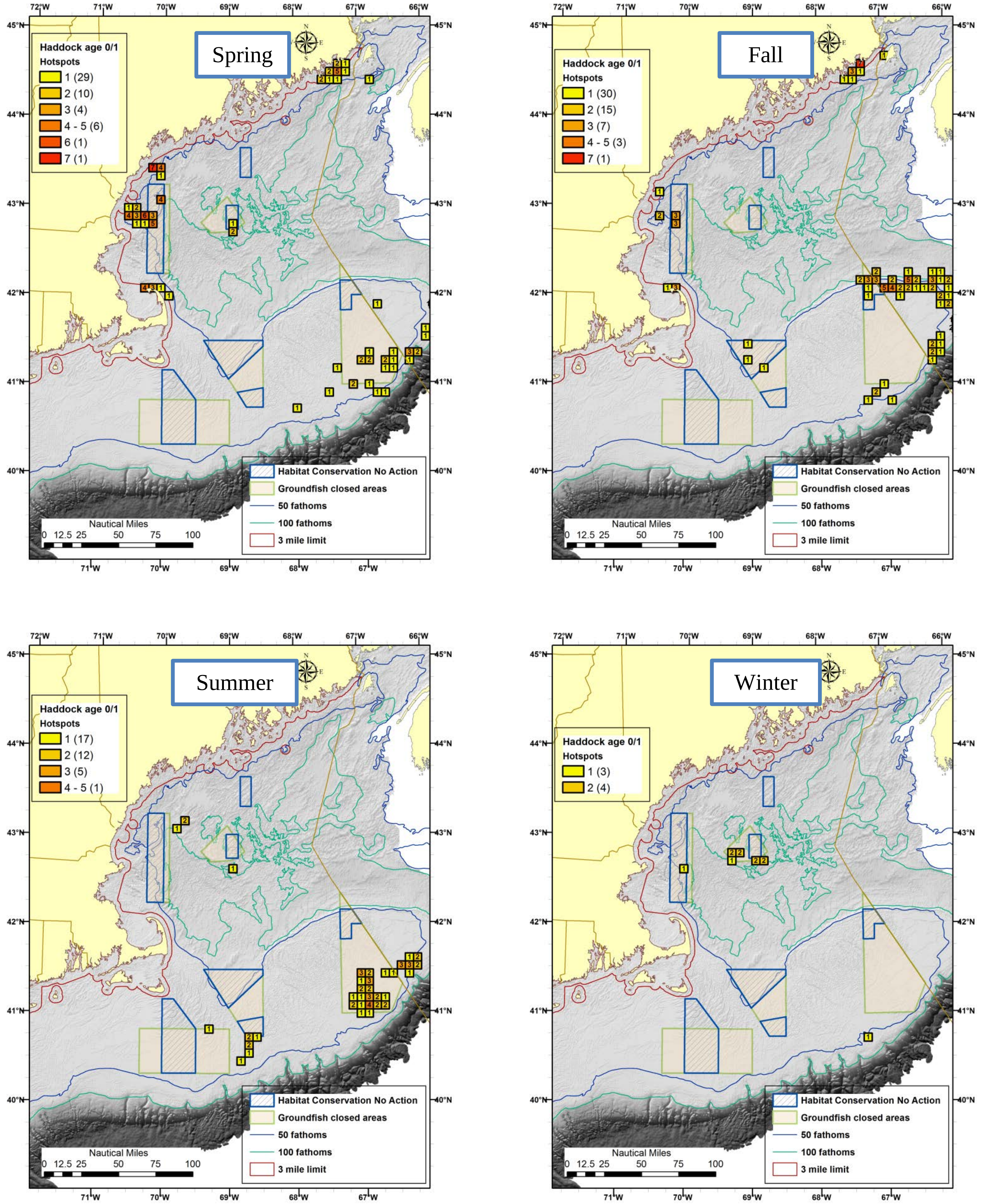
During the summer, age 0/1 haddock a strong cluster of hotspots was identified in the southern part of Georges Bank, mostly within the southern part of Closed Area II, spilling over into Canada. This area was shown to have dense concentrations of amphipod tubes (Vitaliano et al. 2013???) and may be an important nursery and feeding area for juvenile haddock. A few hotspots of age 0/1 haddock were also identified in the southern portion of the Great South Channel, south of and partly overlapping the southern part of Closed Area I.

In the fall surveys, the hotspot analysis detected a strong presence of age 0/1 haddock along the Georges Bank Northern Edge from the Cod HAPC east into Canada. This distribution of hotspots extended into the deeper edges in the Southeast Part of Georges Bank. Fewer hotspots were detected in the Gulf of Maine than in the spring surveys, but were in the same general areas, including the inshore areas around Machias, ME. Six hotspots were also detected on the southern part of Jeffreys Ledge, inside of the Western Gulf of Maine closed area.

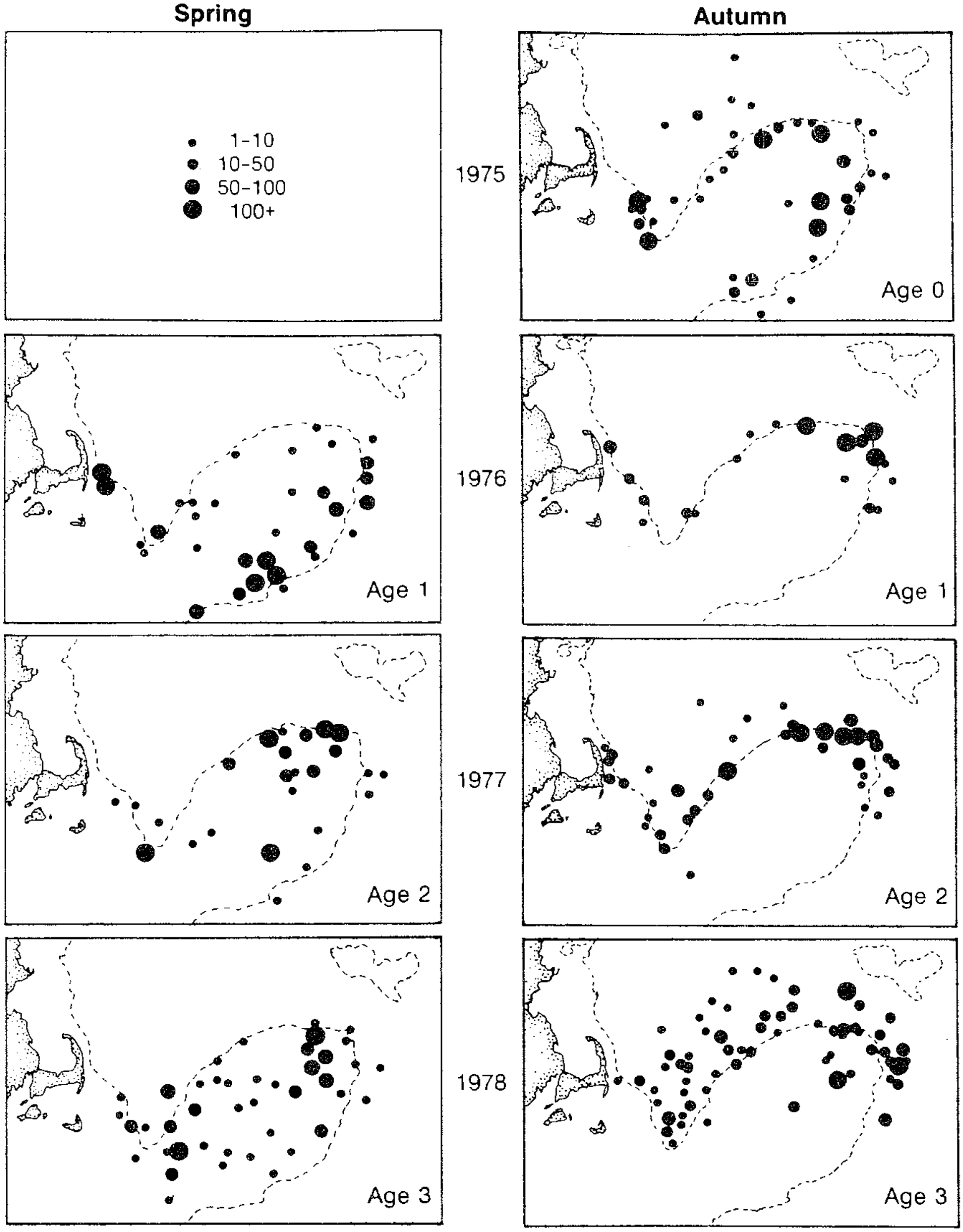
Age 0/1 haddock hotspots were also detected in the central Gulf of Maine, around Cashes and Fippennies Ledges. These results are from the IBS cod survey and hotspots may therefore also occur near the offshore banks and ledges in the central Gulf of Maine, if surveys occurred there during the winter.

Although it was anticipated that there would be more juvenile haddock hotspots on the Georges Bank Northern Edge, these hotspot results are very consistent with a previous analysis of the spring and autumn trawl survey data by Overholtz (1985???). The Overholtz (1985) analysis examined the geographic distribution of the abundant 1975 and 1978 year classes by age. Age 0 haddock in autumn and age 1 haddock in spring were broadly dispersed across the shallower areas of Georges Bank (Map 90). As the haddock aged beginning with age 1 in the fall survey, they became concentrated in the deeper margins of the bank, first in the Canadian and eastern portion of Georges Bank and then further west on the Northern Edge into the Cod HAPC and Closed Area II, until age 3 in the spring. A hotspot analysis of age 2 and 3 haddock probably would have identified more hotspots on the Northern Edge in US waters.

Map 89 – Seasonal distribution of age 0-1 haddock hotspots from 2002-2012 survey abundance.



Map 90 – Georges Bank distribution of the 1975 haddock year class by age in spring and autumn trawl surveys (Overholtz 1985).



Witch flounder

Age 0/1 witch flounder hotspots were detected in the Gulf of Maine along and slightly deeper than the 100 fathom isobaths, generally from offshore of Casco Bay, ME to the Machias area, from spring to fall (Map 91). A few hotspots were detected on the southern portion of Jeffreys Ledge, inshore of the Western Gulf of Maine closed area. Only one hotspot was detected in the winter surveys, primarily due to their limited sampling range.

American plaice

Large areas of age 0/1 American plaice hotspots were detected in the Western Gulf of Maine, shallower than 100 fathoms from off Scituate, MA to off Mt. Desert Island, ME (Map 92). The area with age 0/1 plaice hotspots was nearly the same in the spring and fall surveys. The summer shrimp survey had plaice hotspots in the same area in the Western Gulf of Maine, but also had plaice hotspots near Platts Bank and Cashes Ledge. No plaice hotspots were detected in winter survey catches.

Pollock

Very few age 0/1 pollock hotspots were detected, mainly scattered north and west of the Western Gulf of Maine closed area in the spring (Map 93). The lack of hotspots is probably due to the wide variation of catches on survey tows.

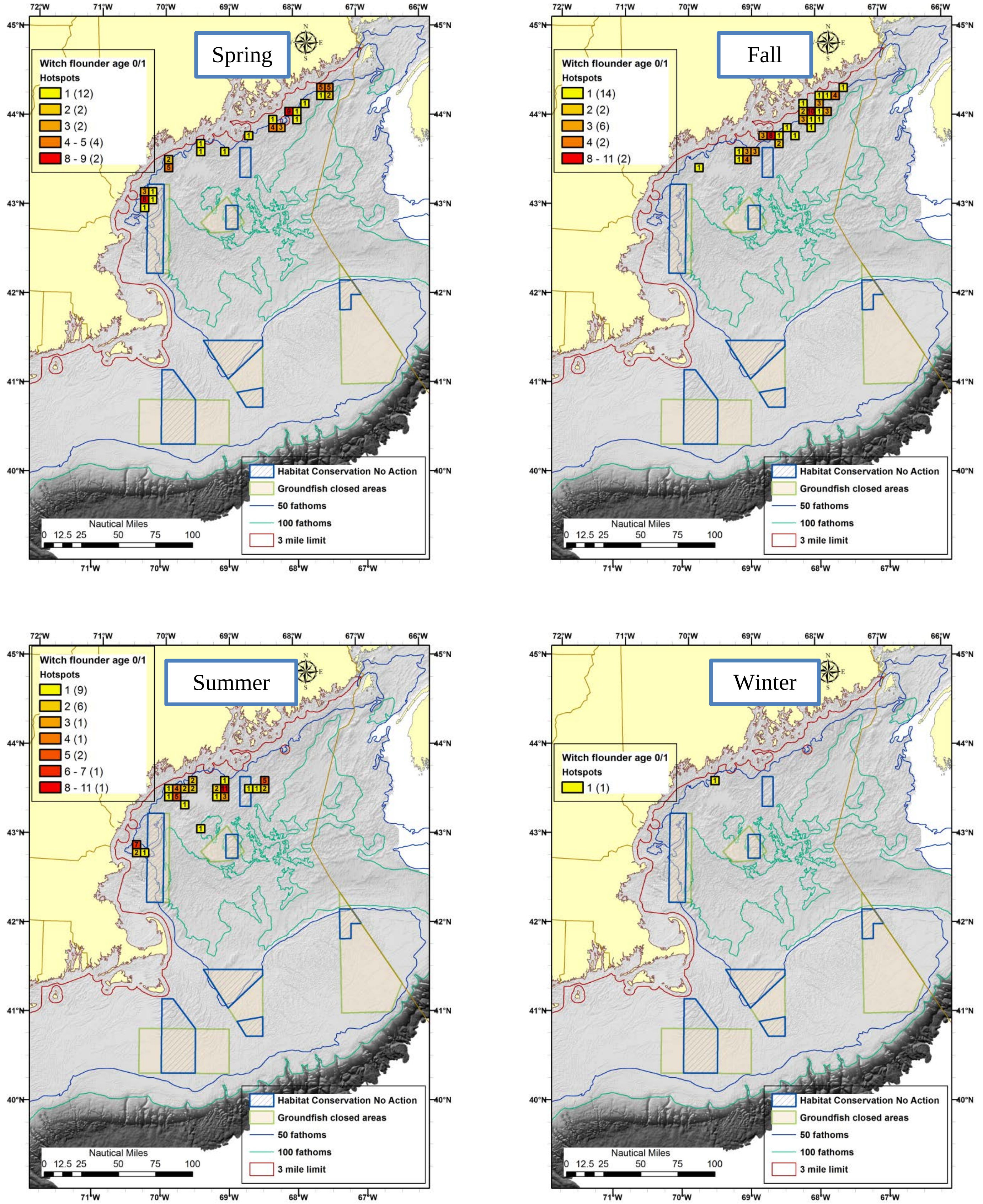
Acadian redfish

Age 0/1 redfish hotspots were prevalent in the spring and summer surveys in depths generally greater than 100 fathoms from the center of the Western Gulf of Maine closed area to Jeffreys Bank (Map 94). The distribution of the hotspots from the summer survey catches overlapped Platts Bank and extended toward but did not reach Cashes Ledge. The fall hotspot distribution was nearly the same as it was in the spring, but extended to the north and east into the Jordan Basin and included areas around Fippennies and Cashes Ledges.

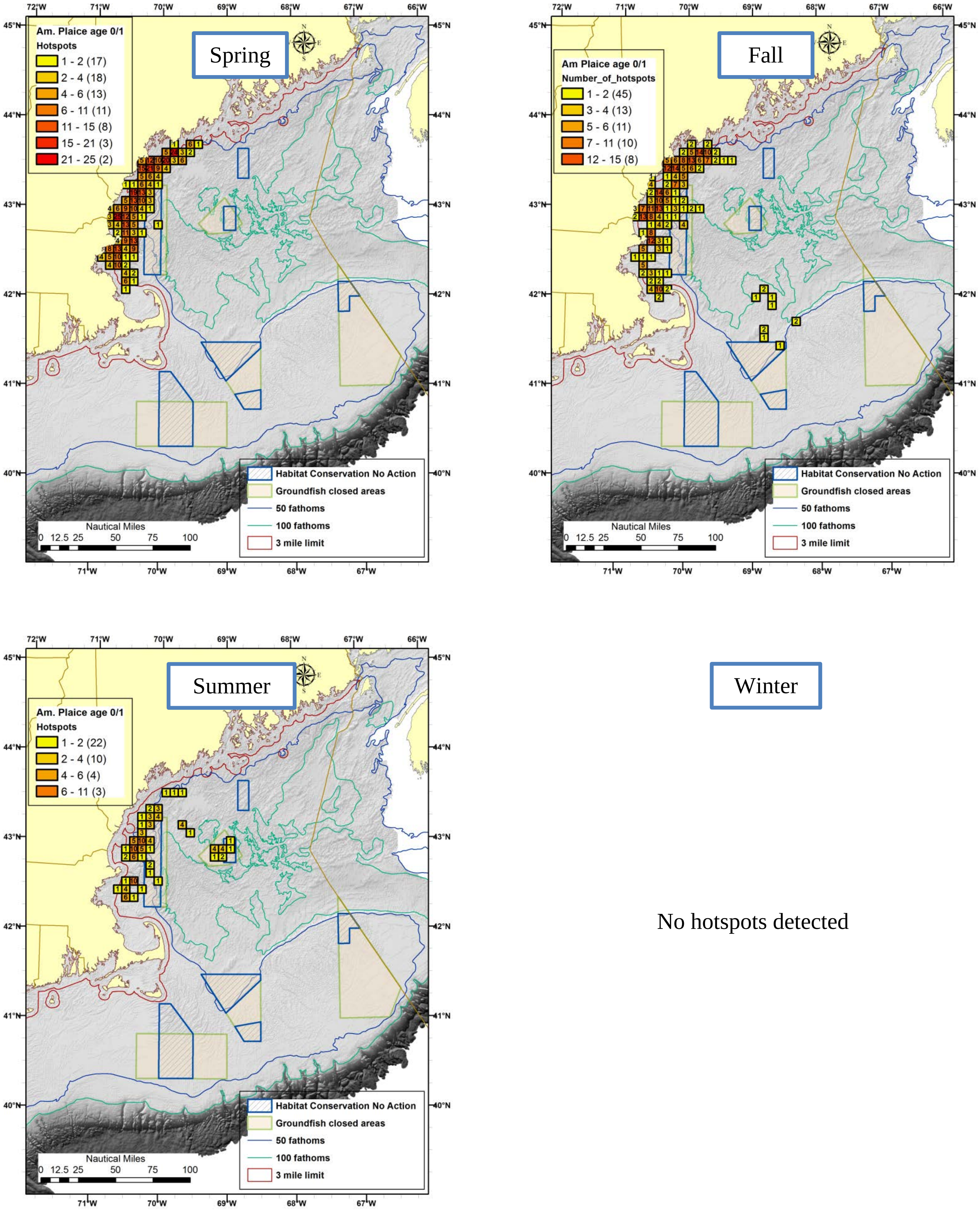
Atlantic halibut

Although occasional catches occur elsewhere, age 0/1 halibut hotspots were detected only in a cluster in the Machias, ME area during the spring (Map 95). These catches were made by the ME/NH trawl survey.

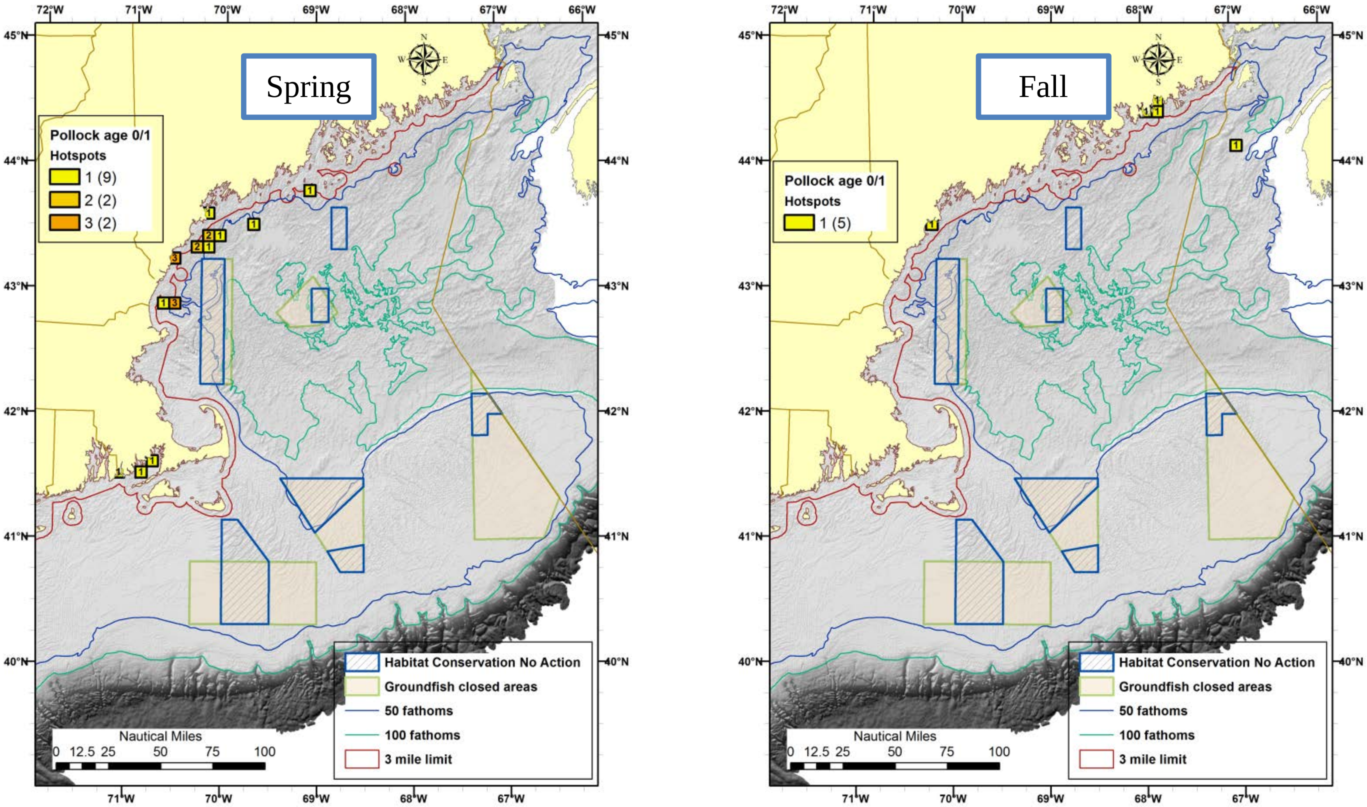
Map 91 – Seasonal distribution of age 0-1 witch flounder hotspots from 2002-2012 survey abundance.



Map 92 – Seasonal distribution of age 0-1 American plaice hotspots from 2002-2012 survey abundance.



Map 93 – Seasonal distribution of age 0-1 pollock hotspots from 2002-2012 survey abundance.



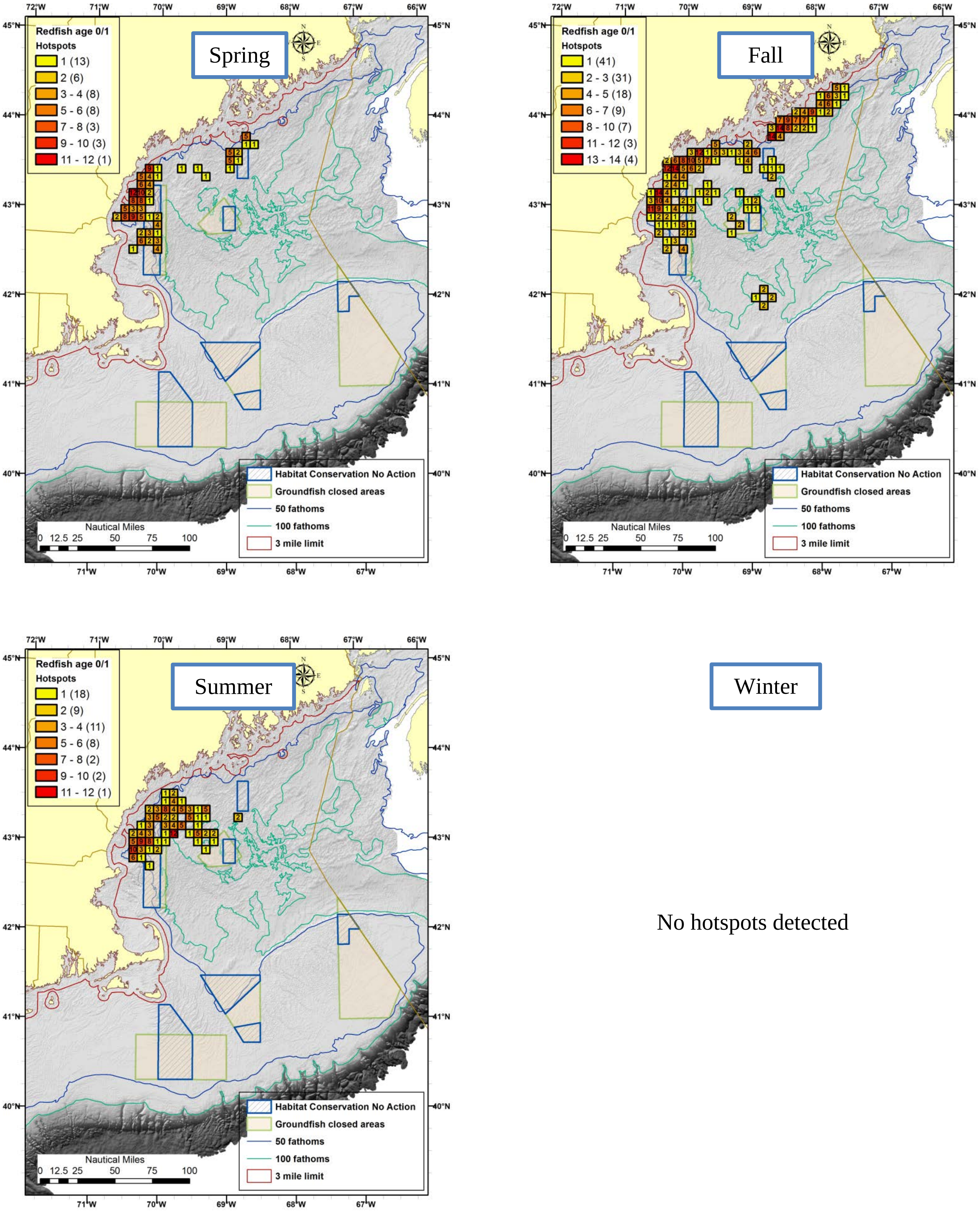
Summer

No hotspots detected

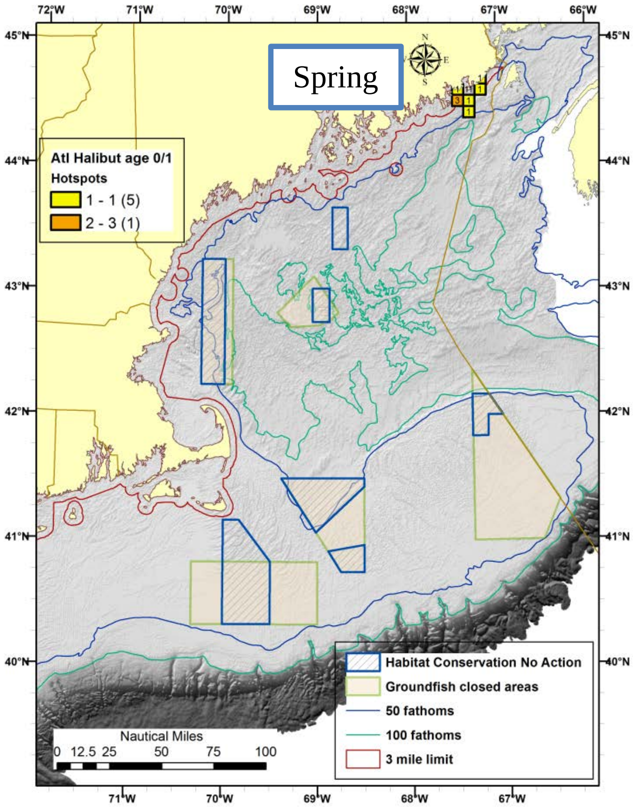
Winter

No hotspots detected

Map 94 – Seasonal distribution of age 0-1 redfish hotspots from 2002-2012 survey abundance.



Map 95 – Seasonal distribution of age 0-1 Atlantic halibut hotspots from 2002-2012 survey abundance.



Spring

Fall

No hotspots detected

Summer

Winter

No hotspots detected

No hotspots detected

Ocean pout

Age 0/1 ocean pout hotspots were detected in the Bigelow Bight, off NH and southern ME from spring and fall trawl survey catches (Map 96). These hotspots were generally shallower than 100 fathoms, north and west of the Western Gulf of Maine closed area. One winter hotspot was detected in Southern New England waters.

Windowpane flounder

Age 0/1 windowpane flounder hotspots were identified mainly around Penobscot Bay and coastal areas just to the east (Map 97). A few scattered windowpane flounder hotspots were identified during the spring, fall, and winter surveys across Georges Bank and Southern New England, NW of the Nantucket Lightship Closed Area.

Atlantic wolffish

No age 0/1 wolffish hotspots were detected. This may be related to the fish's behavior of husbandry of young around hard bottom. Some of the more rugged hard bottom areas are avoided during trawl surveys to avoid gear damage, so they probably do not sample young Atlantic wolfish very well.

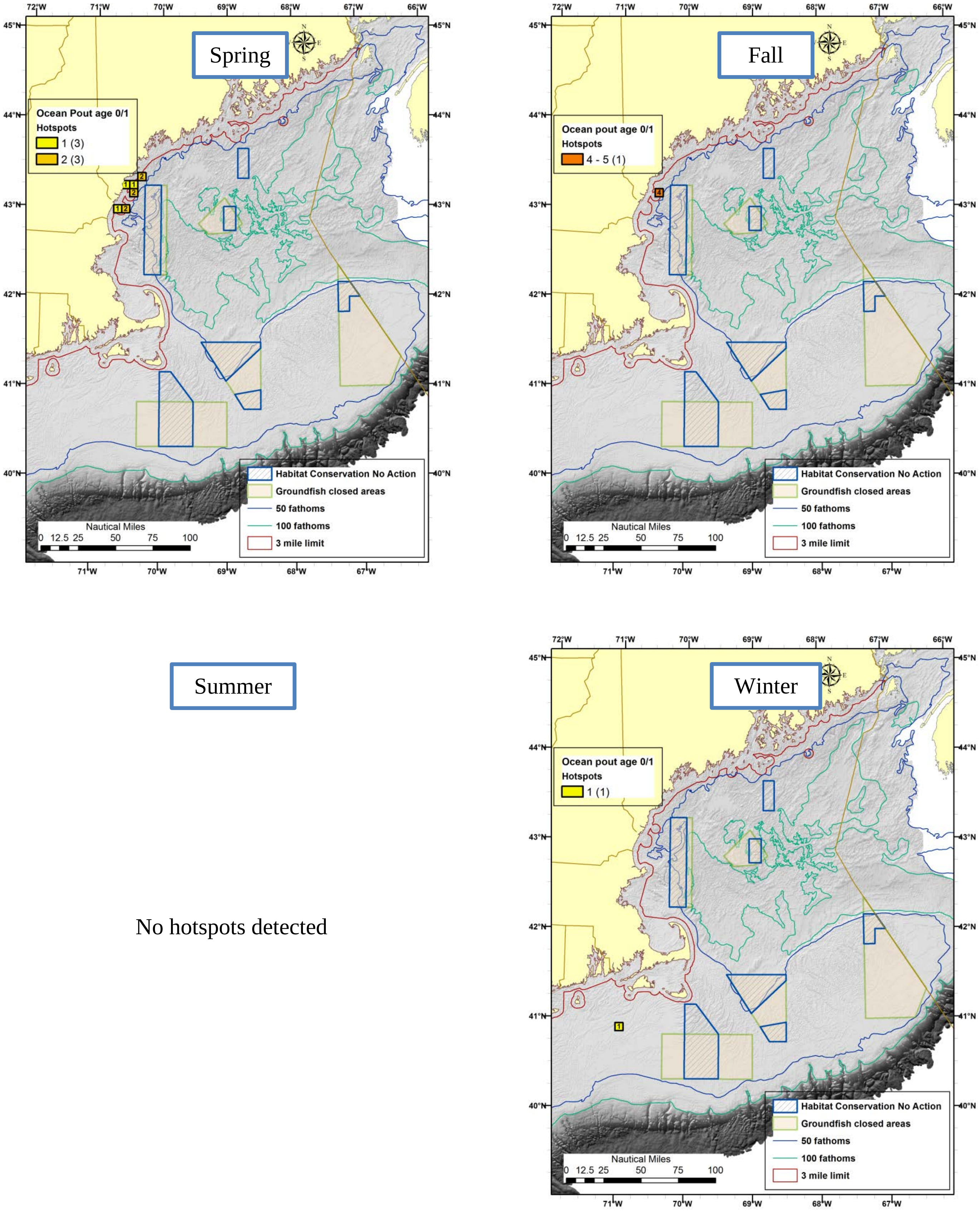
Monkfish

A few scattered hotspots of age 0/1 monkfish were detected in the spring and winter in the Western Gulf of Maine and in Southern New England (Map 98). In the summer shrimp trawl and scallop dredge surveys, denser clusters of age 0/1 monkfish hotspots were detected in the off southern ME and NE of the Western Gulf of Maine closed area, as well as immediately off the tip of Cape Cod and in the south central part of the Nantucket Lightship Area. During the fall surveys, monkfish hotspots were detected in the same area off southern ME as in the spring, but also near the Cashes Ledge area and in waters deeper than 100 fathoms off the tip of Cape Cod.

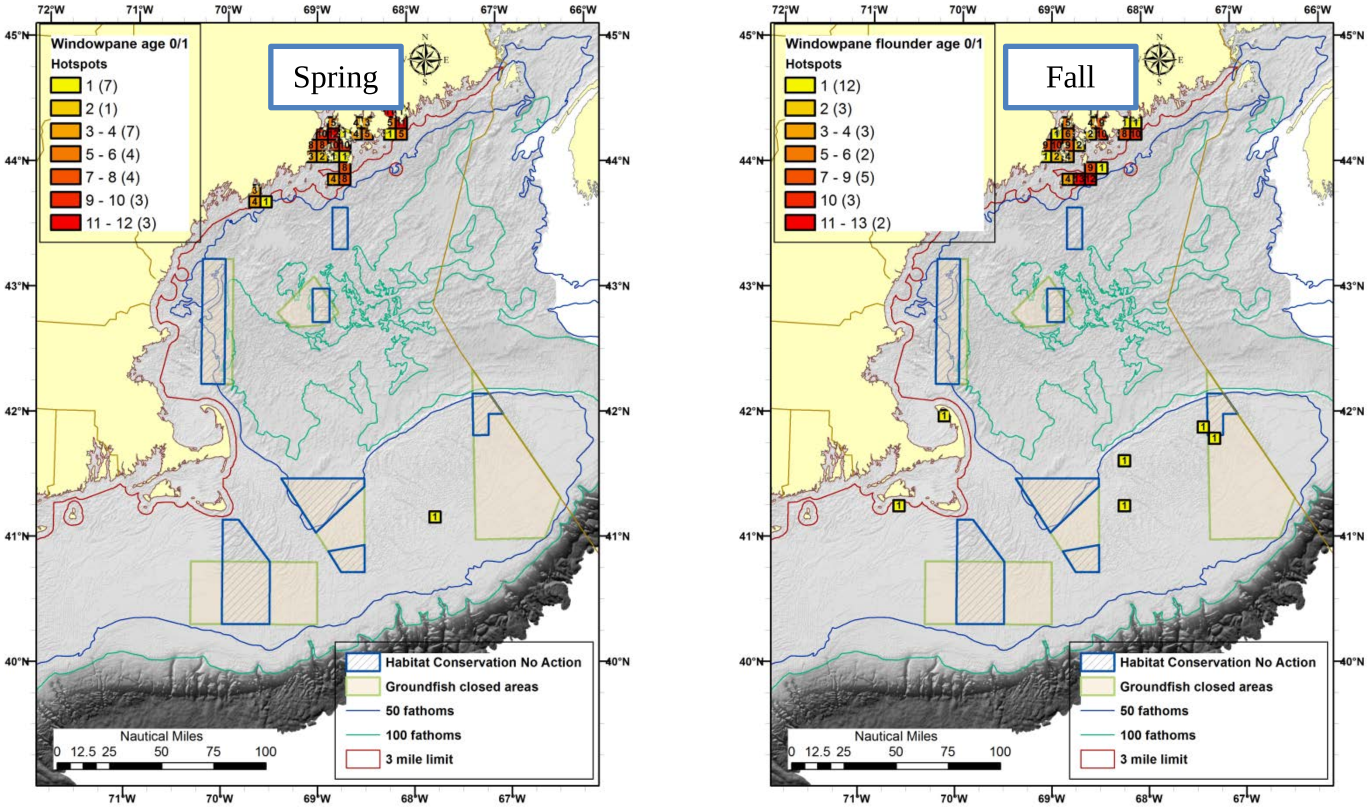
Barndoor skate

Although the trawl surveys that sample Georges Bank and Southern New England catch small barndoor skate, no hotspots were detected despite higher levels of total abundance in the last decade compared to previously collected data. The summer dredge survey, however, had clusters of tows with significantly above average catches in a narrow swath ranging from southwestern Georges Bank to Southern New England, into the Nantucket Lightship Area (Map 99). Although some of these hotspot areas are open to fishing, a considerable number of them occur in the Nantucket Lightship Area which may provide considerable conservation benefit. Some of the hotspots in the Nantucket Lightship Area are in the scallop access area, specifically the portion that is most intensively fished.

Map 96 – Seasonal distribution of age 0-1 ocean pout hotspots from 2002-2012 survey abundance.

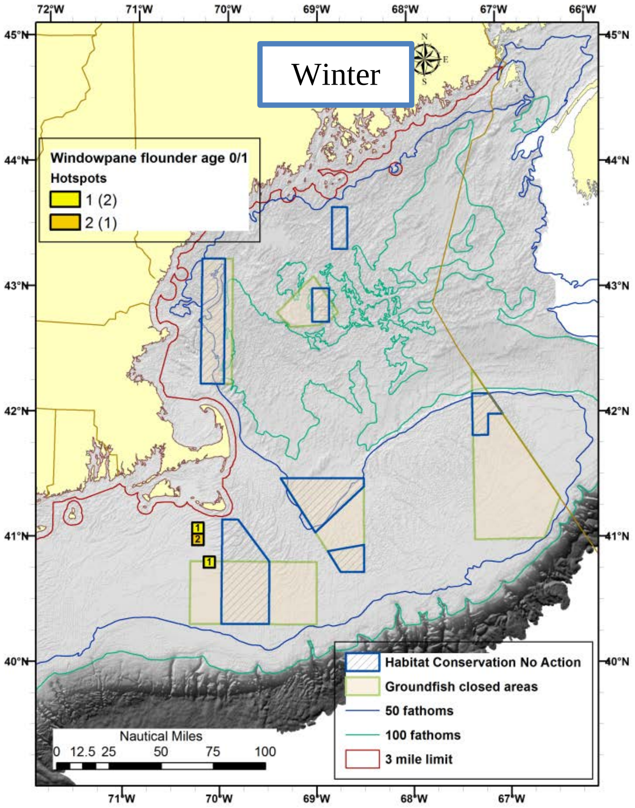


Map 97 – Seasonal distribution of age 0-1 windowpane flounder hotspots from 2002-2012 survey abundance.

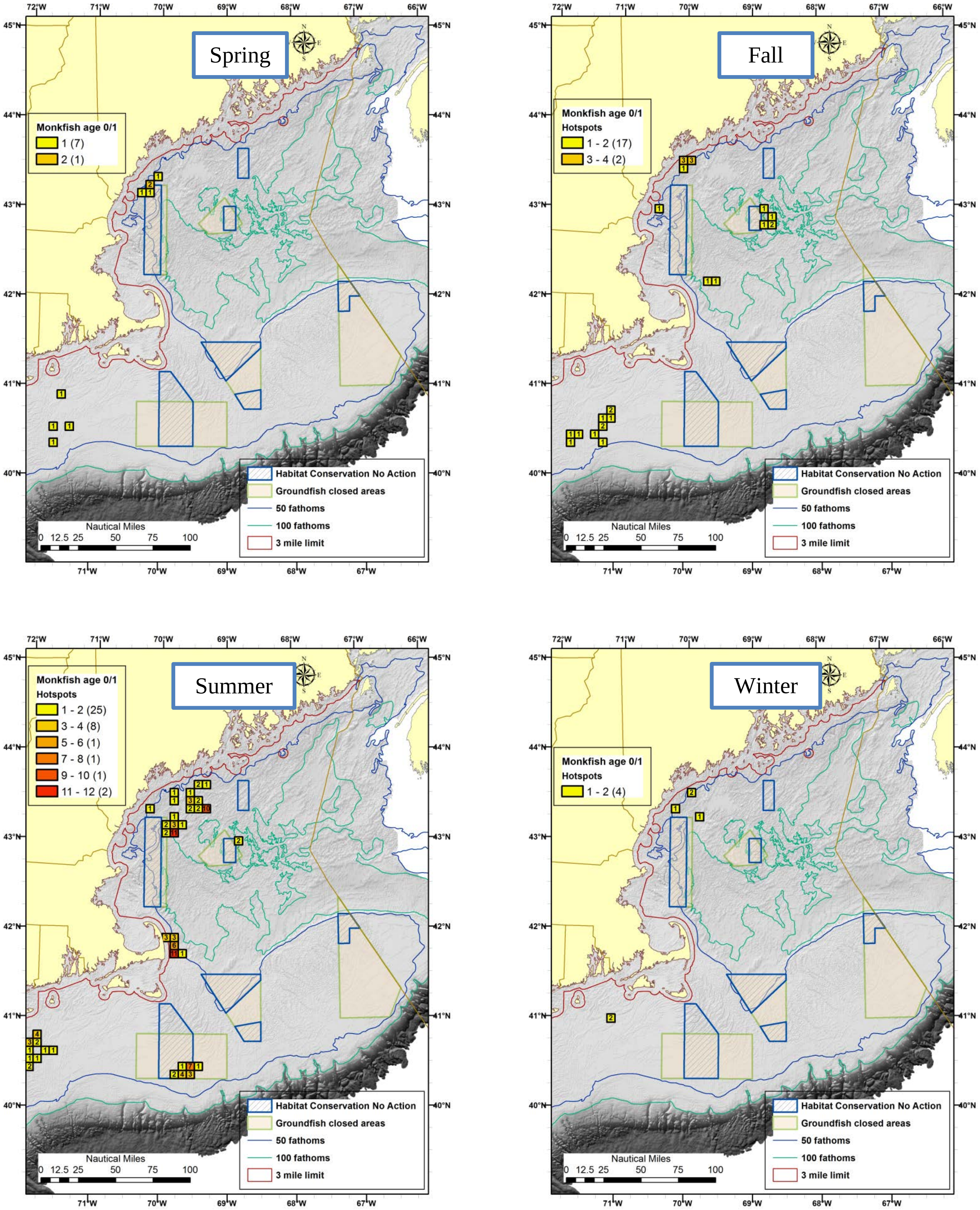


Summer

No hotspots detected



Map 98 – Seasonal distribution of age 0-1 monkfish hotspots from 2002-2012 survey abundance.



Map 99 – Seasonal distribution of age 0-1 barndoor skate hotspots from 2002-2012 survey abundance.

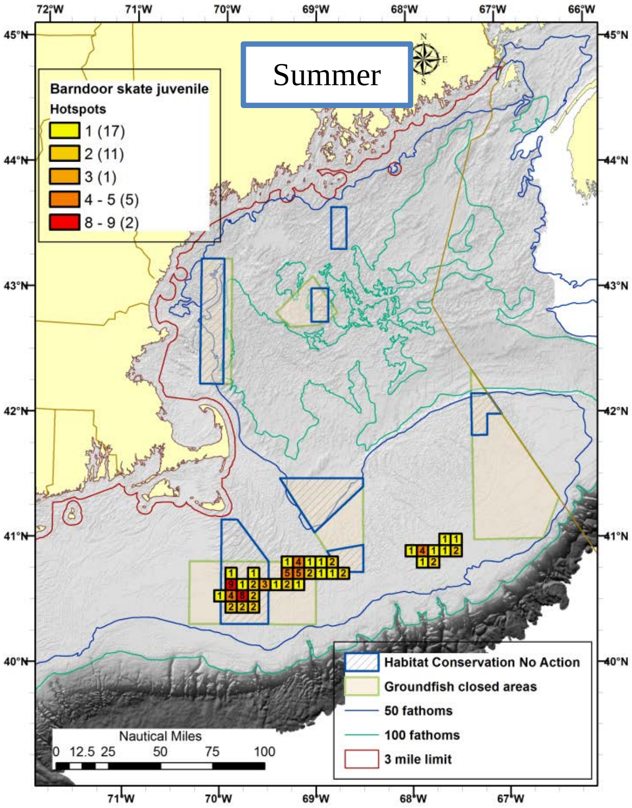
Spring

Fall

No hotspots detected

No hotspots detected

Summer



Winter

No hotspots detected

Silver hake

Age 0/1 silver hake hotspots are common and widely dispersed in a swath of moderate depths off Cape Cod Bay, MA nearly to the Machias, ME area, generally between 50 and 100 fathoms (Map 100). A similar distribution of hotspots occurs in the summer surveys, but these are limited by the extent of the shrimp trawl survey. During the fall and winter trawl surveys, a patch of silver hake hotspots was detected around the Mud Hole in Southern New England.

Juvenile (and adult) silver hake are an important prey species for piscivorous fish like cod. While silver hake are not known to be strongly associated with hard substrates, their presence near these areas may serve as an important food source for large juvenile and adult fish.

Red hake

Like silver hake, age 0/1 red hake hotspots appear to be broadly distributed, but strongly identified in various areas within the Gulf of Maine, Georges Bank, and Southern New England (Map 101). During the spring, red hake hotspots were identified in Cape Cod Bay, Ipswich Bay, off southern ME, in the Machias region and south and east of Cashes Ledge, as well as in deeper water offshore of the Western Gulf of Maine closed area. A few hotspots were found in deep water north of Georges Bank and in the center of the Nantucket Lightship Area, as well as off Buzzard’s Bay.

Fall hotspots were similar, but aggregated in six broad areas. Areas of strong aggregations of hotspots were in Cape Cod Bay to off Scituate, MA; and of NH and southern ME. Other broad areas of age 0/1 red hake hotspots included an area around Jeffreys Bank and Toothaker Ridge off central ME, across the northern part of Georges Bank, the SE part of Georges Bank, and the Mud Hole area in Southern New England. Age 0/1 red hake hotspots were sporadic and dispersed in the summer and winter surveys.

Like silver hake, juvenile red hake may be an important food source for piscivorous groundfish. Red hake are also not known to be associated with hard substrates, preferring sandy, silty, or muddy bottom.

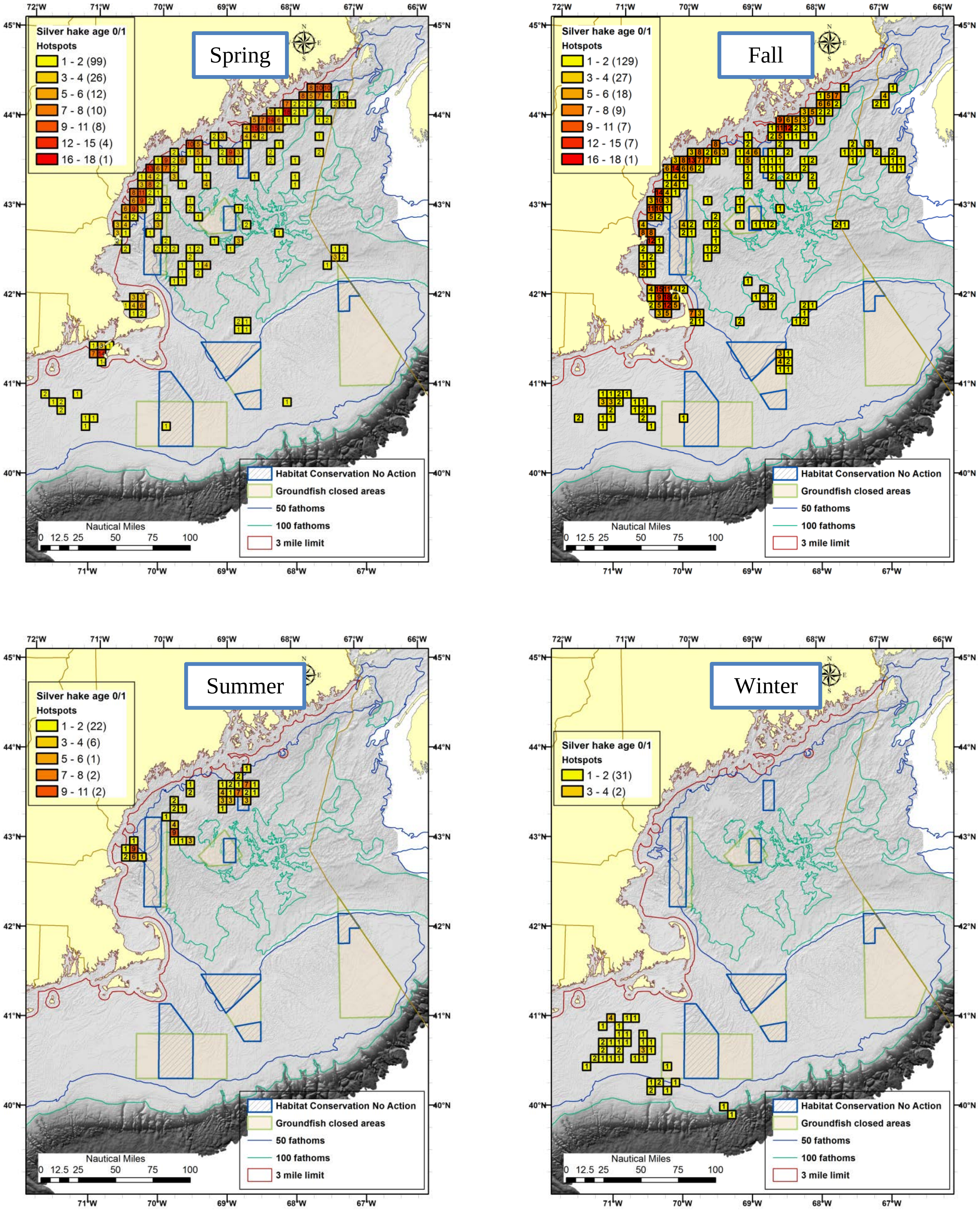
Alewife

Juvenile alewife hotspots were detected in the spring and fall ME/NH survey data along the central to eastern ME coastline (Map 102), generally in depths less than 100 fathoms and often less than 50 fathoms. Strong aggregations of fall hotspots occur further inshore than they do in the spring, particularly notable in Penobscot Bay and around Mt. Desert Island, ME. No hotspots were detected in the summer and winter survey catch data.

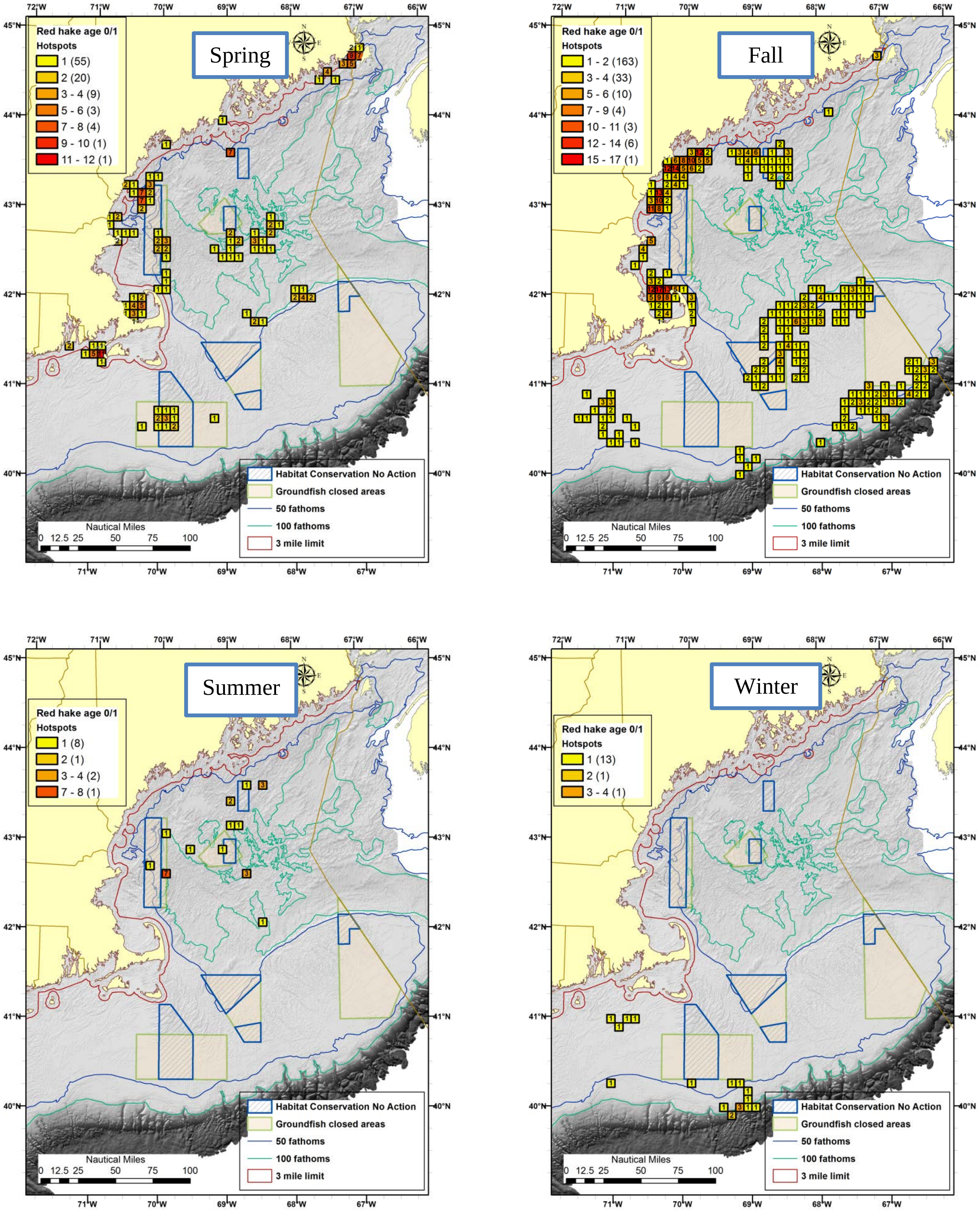
Atlantic herring

Sporadic and dispersed juvenile herring hotspots were detected along the ME coastline in the spring survey catch data (Map 103). No hotspots were detected in the summer, fall, and winter survey catch data.

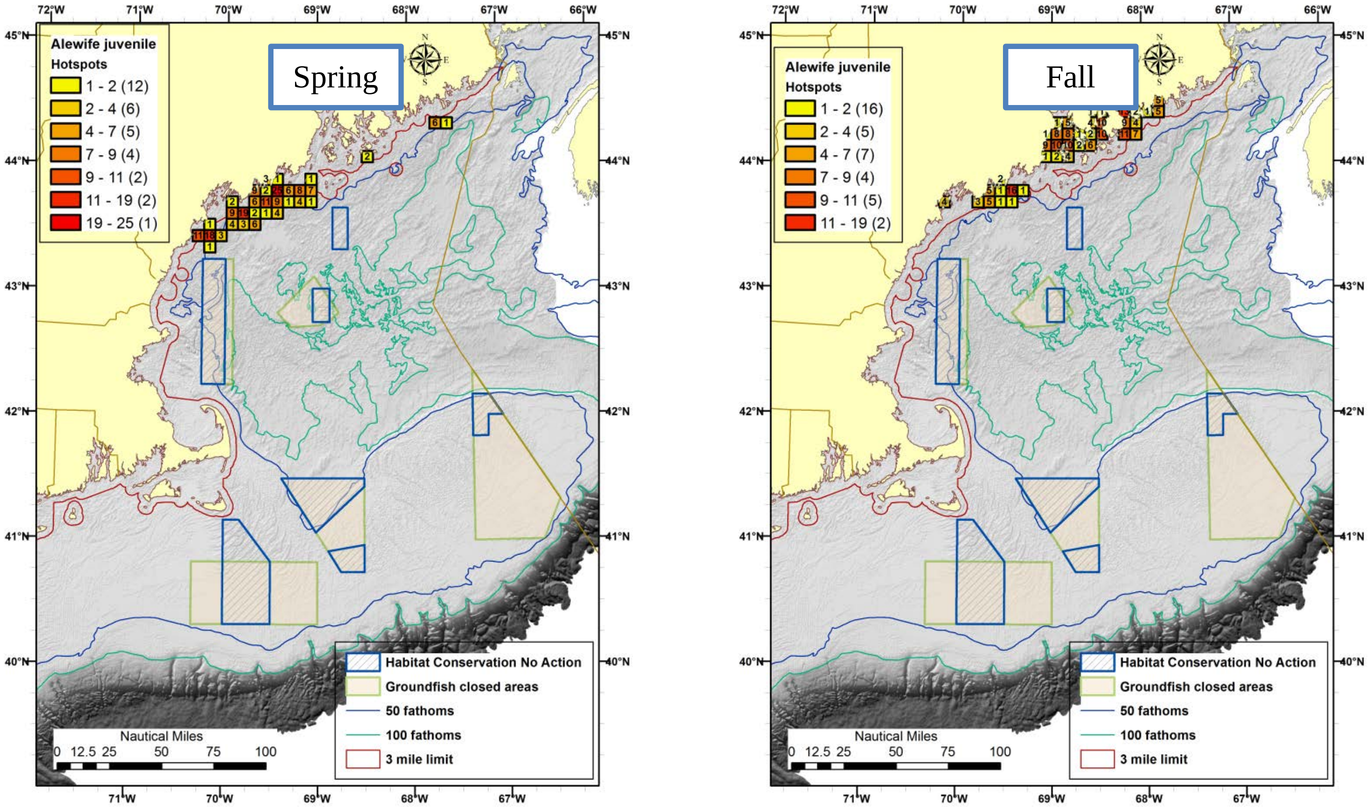
Map 100 - Seasonal distribution of age 0-1 silver hake hotspots from 2002-2012 survey abundance.



Map 101 - Seasonal distribution of age 0-1 red hake hotspots from 2002-2012 survey abundance.



Map 102 – Seasonal distribution of age 0-1 alewife hotspots from 2002-2012 survey abundance.



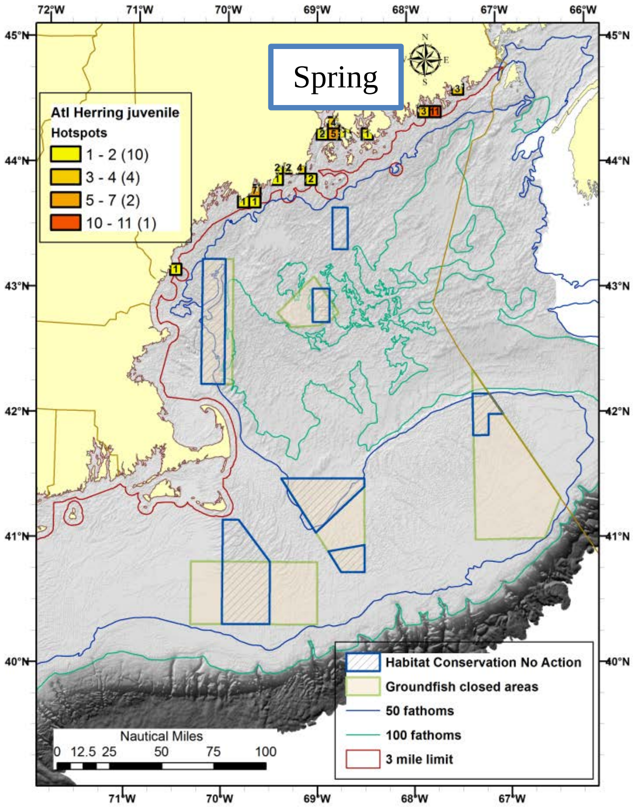
Summer

Winter

No hotspots detected

No hotspots detected

Map 103 - Seasonal distribution of age 0-1 Atlantic herring hotspots from 2002-2012 survey abundance.



Fall

No hotspots detected

Summer

No hotspots detected

Winter

No hotspots detected

4.2.2.1.2 By area

EFH Closed Areas (No Action), Year Round Groundfish Closed Areas (No Action), and Proposed Habitat Management Areas

This section summarizes the age 0/1 groundfish hotspot results by management area, including areas the currently exist as EFH closures to mobile bottom tending gears and as year round closures to all gears capable of catching groundfish. Portions of the year round groundfish closures are open in certain situations with specific gears or seasons, including separator trawl special access programs (SAPs) in Closed Area II, a longline SAP in Closed Area I, and scallop dredge access programs in the Nantucket Lightship Area, Closed Area I, and Closed Area II. In addition, the hotspot results were tabulated and summarized for all areas that were identified and included in OHA2 alternatives. Total area and management categories are listed in the table below. The impacts as they relate to hotspot and other analyses are described in Section ??? (Groundfish Impact Analysis).

Table 20 – Size and location of status quo and proposed habitat management areas.

Management area	Area (km^2)	Area (nm^2)	Type	Region	Sub region
Alternate Roller Gear Restricted Area	4,147	1,209	Habitat Management Area	Gulf of Maine	Western GOM
Ammen Rock	15	4	Habitat Management Area	Gulf of Maine	Central GOM
Bigelow Bight, large	1,691	493	Habitat Management Area	Gulf of Maine	Western GOM
Bigelow Bight, small	561	164	Habitat Management Area	Gulf of Maine	Western GOM
Cashes Ledge EFH	443	129	EFH closure	Gulf of Maine	Central GOM
Cashes Ledge EFH, modified	324	94	Habitat Management Area	Gulf of Maine	Central GOM
Cashes Ledge GF	1,373	400	Groundfish closure	Gulf of Maine	Central GOM
Closed Area I EFH N	1,937	565	EFH closure	Georges Bank/Southern New England	Georges Bank
Closed Area I EFH S	584	170	EFH closure	Georges Bank/Southern New England	Georges Bank
Closed Area I GF	3,939	1,148	Groundfish closure	Georges Bank/Southern New England	Georges Bank
Closed Area II EFH	641	187	EFH closure	Georges Bank/Southern New England	Georges Bank
Closed Area II GF	6,862	2,001	Groundfish closure	Georges Bank/Southern New England	Georges Bank
Cox Ledge 1	143	42	Habitat Management Area	Georges Bank/Southern New England	Southern New England
Cox Ledge 2	70	20	Habitat Management Area	Georges Bank/Southern New England	Southern New England
Eastern Maine, large	1,692	493	Habitat Management Area	Gulf of Maine	Eastern GOM
Eastern Maine, small	483	141	Habitat Management Area	Gulf of Maine	Eastern GOM
Fippennies Ledge	45	13	Habitat Management Area	Gulf of Maine	Central GOM
Georges Shoal Gear Modification Area, large	6,838	1,994	Habitat Management Area	Georges Bank/Southern New England	Georges Bank
Georges Shoal Gear Modification Area, small	1,073	313	Habitat Management Area	Georges Bank/Southern New England	Georges Bank
Georges Shoal MBTG closure	926	270	Habitat Management Area	Georges Bank/Southern New England	Georges Bank
Great South Channel	2,566	748	Habitat Management Area	Georges Bank/Southern New England	Southern New England
Great South Channel Gear Modification Area	2,301	671	Habitat Management Area	Georges Bank/Southern New England	Southern New England
Great South Channel, east	3,356	979	Habitat Management Area	Georges Bank/Southern New England	Southern New England
Inshore Roller Gear Restricted Area	11,327	3,302	Habitat Management Area	Gulf of Maine	Western GOM
Jeffreys Bank EFH	499	145	EFH closure	Gulf of Maine	Central GOM
Jeffreys Bank EFH, modified	494	144	Habitat Management Area	Gulf of Maine	Central GOM
Jeffreys Ledge	733	214	Habitat Management Area	Gulf of Maine	Western GOM
Machias	334	97	Habitat Management Area	Gulf of Maine	Eastern GOM
Nantucket Lightship EFH	3,387	987	EFH closure	Georges Bank/Southern New England	Southern New England
Nantucket Lightship GF	6,248	1,822	Groundfish closure	Georges Bank/Southern New England	Southern New England
Nantucket Shoals	2,350	685	Habitat Management Area	Georges Bank/Southern New England	Southern New England
Nantucket Shoals, west	2,952	861	Habitat Management Area	Georges Bank/Southern New England	Southern New England
Northern Edge	476	139	Habitat Management Area	Georges Bank/Southern New England	Georges Bank
Northern Edge 2	484	128	Habitat Management Area	Georges Bank/Southern New England	Georges Bank
Northern Edge NERO	266	77	Habitat Management Area	Georges Bank/Southern New England	Georges Bank
Platts Bank 1	31	9	Habitat Management Area	Gulf of Maine	Central GOM
Platts Bank 2	41	12	Habitat Management Area	Gulf of Maine	Central GOM
Stellwagen, large	1,177	343	Habitat Management Area	Gulf of Maine	Western GOM
Stellwagen, small	670	195	Habitat Management Area	Gulf of Maine	Western GOM
Toothaker Ridge	700	204	Habitat Management Area	Gulf of Maine	Eastern GOM
Western Gulf of Maine EFH	2,272	662	EFH closure	Gulf of Maine	Western GOM
Western Gulf of Maine GF	3,030	883	Groundfish closure	Gulf of Maine	Western GOM

In the **Gulf of Maine**, the existing EFH closures (Western Gulf of Maine, Cashes Ledge, and Jeffries Bank) contained 92 spring hotspots, 104 summer hotspots, 101 fall hotspots, and 5 winter hotspots. The winter hotspots were limited mainly by the extent of the IBS cod (conducted only in portions of the Western Gulf of Maine) and winter trawl (primarily surveying Georges Bank and Southern New England) surveys. Much of the Gulf of Maine has not been surveyed for fish abundance during the winter.

Total weighted hotspots that account more heavily for stocks with low biomass ("vulnerability") and average or above substrate affinity were 288.1 in the spring, 175.0 in the summer, 386.8 in the fall, and 33.6 in the winter. The majority of age 0/1 groundfish hotspots in existing EFH areas were in the Western Gulf of Maine EFH closure area, with 70 spring, 32 summer, 56 fall, an 1 winter[4] hotspot. Total weighted hotspots were 261.1, 128.4, 265.2, and 6.7 respectively.

Of the 160 total hotspots in the Western Gulf of Maine EFH closure area, 66 were for redfish, 33 for plaice, 20 for silver hake, and 19 for haddock. The remaining 41 hotspots were for cod (8), monkfish (1), red hake (9), white hake (1), winter flounder (1), and witch flounder (2).

The number of hotspots in the existing and proposed habitat management alternatives is a function of both the distribution of age 0/1 groundfish hotspots and by the size of the area. Naturally, a larger area that overlaps a smaller area is going to have a greater number of hotspots.

In the spring, the greatest number of hotspots were in the Inshore Roller Gear Restricted Area (1050), followed by the Large Bigelow Bight Area (462), and the small Bigelow Bight Area (150) and then the Large Eastern Maine Area (115). On the basis of hotspots weighted for stock vulnerability, subpopulation presence, residency, and substrate affinity, being the largest area in the Western Gulf of Maine the Inshore Roller Gear Restricted Area had the highest rank (2686.9), followed by the Large Bigelow Bight Area (826.3) which overlaps it. The next areas in rank order of spring weighted hotspots were the Small Bigelow Bight Area (351.7), the Machias Area (187.7) and the Jeffries Ledge Area (127.8). The weighted hotspots from spring surveys in other areas were 47.3 for the Large Eastern Maine Area, 0.0 for the Small Eastern Maine Area, 81.1 for the Toothaker Ridge Area, 112.9 for the Large Stellwagen Area, and 38.6 for the Small Stellwagen Area. Ammen Rock, Cashes Ledge, Fippennies Ledge, and Platts Bank Areas had zero or low number of age 0/1 groundfish hotspots, but this results is generated by the low number of survey tows in the vicinity of these areas.

Although small, the Machias Area ranked high for weighted hotspots due to the cluster of high ME/NH survey catches of cod (13), haddock (7), and winter flounder (15). The mix of age 0/1 groundfish species that contributed to the high weighted hotspot scores for the Inshore Roller Gear Restricted Area, and the Large and Small Bigelow Bight areas were similar since the areas overlap. They include redfish (72 in the Small Bigelow Bight Area), plaice (137), cod (12), haddock (11), and winter flounder (20). It should be noted that the Small Bigelow Bight Area also has a high number (62) of age 0/1 silver hake hotspots where a small mesh fishery targeting this species takes place.

---

[4] The winter hotspot was from the IBS cod survey. The NMFS winter trawl survey was not conducted in this area.

The fall hotspot results are similar to those from the spring surveys, with larger areas in the Western Gulf of Maine ranking higher than other areas, both in total number of age 0/1 groundfish hotspots and in weighted hotspots. The Inshore and Alternative Roller Gear Areas have 1018 (1886.8 weighted) and 2270 (4579.7 weighted) hotspots, respectively, followed by the Large Bigelow Bight Area (483; 844.6 weighted) which overlaps the roller gear areas.

Unlike surveys in the spring, the age 0/1 hotspots tend more heavily favor areas in the central Gulf of Maine. Next in ranked order of weighted hotspots are the Large Eastern Maine Area (263; 500.2 weighted), the Small Eastern Maine Area (110; 229.8 weighted), the Small Bigelow Bight Area (153; 270.1 weighted), the Toothaker Ridge Area (69; 128.4 weighted), the Large Stellwagen Area (17; 123.5 weighted), the Jeffries Ledge Area (28; 107.9 weighted), the Machias Area (11, 91.5 weighted), the Small Stellwagen Area (9; 82.9 weighted), and the Jeffries Bank Modified Area (15; 27.0 weighted). It is notable that the Machias and Small Stellwagen Areas have a relatively high weighted hotspot ranking compared with the total number of unweighted hotspots, because the hotspots are mostly redfish and cod in the Small Stellwagen Area and cod, haddock, and winter flounder in the Machias area.

Summer and winter age 0/1 hotspots are not as comparable across Gulf of Maine areas as they are elsewhere, because surveys in these seasons do not cover the entire Gulf of Maine. The winter surveys are mainly from the IBS cod survey and cover parts of the Western Gulf of Maine. The summer shrimp survey is somewhat broader in scope but does not survey the eastern Gulf of Maine or the inshore strata in Massachusetts Bay. It is useful however for evaluation of the hotspot species composition in the western and central Gulf of Maine.

Age 0/1 hotspots were less numerous in the **Georges Bank and Southern New England** region than they were in the Gulf of Maine, mainly composed of hotspots for goosefish (aka monkfish; Fig ???), haddock (Fig ???)), red hake (Fig ???), and winter flounder (Fig ???). Goosefish and red hake are not large mesh groundfish and were therefore given zero weight.

The EFH closures on Georges Bank contained 5 summer (0.0 weighted) and 14 fall (23.0 weighted) hotspots. No hotspots were detected in the spring and winter seasonal surveys. The most numerous EFH closure hotspots were for red hake (9), winter flounder (5), and haddock (4).

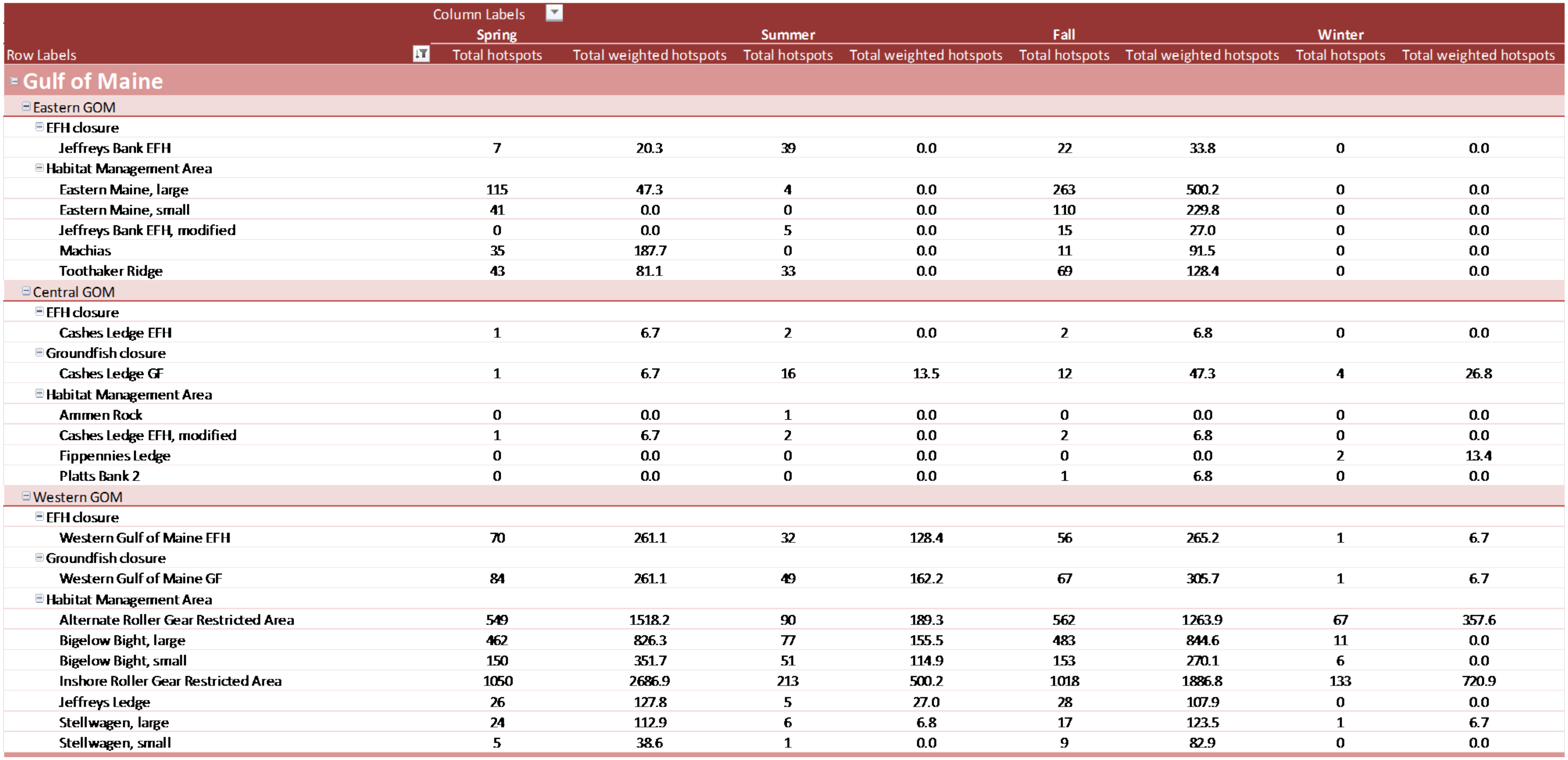
Hotspots of age 0/1 groundfish were more numerous in the year round groundfish closed areas, both due to their location and larger size. Closed Area I had 35 hotspots (17.3 weighted) in the fall survey, comprised mainly of red hake (23) and silver hake (8) hotspots. Closed Area II had 11 hotspots in the spring (63.3 weighted), 39 in the summer (195.5 weighted), 16 in the fall (28.8 weighted), and 0 in the winter. These hotspots were comprised mainly of haddock (50) and red hake (10) hotspots. The proposed habitat management areas include the Large Georges Shoal Gear Modification Area which has a higher number of hotspots than the existing EFH closure, but fewer than neighboring Closed Area II, a year round groundfish closed area.

In Southern New England, the larger Nantucket Lightship Area groundfish closure had more hotspots than the smaller but overlapping EFH closure (Table 20), mostly of species that were given zero weight. The Nantucket Lightship Area groundfish closure had 10 spring (0.0

unweighted), 54 summer (0.0 unweighted), 0 fall, and 2 winter (40.2 weighted) hotspots. These hotspots were comprised mainly from goosefish (17; aka monkfish) and red hake (9).

The smaller proposed habitat management areas had fewer hotspots and none with a non-zero weight. The Great South Channel Gear Modification Area, for example, had only 12 hotspots in the fall survey, 0.0 weighted hotspots, comprising mainly of winter flounder (due to low substrate affinity).

Table 21 – Summary of number of age 0 and 1 total groundfish hotspots and hotspots weighted to account for stock status, existence of sub-populations, degree of residency, and substrate affinity in status quo and proposed Habitat Management Areas (HMA). Analyzed data included numbers per tow caught by seasonal NMFS, state, and industry-based surveys during 2002-2012. Hotspots were assigned relative weights by stock based on factors listed in Table 19.



	Column Labels							
	Spring		Summer		Fall		Winter	
Row Labels	Total hotspots	Total weighted hotspots	Total hotspots	Total weighted hotspots	Total hotspots	Total weighted hotspots	Total hotspots	Total weighted hotspots
Gulf of Maine								
Eastern GOM								
EFH closure								
Jeffreys Bank EFH	7	20.3	39	0.0	22	33.8	0	0.0
Habitat Management Area								
Eastern Maine, large	115	47.3	4	0.0	263	500.2	0	0.0
Eastern Maine, small	41	0.0	0	0.0	110	229.8	0	0.0
Jeffreys Bank EFH, modified	0	0.0	5	0.0	15	27.0	0	0.0
Machias	35	187.7	0	0.0	11	91.5	0	0.0
Toothaker Ridge	43	81.1	33	0.0	69	128.4	0	0.0
Central GOM								
EFH closure								
Cashes Ledge EFH	1	6.7	2	0.0	2	6.8	0	0.0
Groundfish closure								
Cashes Ledge GF	1	6.7	16	13.5	12	47.3	4	26.8
Habitat Management Area								
Ammen Rock	0	0.0	1	0.0	0	0.0	0	0.0
Cashes Ledge EFH, modified	1	6.7	2	0.0	2	6.8	0	0.0
Fippennies Ledge	0	0.0	0	0.0	0	0.0	2	13.4
Platts Bank 2	0	0.0	0	0.0	1	6.8	0	0.0
Western GOM								
EFH closure								
Western Gulf of Maine EFH	70	261.1	32	128.4	56	265.2	1	6.7
Groundfish closure								
Western Gulf of Maine GF	84	261.1	49	162.2	67	305.7	1	6.7
Habitat Management Area								
Alternate Roller Gear Restricted Area	549	1518.2	90	189.3	562	1263.9	67	357.6
Bigelow Bight, large	462	826.3	77	155.5	483	844.6	11	0.0
Bigelow Bight, small	150	351.7	51	114.9	153	270.1	6	0.0
Inshore Roller Gear Restricted Area	1050	2686.9	213	500.2	1018	1886.8	133	720.9
Jeffreys Ledge	26	127.8	5	27.0	28	107.9	0	0.0
Stellwagen, large	24	112.9	6	6.8	17	123.5	1	6.7
Stellwagen, small	5	38.6	1	0.0	9	82.9	0	0.0

Continued.

Georges Bank/Southern New England								
Georges Bank								
EFH closure								
Closed Area I EFH N	0	0.0	0	0.0	10	11.5	0	0.0
Closed Area II EFH	0	0.0	5	0.0	4	11.5	0	0.0
Groundfish closure								
Closed Area I GF	0	0.0	0	0.0	35	17.3	0	0.0
Closed Area II GF	11	63.3	39	195.5	16	28.8	0	0.0
Habitat Management Area								
Georges Shoal Gear Modification Area, large	6	0.0	15	0.0	33	11.5	0	0.0
Georges Shoal Gear Modification Area, small	0	0.0	1	0.0	4	0.0	0	0.0
Northern Edge	0	0.0	0	0.0	8	34.5	0	0.0
Southern New England								
EFH closure								
Nantucket Lightship EFH	10	0.0	54	0.0	0	0.0	2	40.2
Groundfish closure								
Nantucket Lightship GF	16	0.0	79	5.8	1	0.0	4	40.2
Habitat Management Area								
Great South Channel	0	0.0	0	0.0	6	0.0	0	0.0
Great South Channel Gear Modification Area	0	0.0	0	0.0	12	0.0	0	0.0
Great South Channel, east	0	0.0	0	0.0	9	0.0	0	0.0
Nantucket Shoals	0	0.0	0	0.0	1	0.0	0	0.0
Nantucket Shoals, west	0	0.0	0	0.0	1	0.0	0	0.0

Table 22 – Summary of number of age 0 and 1 total groundfish hotspots and hotspots weighted to account for stock status, existence of sub-populations, degree of residency, and substrate affinity in status quo and proposed Habitat Management Areas (HMA). Analyzed data included numbers per tow caught by seasonal NMFS, state, and industry-based surveys during 2002-2012.

	Spring		Summer		Fall		Winter	
Row Labels	Total hotspots	Total weighted hotspots	Total hotspots	Total weighted hotspots	Total hotspots	Total weighted hotspots	Total hotspots	Total weighted hotspots
⊟ **Gulf of Maine**								
⊟ Eastern GOM								
⊟ **EFH closure**	**7**	**20.3**	**39**	**0.0**	**22**	**33.8**	**0**	**0.0**
Jeffreys Bank EFH	**7**	**20.3**	**39**	**0.0**	**22**	**33.8**	**0**	**0.0**
⊟ **Habitat Management Area**	**234**	**316.1**	**42**	**0.0**	**468**	**977.1**	**0**	**0.0**
Eastern Maine, large	**115**	**47.3**	**4**	**0.0**	**263**	**500.2**	**0**	**0.0**
Eastern Maine, small	**41**	**0.0**	**0**	**0.0**	**110**	**229.8**	**0**	**0.0**
Jeffreys Bank EFH, modified	**0**	**0.0**	**5**	**0.0**	**15**	**27.0**	**0**	**0.0**
Machias	**35**	**187.7**	**0**	**0.0**	**11**	**91.5**	**0**	**0.0**
Toothaker Ridge	**43**	**81.1**	**33**	**0.0**	**69**	**128.4**	**0**	**0.0**
⊟ Central GOM								
⊟ **EFH closure**	**1**	**6.7**	**2**	**0.0**	**2**	**6.8**	**0**	**0.0**
Cashes Ledge EFH	**1**	**6.7**	**2**	**0.0**	**2**	**6.8**	**0**	**0.0**
⊟ **Groundfish closure**	**1**	**6.7**	**16**	**13.5**	**12**	**47.3**	**4**	**26.8**
Cashes Ledge GF	**1**	**6.7**	**16**	**13.5**	**12**	**47.3**	**4**	**26.8**
⊟ **Habitat Management Area**	**1**	**6.7**	**3**	**0.0**	**3**	**13.5**	**2**	**13.4**
Ammen Rock	**0**	**0.0**	**1**	**0.0**	**0**	**0.0**	**0**	**0.0**
Cashes Ledge EFH, modified	**1**	**6.7**	**2**	**0.0**	**2**	**6.8**	**0**	**0.0**
Fippennies Ledge	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**	**2**	**13.4**
Platts Bank 2	**0**	**0.0**	**0**	**0.0**	**1**	**6.8**	**0**	**0.0**
⊟ Western GOM								
⊟ **EFH closure**	**70**	**261.1**	**32**	**128.4**	**56**	**265.2**	**1**	**6.7**
Western Gulf of Maine EFH	**70**	**261.1**	**32**	**128.4**	**56**	**265.2**	**1**	**6.7**
⊟ **Groundfish closure**	**84**	**261.1**	**49**	**162.2**	**67**	**305.7**	**1**	**6.7**
Western Gulf of Maine GF	**84**	**261.1**	**49**	**162.2**	**67**	**305.7**	**1**	**6.7**
⊟ **Habitat Management Area**	**2266**	**5662.4**	**443**	**993.7**	**2270**	**4579.7**	**218**	**1085.2**
Alternate Roller Gear Restricted Area	**549**	**1518.2**	**90**	**189.3**	**562**	**1263.9**	**67**	**357.6**
Bigelow Bight, large	**462**	**826.3**	**77**	**155.5**	**483**	**844.6**	**11**	**0.0**
Bigelow Bight, small	**150**	**351.7**	**51**	**114.9**	**153**	**270.1**	**6**	**0.0**
Inshore Roller Gear Restricted Area	**1050**	**2686.9**	**213**	**500.2**	**1018**	**1886.8**	**133**	**720.9**
Jeffreys Ledge	**26**	**127.8**	**5**	**27.0**	**28**	**107.9**	**0**	**0.0**
Stellwagen, large	**24**	**112.9**	**6**	**6.8**	**17**	**123.5**	**1**	**6.7**
Stellwagen, small	**5**	**38.6**	**1**	**0.0**	**9**	**82.9**	**0**	**0.0**

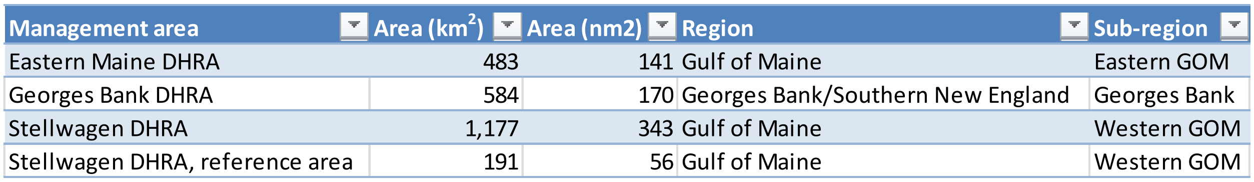
Continued.

Georges Bank/Southern New England								
Georges Bank								
EFH closure	0	0.0	5	0.0	14	23.0	0	0.0
Closed Area I EFH N	0	0.0	0	0.0	10	11.5	0	0.0
Closed Area II EFH	0	0.0	5	0.0	4	11.5	0	0.0
Groundfish closure	11	63.3	39	195.5	51	46.0	0	0.0
Closed Area I GF	0	0.0	0	0.0	35	17.3	0	0.0
Closed Area II GF	11	63.3	39	195.5	16	28.8	0	0.0
Habitat Management Area	6	0.0	16	0.0	45	46.0	0	0.0
Georges Shoal Gear Modification Area, large	6	0.0	15	0.0	33	11.5	0	0.0
Georges Shoal Gear Modification Area, small	0	0.0	1	0.0	4	0.0	0	0.0
Northern Edge	0	0.0	0	0.0	8	34.5	0	0.0
Southern New England								
EFH closure	10	0.0	54	0.0	0	0.0	2	40.2
Nantucket Lightship EFH	10	0.0	54	0.0	0	0.0	2	40.2
Groundfish closure	16	0.0	79	5.8	1	0.0	4	40.2
Nantucket Lightship GF	16	0.0	79	5.8	1	0.0	4	40.2
Habitat Management Area	0	0.0	0	0.0	29	0.0	0	0.0
Great South Channel	0	0.0	0	0.0	6	0.0	0	0.0
Great South Channel Gear Modification Area	0	0.0	0	0.0	12	0.0	0	0.0
Great South Channel, east	0	0.0	0	0.0	9	0.0	0	0.0
Nantucket Shoals	0	0.0	0	0.0	1	0.0	0	0.0
Nantucket Shoals, west	0	0.0	0	0.0	1	0.0	0	0.0

Dedicated Habitat Research Areas

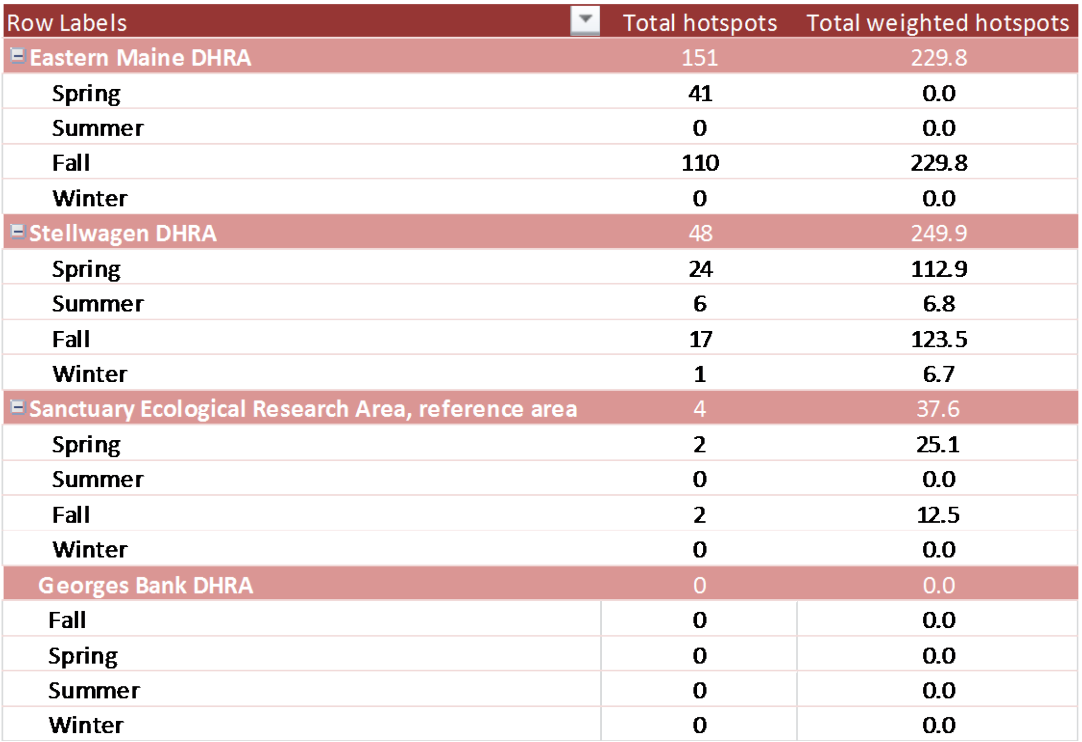
Similarly, the Georges Bank DHRA (overlapping the northern part of Closed Area I) had no hotspots for small juvenile groundfish (Table 24). More small juvenile groundfish hotspots were found in the DHRAs in the Gulf of Maine. Two spring (25.1 weighted) and two fall (12.5 weighted) were found in the SERA reference area, comprised mainly of cod (3) (Table 25). The larger Stellwagen DHRA contained 24 spring (112.9 weighted), 6 summer (6.8 weighted), 17 fall (123.5 weighted) and 1 winter (6.7 weighted) hotspots, comprising mainly of redfish (23), red hake (6), and cod (5). The Eastern Maine DHRA contained 41 spring (0.0 weighted) and 110 fall (229.8 weighted) hotspots, comprised mainly of silver hake (62), white hake (36) and redfish (34).

Table 23 – Size and location of status quo and proposed DHRA management areas.



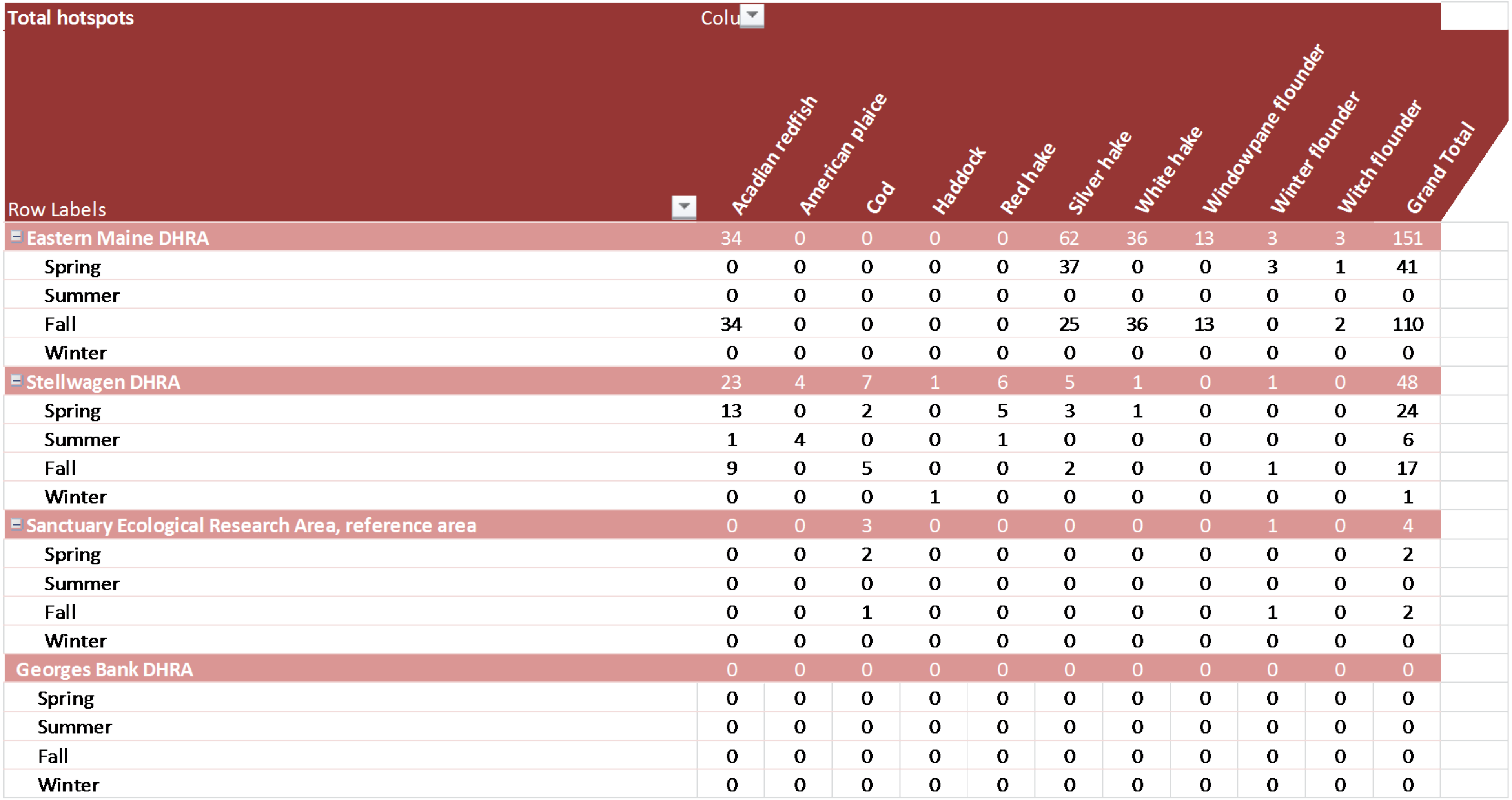
Management area	Area (km^2)	Area (nm2)	Region	Sub-region
Eastern Maine DHRA	483	141	Gulf of Maine	Eastern GOM
Georges Bank DHRA	584	170	Georges Bank/Southern New England	Georges Bank
Stellwagen DHRA	1,177	343	Gulf of Maine	Western GOM
Stellwagen DHRA, reference area	191	56	Gulf of Maine	Western GOM

Table 24 – Summary of number of age 0 and 1 total groundfish hotspots and hotspots weighted to account for stock status, existence of sub-populations, degree of residency, and substrate affinity in proposed Dedicated Habitat Research Areas (DHRA), Analyzed data included numbers per tow caught by seasonal NMFS, state, and industry-based surveys during 2002-2012.



Row Labels	Total hotspots	Total weighted hotspots
⊟ Eastern Maine DHRA	151	229.8
Spring	41	0.0
Summer	0	0.0
Fall	110	229.8
Winter	0	0.0
⊟ Stellwagen DHRA	48	249.9
Spring	24	112.9
Summer	6	6.8
Fall	17	123.5
Winter	1	6.7
⊟ Sanctuary Ecological Research Area, reference area	4	37.6
Spring	2	25.1
Summer	0	0.0
Fall	2	12.5
Winter	0	0.0
Georges Bank DHRA	0	0.0
Fall	0	0.0
Spring	0	0.0
Summer	0	0.0
Winter	0	0.0

Table 25 –Total number of age 0 and 1 hotspots by species and season in proposed DHRAs. Analyzed data included numbers per tow caught by seasonal NMFS, state, and industry-based surveys during 2002-2012.



Row Labels	Acadian redfish	American plaice	Cod	Haddock	Red hake	Silver hake	White hake	Windowpane flounder	Winter flounder	Witch flounder	Grand Total
⊟ Eastern Maine DHRA	34	0	0	0	0	62	36	13	3	3	151
Spring	0	0	0	0	0	37	0	0	3	1	41
Summer	0	0	0	0	0	0	0	0	0	0	0
Fall	34	0	0	0	0	25	36	13	0	2	110
Winter	0	0	0	0	0	0	0	0	0	0	0
⊟ Stellwagen DHRA	23	4	7	1	6	5	1	0	1	0	48
Spring	13	0	2	0	5	3	1	0	0	0	24
Summer	1	4	0	0	1	0	0	0	0	0	6
Fall	9	0	5	0	0	2	0	0	1	0	17
Winter	0	0	0	1	0	0	0	0	0	0	1
⊟ Sanctuary Ecological Research Area, reference area	0	0	3	0	0	0	0	0	1	0	4
Spring	0	0	2	0	0	0	0	0	0	0	2
Summer	0	0	0	0	0	0	0	0	0	0	0
Fall	0	0	1	0	0	0	0	0	1	0	2
Winter	0	0	0	0	0	0	0	0	0	0	0
Georges Bank DHRA	0	0	0	0	0	0	0	0	0	0	0
Spring	0	0	0	0	0	0	0	0	0	0	0
Summer	0	0	0	0	0	0	0	0	0	0	0
Fall	0	0	0	0	0	0	0	0	0	0	0
Winter	0	0	0	0	0	0	0	0	0	0	0

4.2.2.2 Large spawner groundfish hotspot analysis

Although there are some specific studies of groundfish spawning that have been published, these analyses focused either in a specific area and season (e.g. Dean et al. 2013) or a specific species (e.g. cod, winter flounder, and haddock, see individual species headings under section 4.2.1). The most comprehensive analysis to identify location and seasonal spawning activity was the Ames (2004) analysis that focused on cod spawning along the ME and NH coastline. The Ames (2004) study identified historic cod spawning grounds based primarily on interviews with fishermen.

Since specific location-based information on groundfish spawning was limited, the Council undertook a broad-based and seasonal analysis of groundfish spawning using all available survey data, including NMFS spring, fall, and winter trawl surveys, MADMF spring and fall trawl surveys, ME-NH spring and fall trawl surveys, Industry Based Surveys (IBS) for cod, yellowtail flounder, and monkfish (which also measured and recorded catches of other groundfish), the NMFS shrimp trawl survey, and the NMFS scallop dredge survey. Other surveys were considered, but were either unavailable for a compatible analysis or did not measure the characteristics of interest (especially fish size in photographic/video surveys).

Some ad hoc industry surveys, such as the Closed Area II scallop dredge survey by VIMS and Connamessett Farms were also analyzed separately, but generally provided localized information about a specific area. Although the research focused on relative changes in scallop and yellowtail flounder CPUE, the results were helpful in identifying peak spawning of yellowtail flounder occurring in June to August.

MADMF has been conducting targeted surveys and acoustic tagging experiments, focusing on inshore cod spawning. These results were presented to the Council's Closed Area Technical Team by MADMF's Micah Dean, showing the characteristics of cod spawning activity, including where the behavior of mature male and female cod have specific diel cycles during spawning. This research focused on an area in Northern Massachusetts Bay, south of Gloucester, MA and is now protected by a spring closure in state waters. Similar characteristics have been observed by others in the Whaleback region of Ipswich Bay, which is now protected by a late spring spawning closure in Federal waters.

A third area is currently being investigated by MADMF and Sector X fishermen off Scituate, MA, straddling State and Federal waters. Acoustic tagging work is just getting underway in November 2013 and results should be available in early 2014. This area also was identified in the Council's hotspot analysis as an area that holds high concentrations of both juvenile and spawning size cod. These preliminary results led the Council to include an alternative that proposes a winter cod spawning closure in this area.

The survey data that covers broad areas of the Gulf of Maine and Georges Bank/Southern New England regions have some biological data that might be used to identify spawning activity, including maturity stage and sex ratios. While the MADMF cod spawning studies identified a separation of male and female cod in localized areas as a key characteristic of spawning activity, this characteristic was difficult to detect in survey data. Survey tows typically are about a nautical mile long and probably cannot detect the fine-scale biological characteristics that were identified in the localized MADMF study. The observed maturity stage of groundfish caught on survey tows are also available, but the surveys typically take place during specific windows of time and may or may not coincide with key spawning times that may only last a week or so in a specific area. The Council's Closed Area Technical Team (CATT) members thought that the spring trawl surveys were too early to detect spawning activity off Southern ME and around Closed Area I. The winter trawl survey (which was terminated in 2007) would be ideal to identify winter cod spawning, but the sampling domain did not extend far into Massachusetts Bay (see Map 79 in section 4.2.2.1).

Observed commercial fishing data could also have been used to determine spawning activity based on the presence of large fish. Biological data such as maturity stage and sex are however rarely collected by the observers. Just as problematic, the existing closed areas and rolling closures inhibit the use of observer data to detect spawning sites and activity since these areas often overlap where spawning occurs. This is particularly true for the spring rolling closures in the Western Gulf of Maine and Closed Area II.

Due to the limits on biological data and other sources of information, the Council focused on analyzing concentrations of large mature groundfish. This analysis was done using a standard hurdle model approach and hotspot analysis of the transformed data. To characterize spawning, the CATT focused the analysis on large fish, comprising the longest fish that comprise the top 20% of total biomass during 2002-2012. Several biological considerations that led to these choices about survey data used in the analysis included the following:

- Recent data more accurately reflected current and potentially future spawning distributions, particularly in the face of generally increasing water temperature that has been observed in the NE Region.
- Less than 10 years of survey data would be insufficient to identify many clusters of significantly high biomass. The spring and fall surveys each take about 300-400 tows per year, so 10 years of survey data includes observations for 3000-4000 tow locations.
- Larger spawners are more fecund, so protection of these large spawning fish could have more positive population impacts.
- Larger spawners are more likely to exhibit mature spawning behavior and therefore be easier to detect.

Details about the analysis is given in Appendix E, which was reviewed and approved by the Council's SSC. Aggregated across all the groundfish species, the CATT assigned weights to the number of hotspots for each species (see table below), based on seasons when spawning occurred for that species, stock status (a ratio of B_{MSY} to current biomass), and whether the species exhibited a higher degree of residency and/or formed sub-populations. Atlantic halibut (32.7) and ocean pout (14.9) were assigned relatively high weights (compared to an 8.73 average weight), but few hotspots were identified for these species. Georges Bank cod (17.1) and Georges Bank yellowtail flounder (12.4) were assigned relatively high weights mainly due to low stock biomass relative to the target biomass. Haddock (2.7-3.7) and redfish (3.8) were given low weights in the aggregate totals. Red and silver hake were not included in the aggregate totals, since they are not considered to be large-mesh groundfish and the focus of the spawning closure alternatives.

Summaries of aggregated weighted groundfish hotspots as well as distributions of large spawner hotspots for individual species are presented in the following two sections.

Table 26 – Selection of and weighting factors applied to large spawner groundfish hotspot data to sum hotspots across species and develop area management options. The final weighting sum was applied by season to the gridded hotspots for each species shaded in red. Grey shaded rows designate species that are not managed by catch shares.

Stock	**Large spawner threshold (20% of total biomass)**	**Length at 80% female maturity (cm) (re-estimated by CATT)**	**Vulnerability of species (Bmsy/B)[1]**	**Sub-populations[2]**	**Residency[3]**	**Final weighting sum[4]**	**Spring multiplier**	**Summer multiplier**	**Fall multiplier**	**Winter multiplier**
GB Cod	75	52	14.11	2	1	17.1	1	1	*0*	1
GOM Cod	75	52	5.53	3	1	9.5	1	1	*0*	1
GB YTF	40	30	9.39	1	2	12.4	1	*0*	*0*	*0*
CC/GOM YTF	40	30	4.21	1	2	7.2	1	*0*	*0*	*0*
SNE/MA YTF	40	30	0.77	1	2	3.8	1	*0*	*0*	*0*
GOM Wint. Fl.	45	31	UNK	UNK	2	9.0	1	*0*	*0*	1
GB Wint. Fl.	45	31	1.22	3	2	6.2	1	*0*	*0*	1
SNE/MA Wint. Fl.	45	31	6.17	3	2	11.2	1	*0*	*0*	1
White Hake	75	45	1.21	UNK	2	5.0	1	*0*	*0*	*0*
GOM Haddock	50	40	1.71	1	1	3.7	1	*0*	*0*	*0*
GB Haddock	50	40	0.75	1	1	2.7	1	*0*	*0*	*0*
Witch Flounder	45		2.45	3	2	7.5	1	1	1	*0*
Am. Plaice	40	32	1.70	UNK	1	4.5	1	*0*	*0*	*0*
Pollock	75	52	0.46	2	2	4.5	*0*	*0*	*0*	1
Redfish	30	25	0.76	1	2	3.8	1	1	*0*	*0*
Halibut	45	NA	28.82	UNK	2	32.7	1	1	1	1
Ocean Pout	60	NA	12.05	UNK	1	14.9	*0*	1	1	1
Northern (GOM-GB) Windowpane	30	24	3.48	UNK	2	7.3	1	1	1	1
Southern (SNE-MA) Windowpane	30	24	0.69	UNK	2	4.5	1	1	1	1
Atlantic Wolffish	45	NA	3.48	UNK	UNK	7.0	1	*0*	*0*	*0*
Sum						174.5	18	8	5	10
Mean			**5.21**	**1.83**	**1.68**	**8.73**				

[1] Either SSBmsy/SSB or Bmsy/B used depending on what is reported in the assessment

[2] Derived from Table 81 in Framework 48 or from NEFSC biological data. 1=no subpopulations, 2=some evidence, 3=known subpopulations

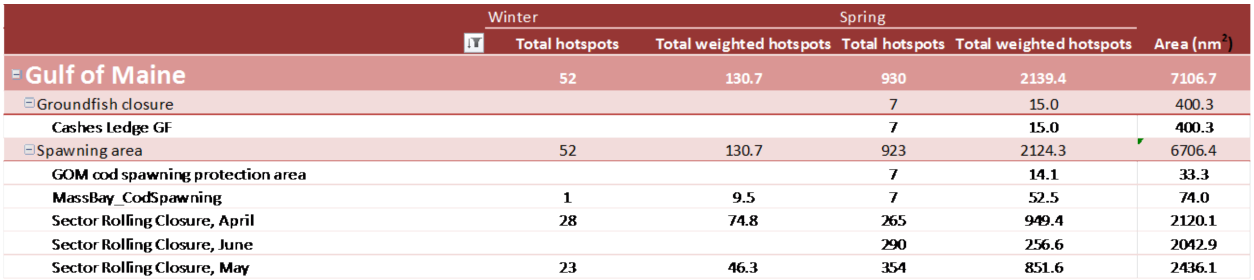
[3] Based on information in literature. 1=less resident, more migratory; 2=more resident, less migratory

[4] Sums include a mean value for unknowns

4.2.2.2.1 Gulf of Maine region

The total number of hotspots and weighted hotspots summed over all groundfish species for Gulf of Maine management areas is summarized in the table below. The totals for spawning areas are added, but include some duplicated hotspots because the seasonal rolling closures overlap. Nonetheless the total weighted large spawner hotspots are most numerous in the spring, particular in the April and May Sector Rolling Closure Areas (see table below). Large spawner groundfish hotspots area were also detected in the winter survey season in the April and May Sector Rolling Closure Areas, but are much less numerous than in the spring. Some of these management areas do not correspond to locations where winter surveys were conducted, however.

Table 27 - Total unweighted and weighted groundfish large spawner hotspots from 2002-2007 winter and 2002-2011 spring surveys by management area in the Gulf of Maine region.



	Winter		Spring		
	Total hotspots	Total weighted hotspots	Total hotspots	Total weighted hotspots	Area (nm^2)
⊟ **Gulf of Maine**	52	130.7	930	2139.4	7106.7
⊟ Groundfish closure			7	15.0	400.3
Cashes Ledge GF			7	15.0	400.3
⊟ Spawning area	52	130.7	923	2124.3	6706.4
GOM cod spawning protection area			7	14.1	33.3
MassBay_CodSpawning	1	9.5	7	52.5	74.0
Sector Rolling Closure, April	28	74.8	265	949.4	2120.1
Sector Rolling Closure, June			290	256.6	2042.9
Sector Rolling Closure, May	23	46.3	354	851.6	2436.1

The general distribution of the weighted hotspots for the spring, fall, summer, and winter seasons are shown in Map 104. Generally, the weighted large spawner groundfish hotspots are distributed from Massachusetts Bay through southern ME during the spring. Notable areas include off the North Shore of MA, overlapping the MADMF winter and spring spawning protection areas, inshore in the Bigelow Bight overlapping the Whaleback Gulf of Maine cod spawning area, an area in the center of the Western Gulf of Maine closed area, and an area on the southern boundary of the Western Gulf of Maine closed area north of Cape Cod. A smaller number of weighted hotspots were identified near and east of Cashes Ledge.

Largely because only windowpane flounder, witch flounder, and ocean pout appear to spawn in the fall, there are few hotspots in the Gulf of Maine during the fall survey season (Map 104). During the summer shrimp survey, clusters of weighted hotspots were identified mainly NW and NE of the Cashes Ledge Closed Area and a few on the northern tip of Jeffries Ledge. During the winter survey season, hotspots were detected in Massachusetts Bay off Scituate, MA and around Tillies Ledge at the western edge of the Western Gulf of Maine Closed Area.

A summary of large spawner hotspots by species is given in Table 28 and the distribution of these hotspots during seasons when spawning occurs is shown in Map 105. Generally, there are many more hotspots for red and silver hake than there are for other species, but they are given a very zero weight in the aggregated hotspot distribution.

Redfish hotspots were found mainly surrounding the Cashes Ledge and Fippenies Area (Map 105) in the summer. American plaice hotspots were primarily distributed in the Western Gulf of Maine during the spring surveys, with a strong signal in the Tillies Bank area.

Cod hotspots were more numerous in the spring: 28 in the April rolling closure and 17 in the May rolling closure. Most of the hotspots were identified in the April and May Sector Rolling Closure areas, primarily offshore on Stellwagen and Tillies Banks (Map 105). Some hotspots were also identified in the Ipswich Bay area, near the Whaleback Closure in the spring, and off Scituate, MA in the winter. A short discussion about the distribution of cod in spawning condition and the relative distribution of large and small mature cod with respect to proposed spawning alternatives is given in the groundfish impacts of spawning alternatives section of Volume 3.

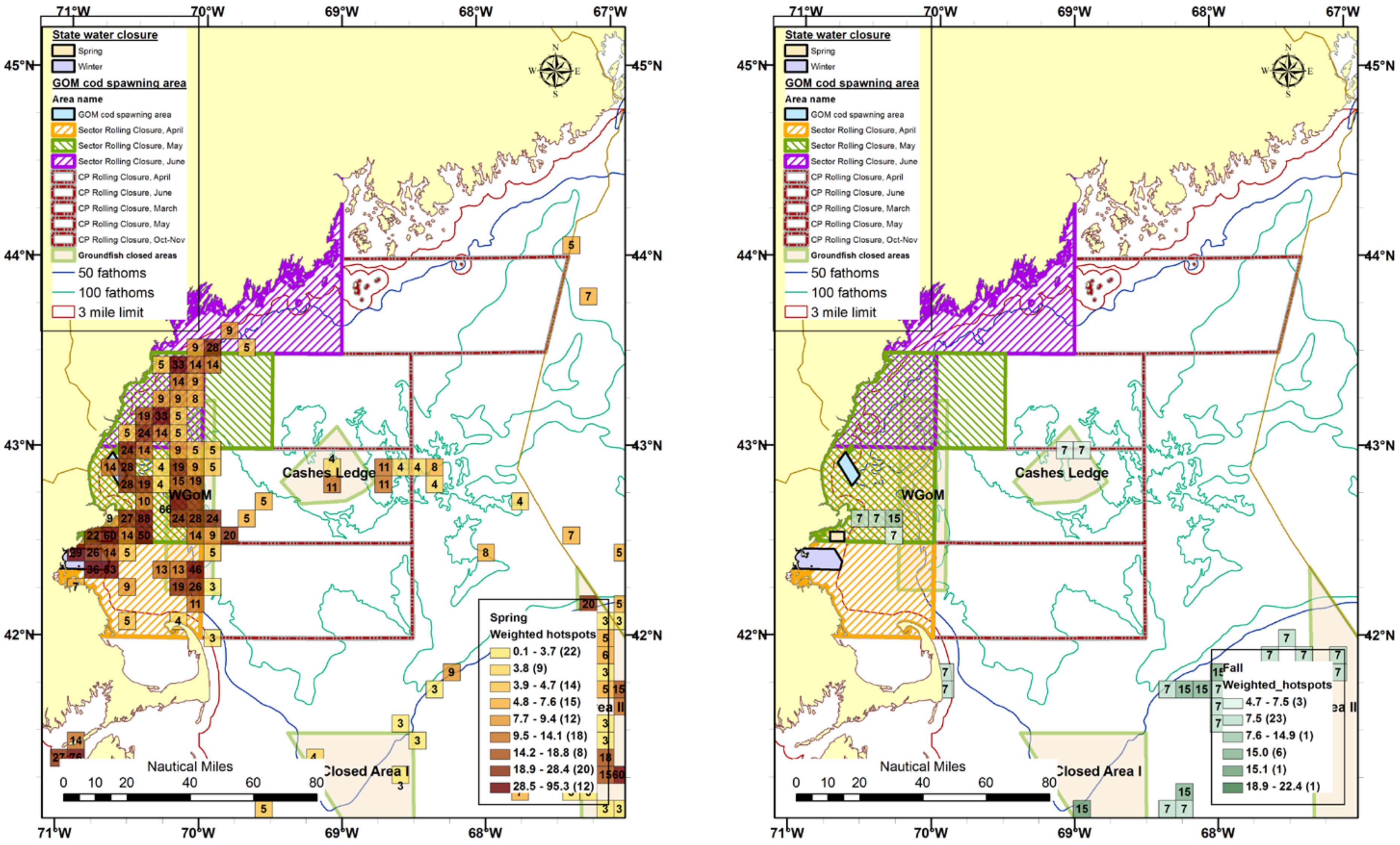
Haddock hotspots were more associated with Jeffries Ledge and on the offshore side of Stallwagen Bank (Map 105) in the spring. No ocean pout hotspots and only 4 pollock hotspots were identified in the Gulf of Maine (Map 105). (A large number of ocean pout hotspots were detected in the spring off the northern point of Cape Cod, but ocean pout are not known to spawn during the spring. Further investigation of this area for ocean pout spawning would be warranted). As mentioned above, red and silver hake hotspots were much more numerous than those for other species, but were more broadly distributed throughout the Gulf of Maine in the spring and fall trawl seasons, although red hake hotspots in the spring tended to be in relatively deep water (Map 105). Four white hake hotspots from spring surveys were identified by the analysis in deep water of the Gulf of Maine, and five windowpane flounder hotspots were identified off Gloucester, MA in the spring and fall and off Cape Cod in the spring (Map 105). No winter flounder hotspots were identified in the Gulf of Maine and a handful of witch flounder hotspots were identified in deep water of the Gulf of Maine from the spring, summer, and fall surveys (Map 105).

Table 28 – Total number of large spawner hotspots by species, management area, and survey season in the Gulf of Maine region.

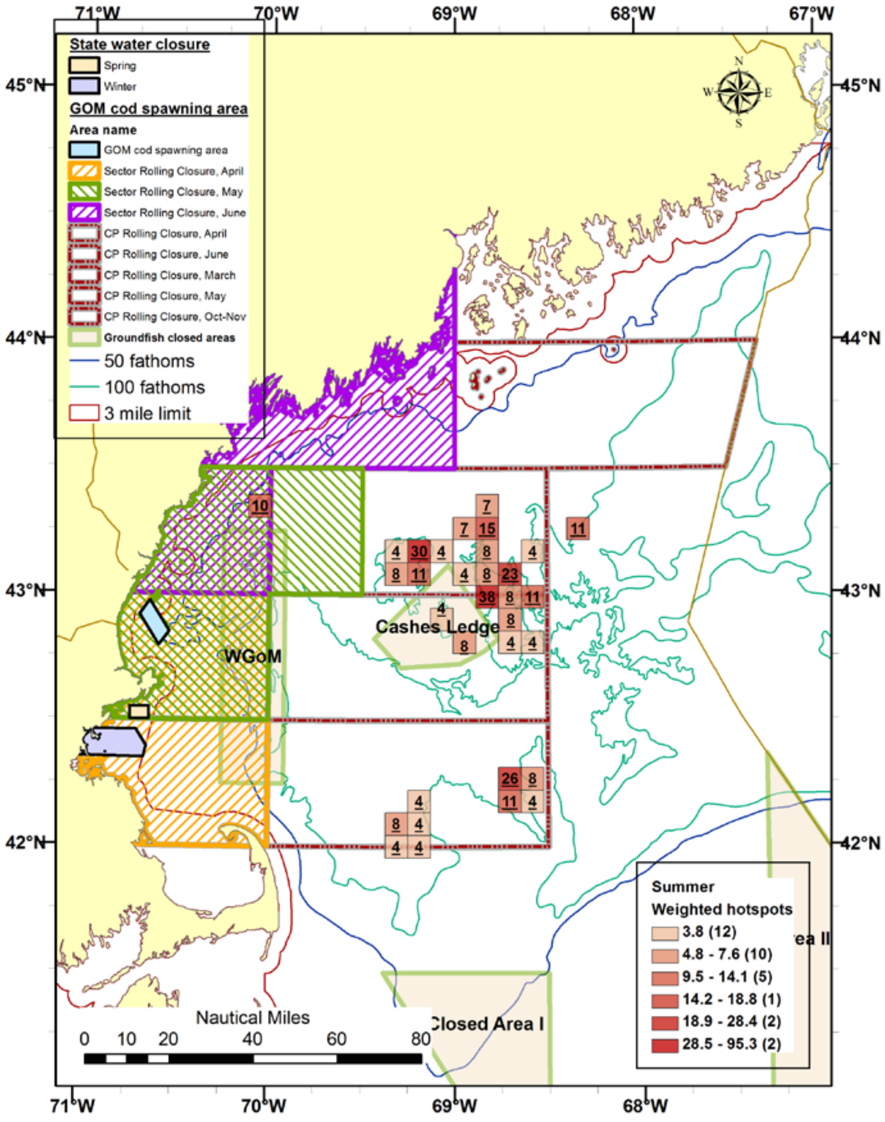
	Acadian redfish	Alewife	American plaice	Atlantic herring	Cod	Haddock	Ocean pout	Pollock	Red hake	Silver hake	White hake	Windowpane flounder	Witch flounder	Yellowtail flounder	Grand Total
⊟ Gulf of Maine															
⊟ Groundfish closure	13		31	1	32	36		13	89	17	13		4	21	270
⊟ Cashes Ledge GF	13								6				2		21
Spring	4								3						7
Summer	3														3
Fall	6								3				2		11
⊟ Western Gulf of Maine GF			31	1	32	36		13	83	17	13		2	21	249
Spring			30	1	21	10		1	23	16			2	14	118
Summer			1			8			21						30
Fall					8	5		12	39	1	13			4	82
Winter					3	13								3	19
⊟ Spawning area	91	143	237	240	91	105	35	30	519	334	14	6	8	510	2363
⊟ Sector Rolling Closure, April	23		71	60	57	59	35	15	172	101	7	3	5	272	880
Spring	4		69	28	27	33	35	1	17	19		1	2	265	501
Summer						7			52						59
Fall	19			32	24	6		10	103	82	7	2	3	4	292
Winter			2		6	13		4						3	28
⊟ Sector Rolling Closure, June	23	135	55	68	1				84	89				58	513
Spring	2	116	53	50					14	55				58	348
Summer					1				19						20
Fall	21	19	2	18					51	34					145
⊟ Sector Rolling Closure, May	45	8	111	112	33	46		15	263	144	7	3	3	180	970
Spring	6	8	107	72	17	23		1	26	83		1		173	517
Summer					1	6			116						123
Fall	39		2	40	12	6		10	121	61	7	2	3	4	307
Winter			2		3	11		4						3	23

Map 104 – Distribution of weighted large spawner groundfish hotspots in the Gulf of Maine by season, derived from 2002-2012 NMFS, MADMF, ME-NH, and IBS survey data. Continued on the next page.

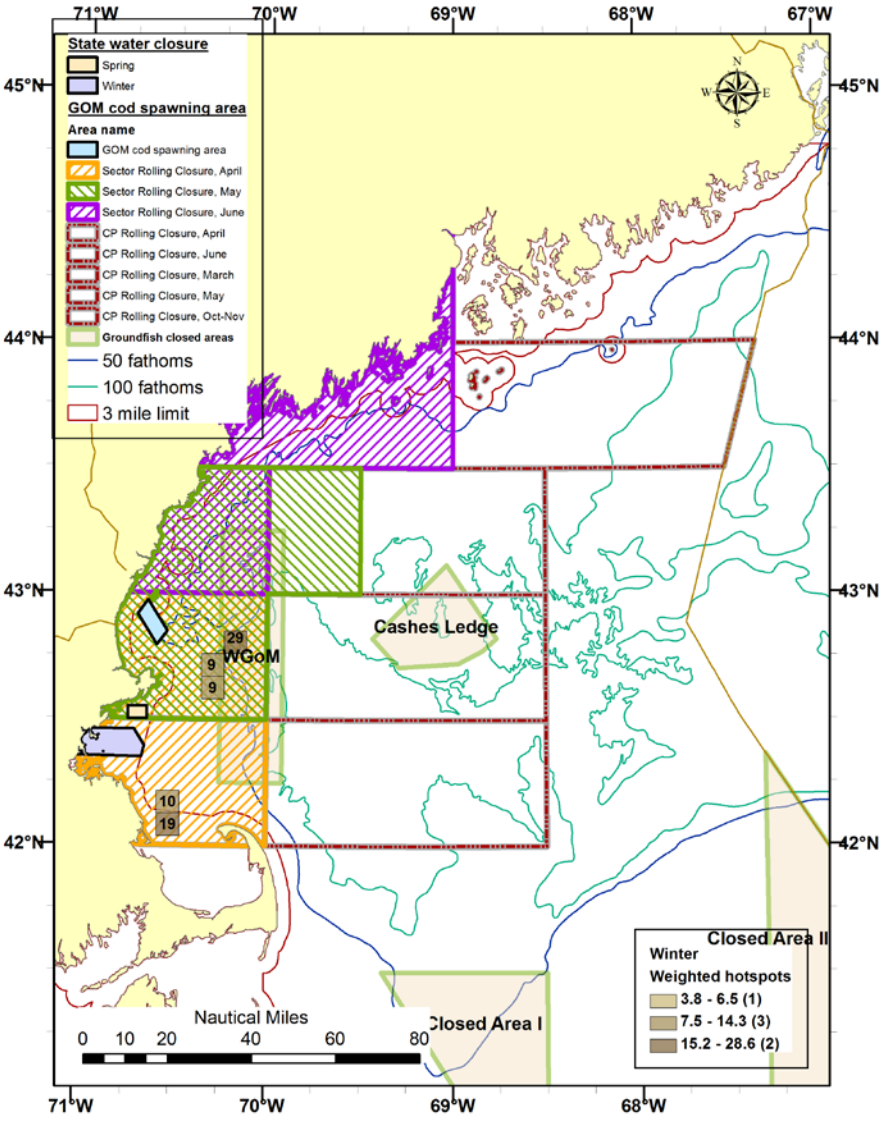
Spring	Fall



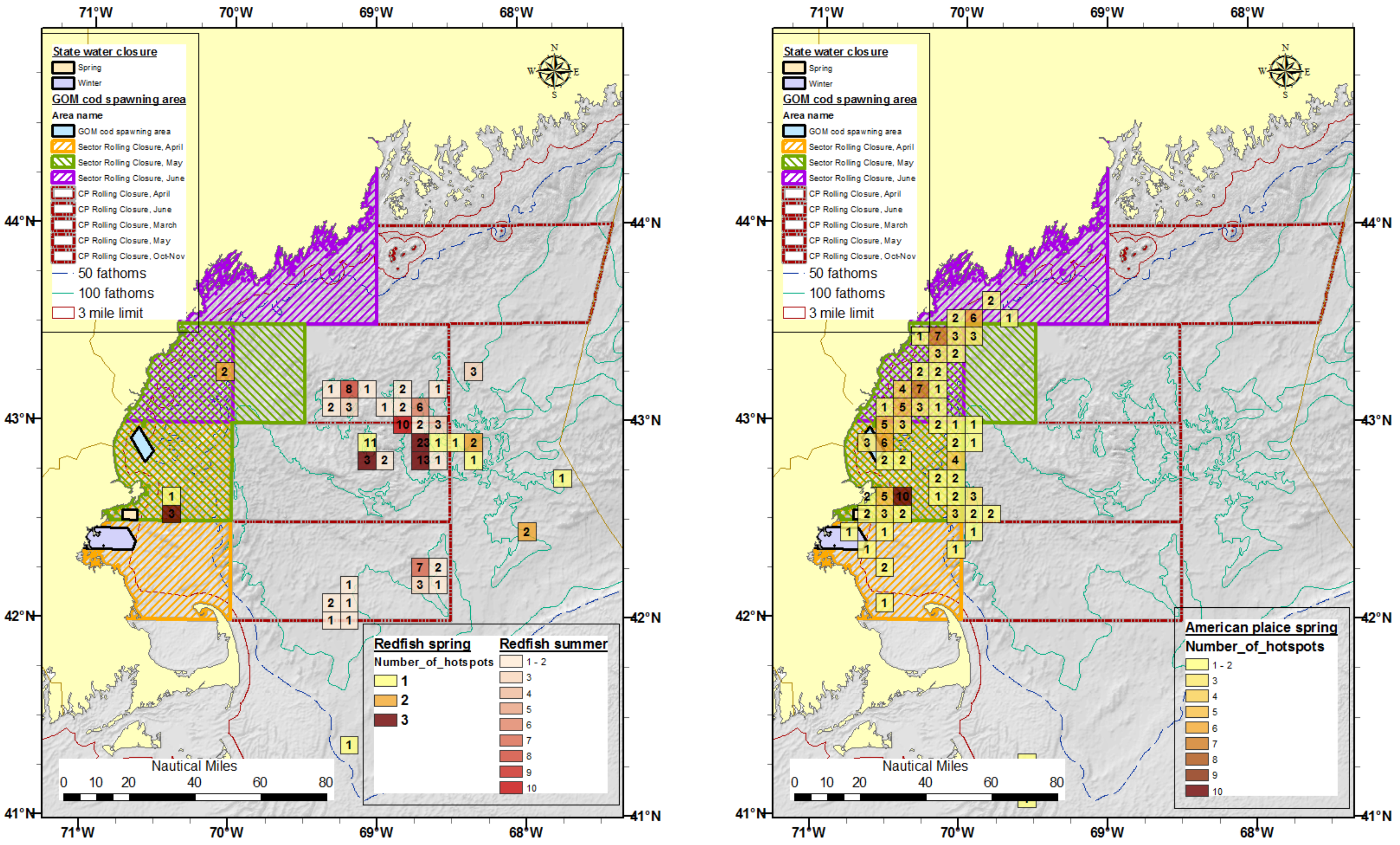
Summer



Winter



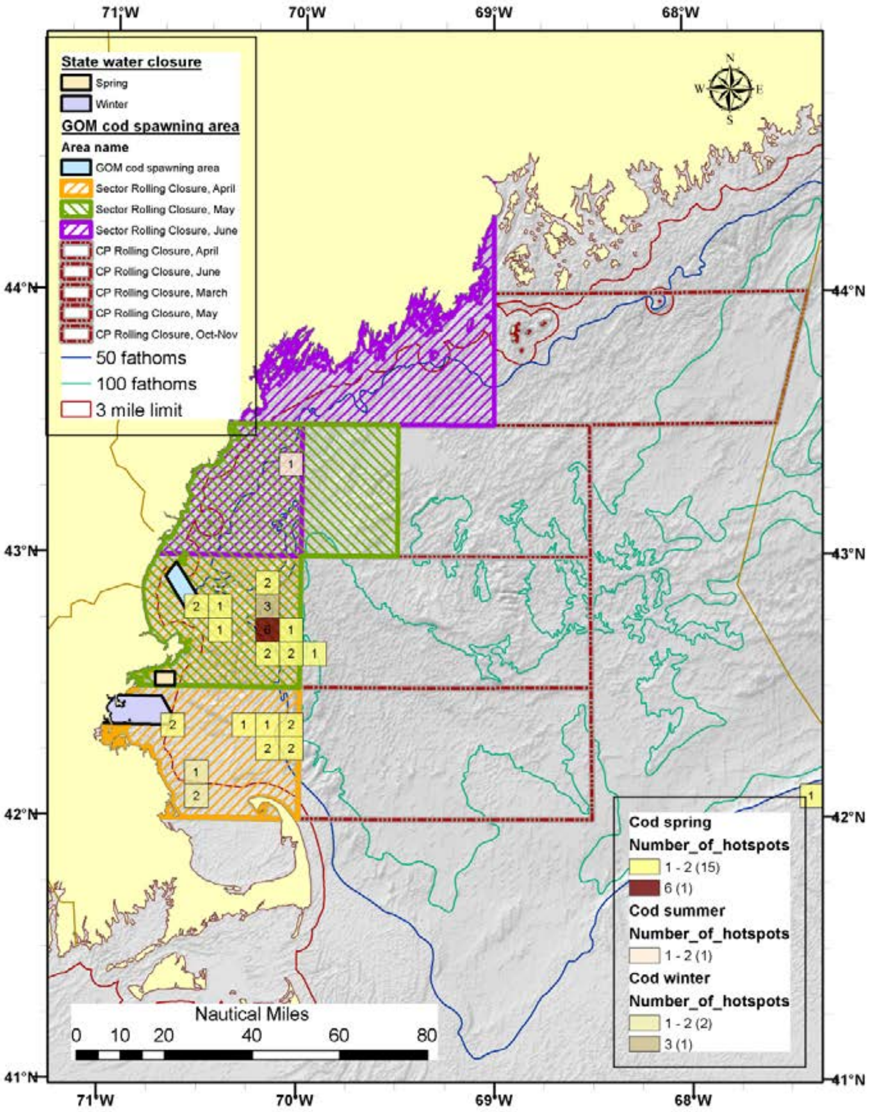
Map 105 – Seasonal distribution of large spawner hotspots for individual groundfish species in the Gulf of Maine region identified from 2002-2012 NMFS, MADMF, ME-NH, and IBS trawl surveys. Continued on the following 6 pages.

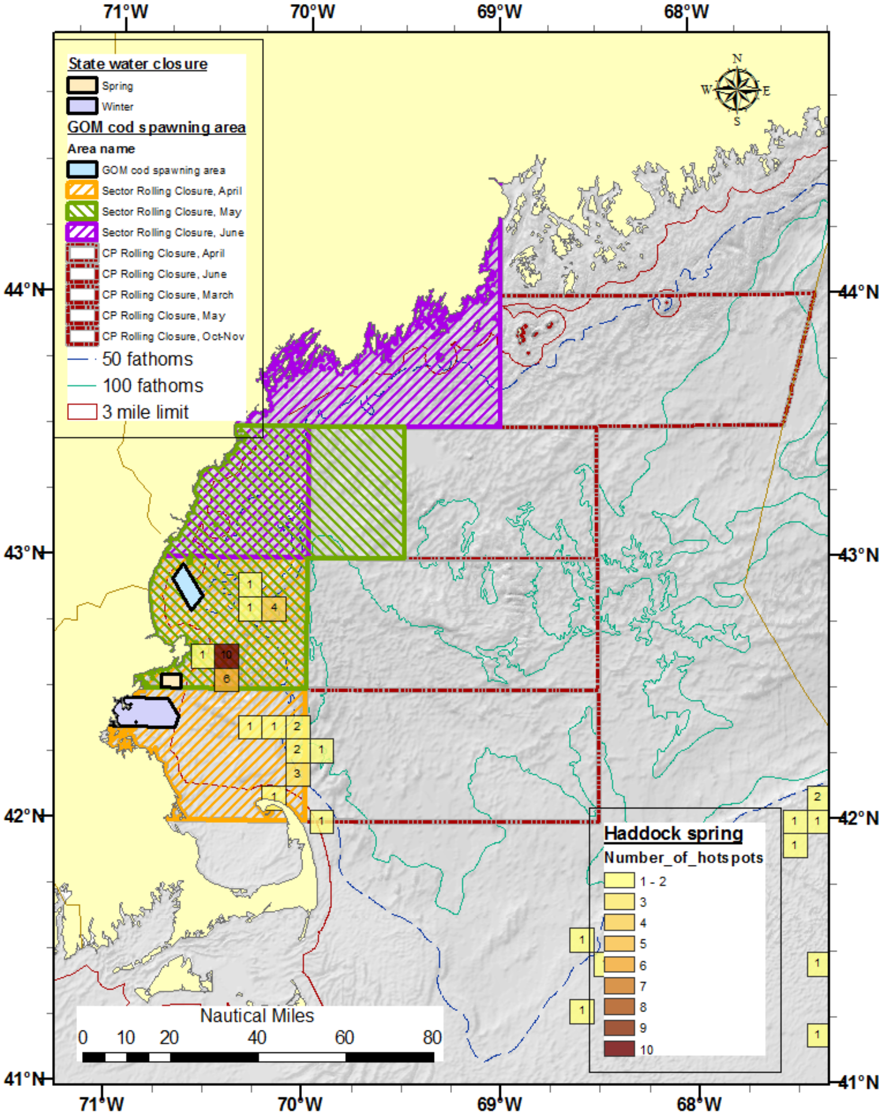


Acadian redfish

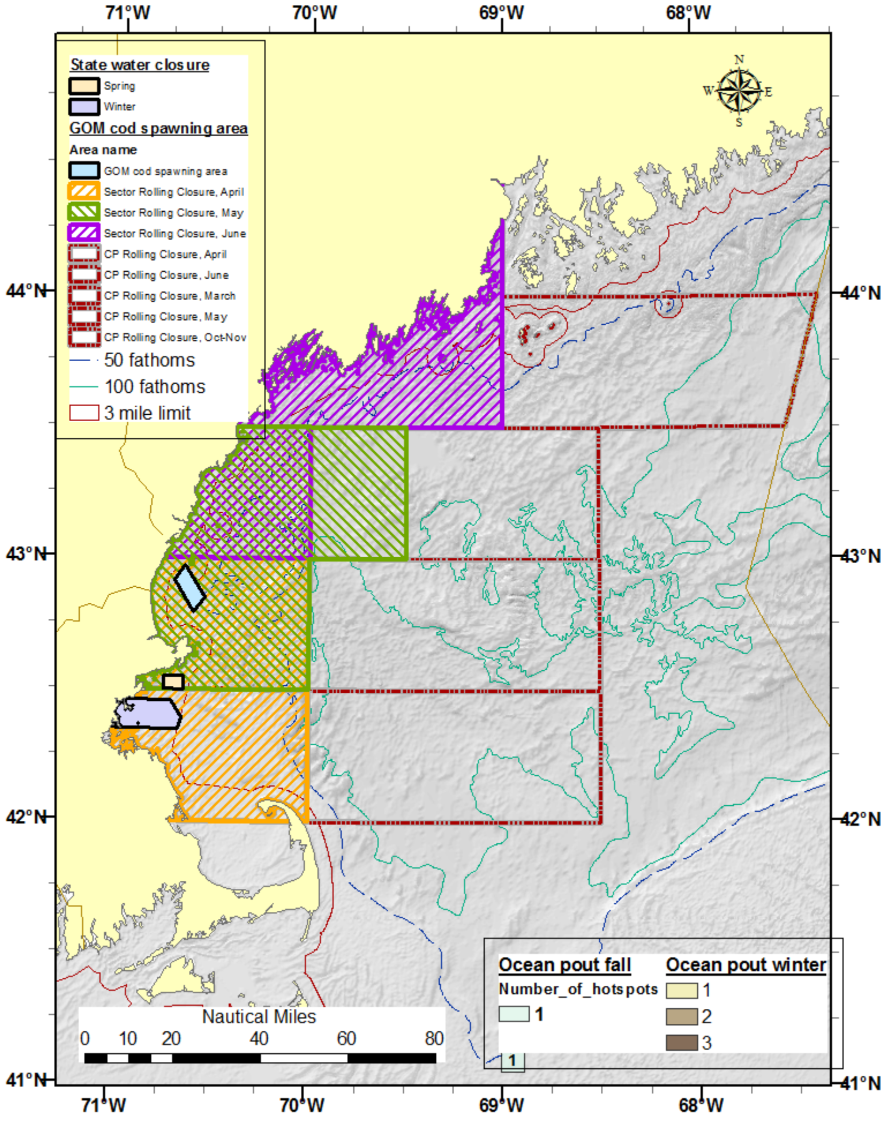
American plaice

Cod	Haddock

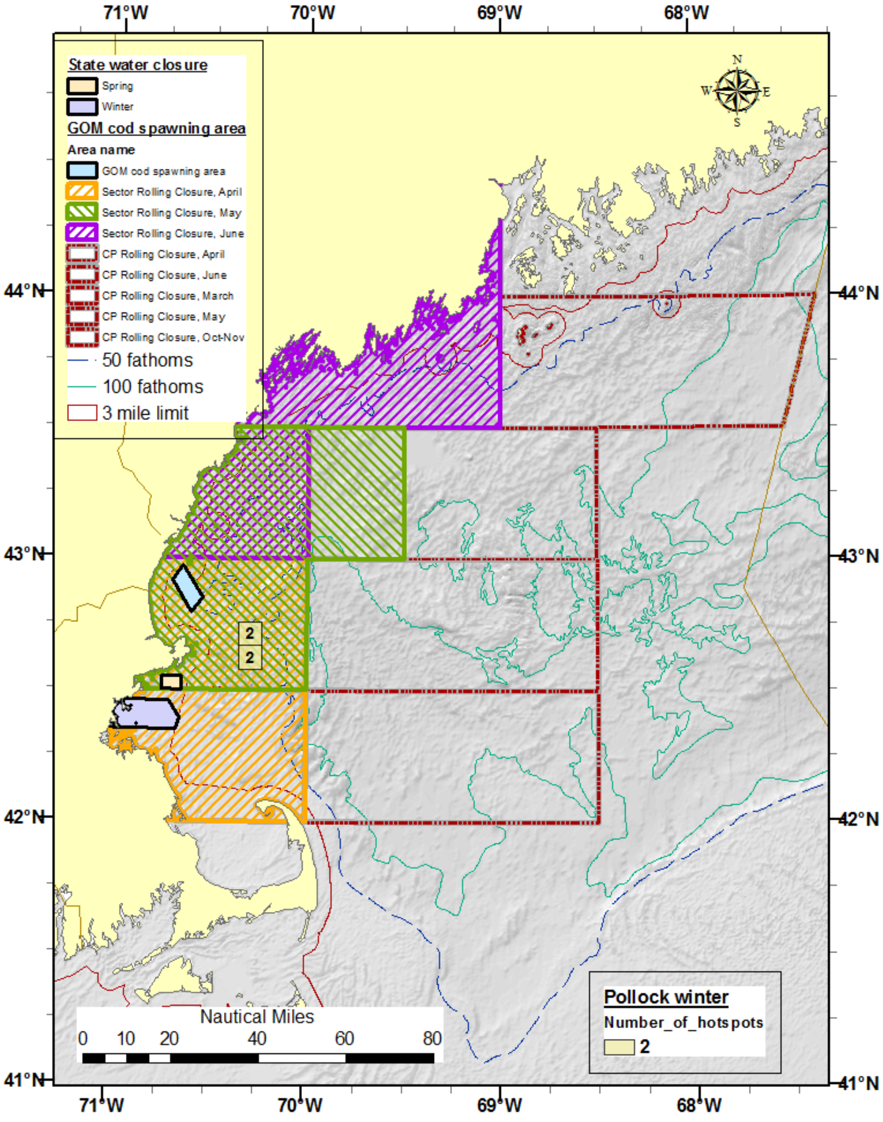

71°W
70°W
69°W
68°W
44°N
43°N
42°N
41°N
State water closure
Spring
Winter
GOM cod spawning area
Area name
GOM cod spawning area
Sector Rolling Closure, April
Sector Rolling Closure, May
Sector Rolling Closure, June
CP Rolling Closure, April
CP Rolling Closure, June
CP Rolling Closure, March
CP Rolling Closure, May
CP Rolling Closure, Oct-Nov
50 fathoms
100 fathoms
3 mile limit
N
W
E
S
Cod spring
Number_of_hotspots
1 - 2 (15)
6 (1)
Cod summer
Number_of_hotspots
1 - 2 (1)
Cod winter
Number_of_hotspots
1 - 2 (2)
3 (1)
Nautical Miles
0 10 20 40 60 80


71°W
70°W
69°W
68°W
44°N
43°N
42°N
41°N
State water closure
Spring
Winter
GOM cod spawning area
Area name
GOM cod spawning area
Sector Rolling Closure, April
Sector Rolling Closure, May
Sector Rolling Closure, June
CP Rolling Closure, April
CP Rolling Closure, June
CP Rolling Closure, March
CP Rolling Closure, May
CP Rolling Closure, Oct-Nov
50 fathoms
100 fathoms
3 mile limit
N
W
E
S
Haddock spring
Number_of_hotspots
1 - 2
3
4
5
6
7
8
9
10
Nautical Miles
0 10 20 40 60 80

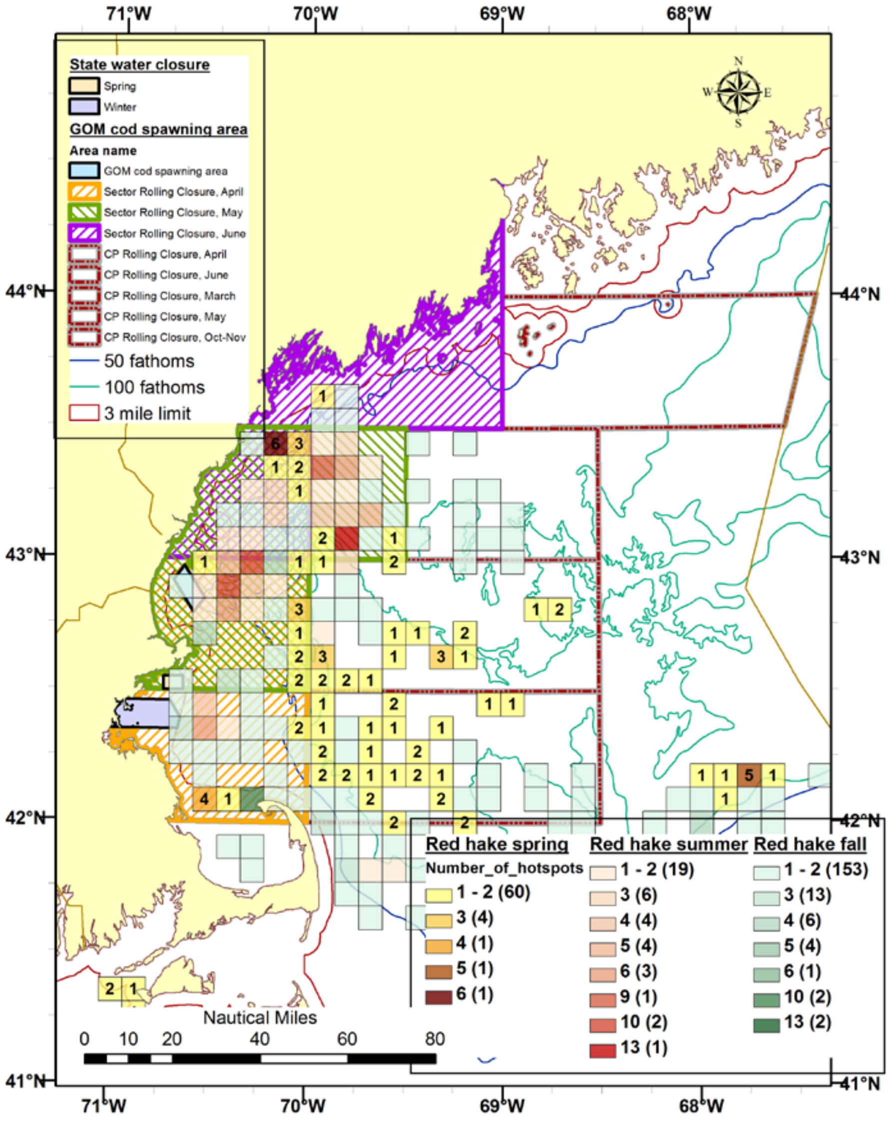
Ocean pout



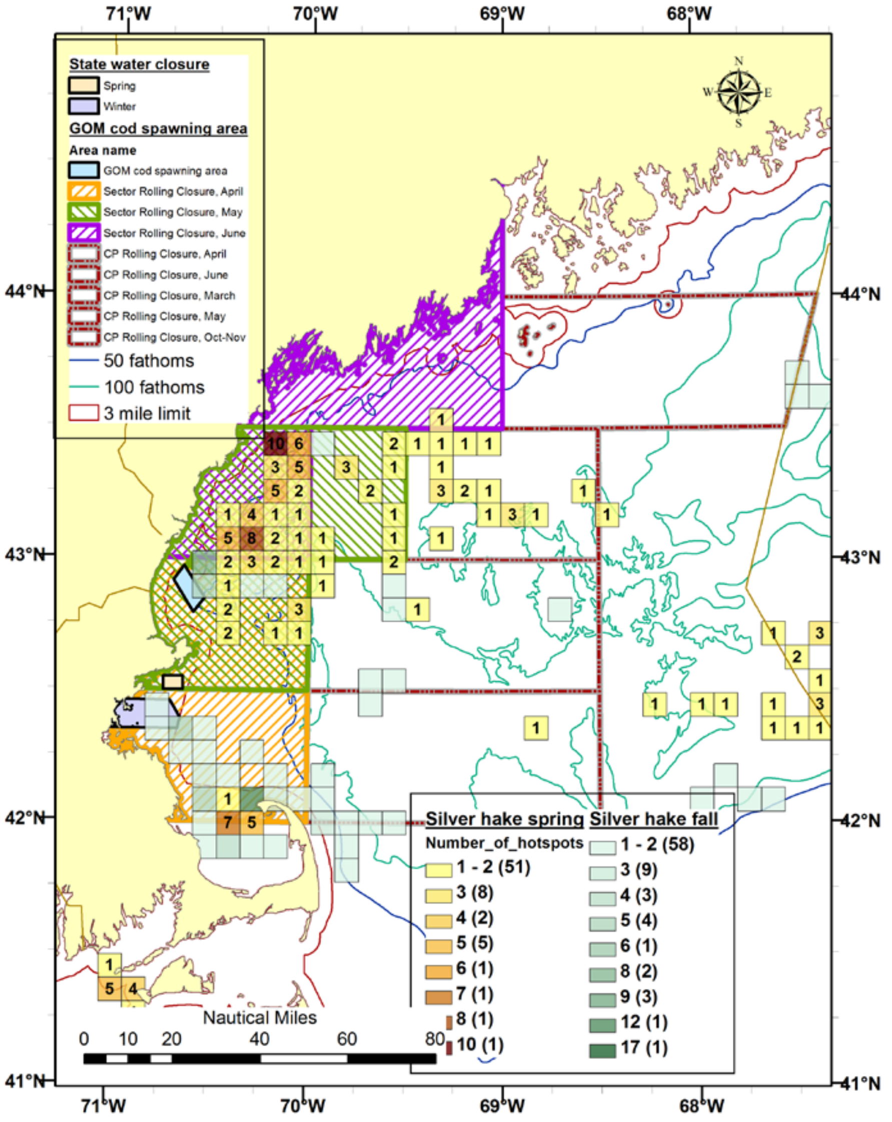
Pollock



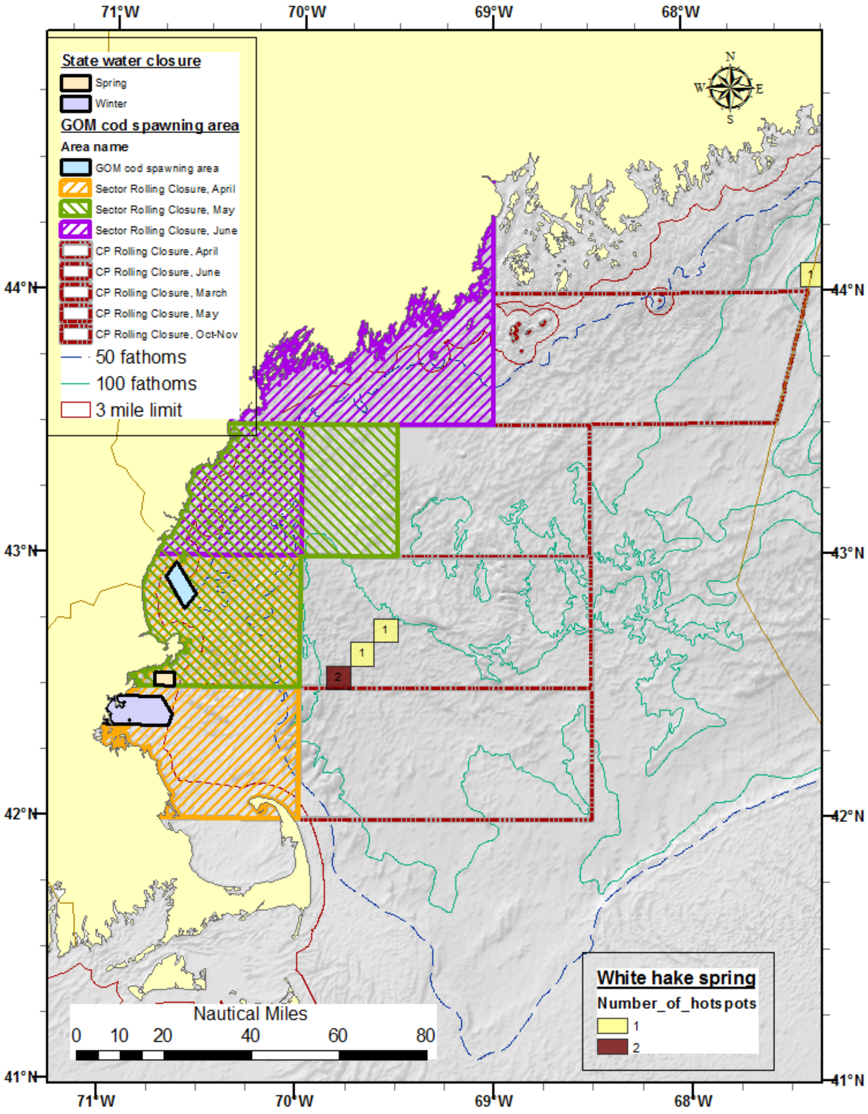
Red hake



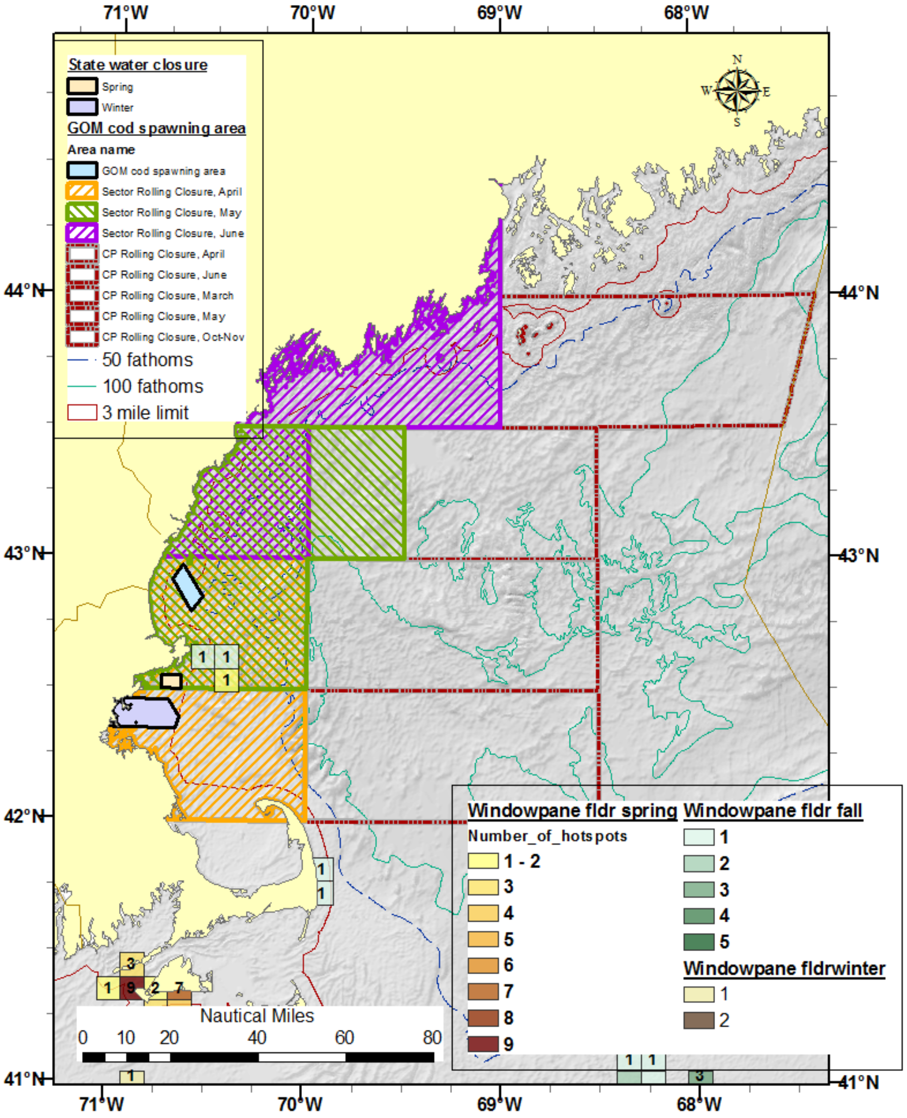
Silver hake



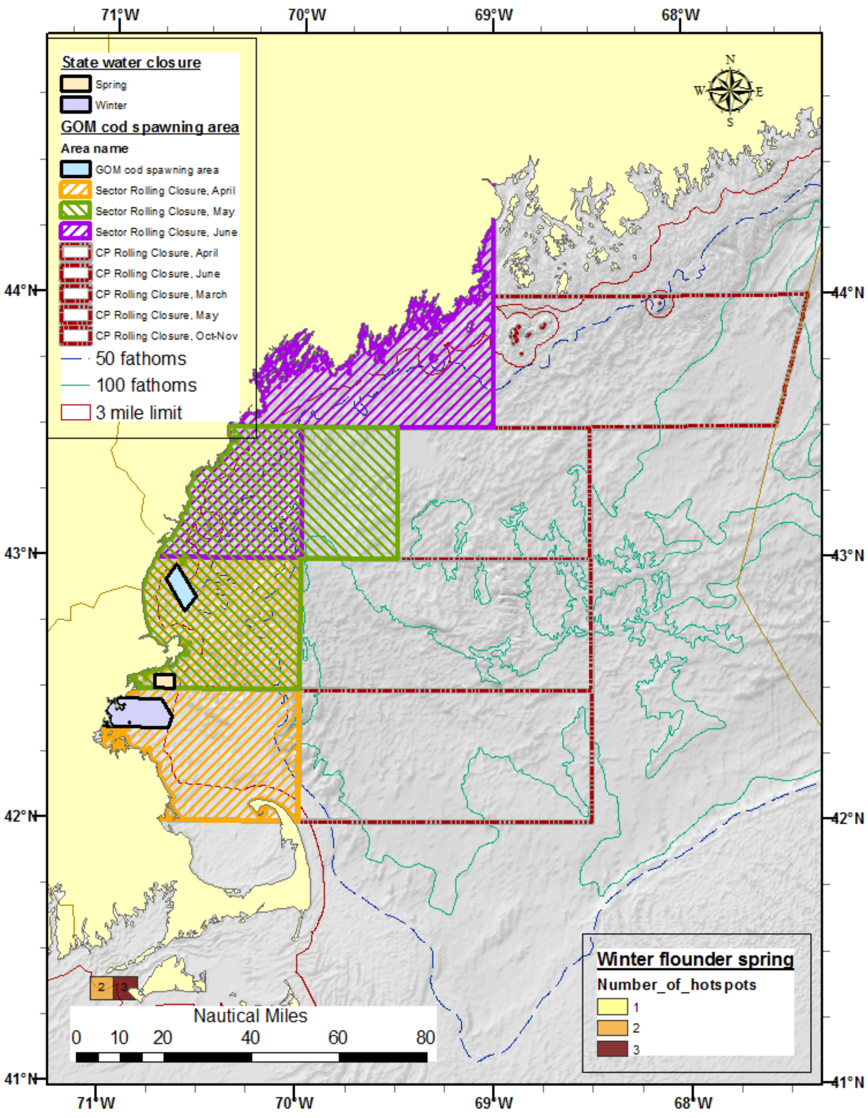
White hake



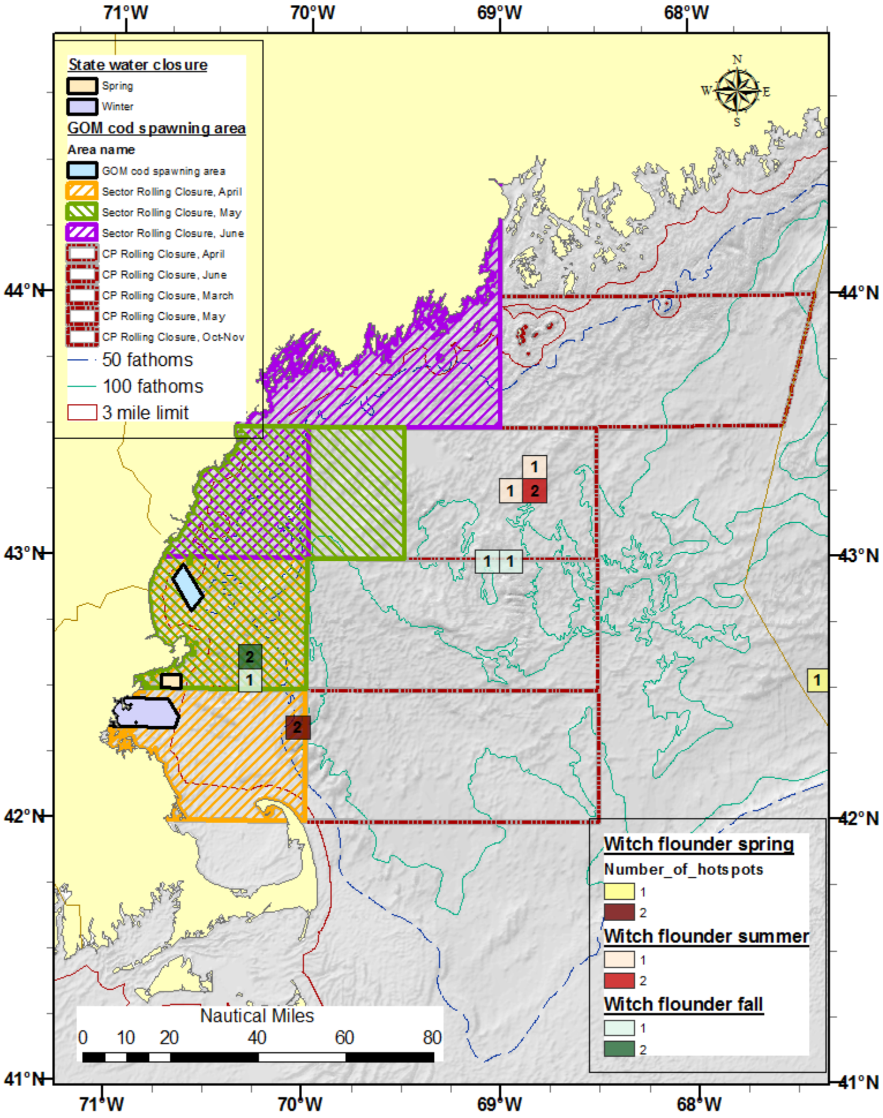
Windowpane flounder



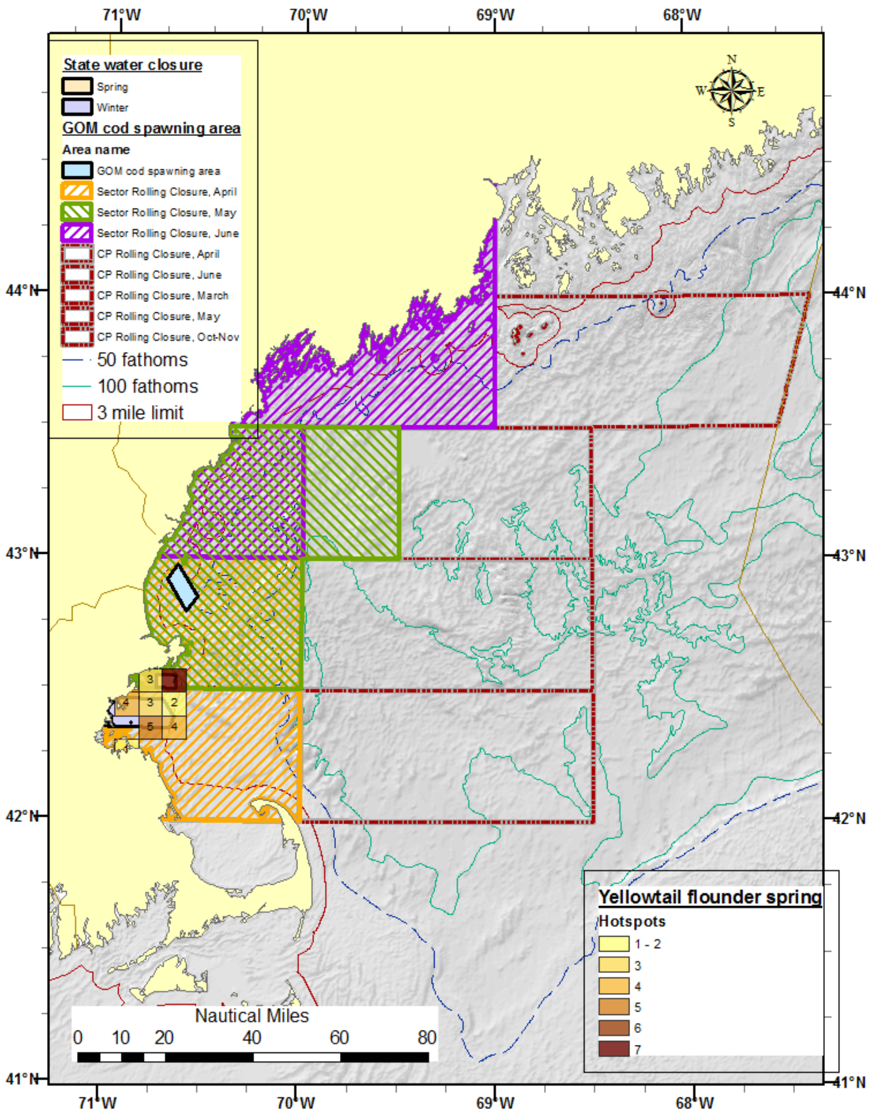
Winter flounder



Witch flounder



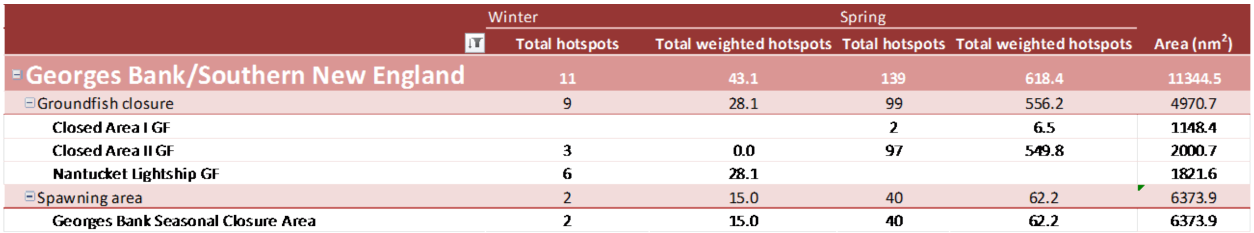
Yellowtail flounder



4.2.2.2.2 Georges Bank/Southern New England region

The total number of hotspots and weighted hotspots summed over all groundfish species for Georges Bank No Action management areas is summarized in the table below. The total weighted large spawner hotspots are most numerous in the spring, particular in Closed Area II. Some large spawner groundfish hotspots were identified (weighted value 62.2) in the Georges Bank Seasonal Closure Area, but the spring trawl survey occurs a few months before this area is closed in May and the summer dredge survey occurs a few months after. A few hotspots were identified in the Nantucket Lightship Area (weighted value 15.0), but these hotspots were from windowpane flounder catches, not cod.

Table 29 – Tota unweighted and weighted groundfish large spawner hotspots from 2002-2007 winter and 2002-2011 spring surveys by management area in the Georges Bank/Southern New England region.



	Winter		Spring		
	Total hotspots	Total weighted hotspots	Total hotspots	Total weighted hotspots	Area (nm^2)
⊟ **Georges Bank/Southern New England**	11	43.1	139	618.4	11344.5
⊟ Groundfish closure	9	28.1	99	556.2	4970.7
Closed Area I GF			2	6.5	1148.4
Closed Area II GF	3	0.0	97	549.8	2000.7
Nantucket Lightship GF	6	28.1			1821.6
⊟ Spawning area	2	15.0	40	62.2	6373.9
Georges Bank Seasonal Closure Area	2	15.0	40	62.2	6373.9

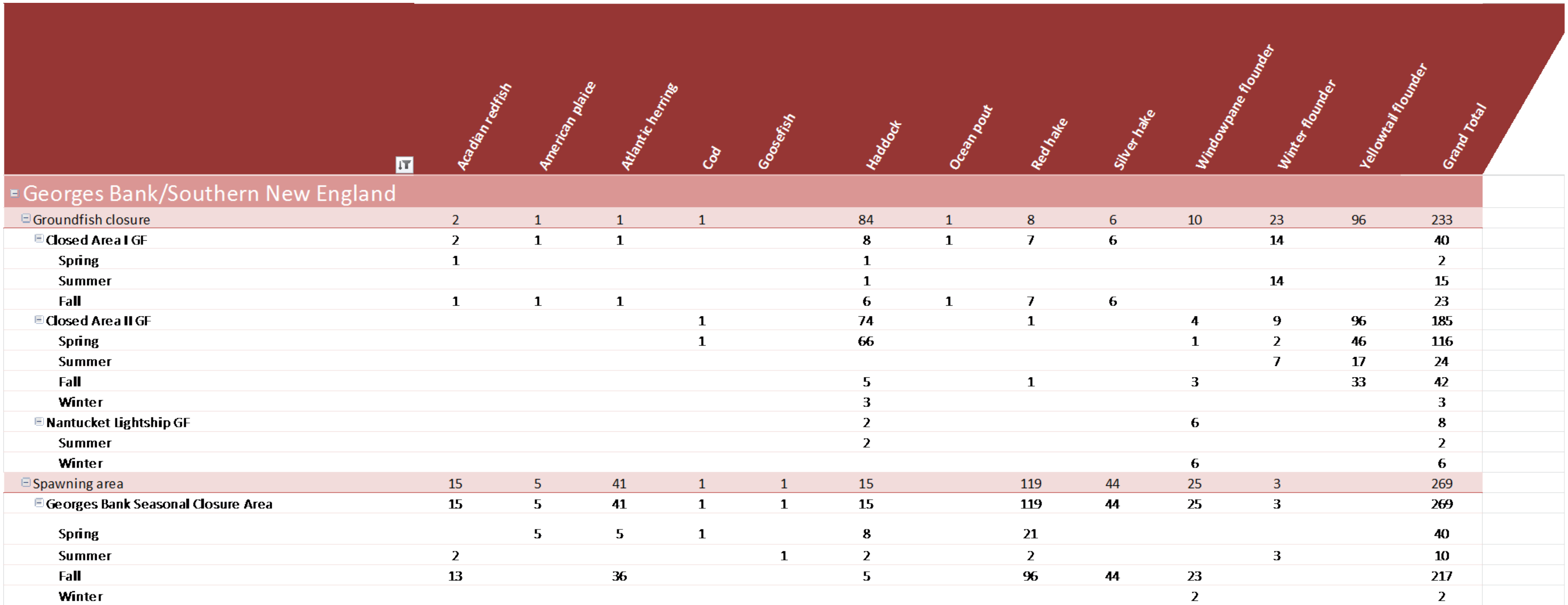
The general distribution of the weighted hotspots for the spring, fall, summer, and winter seasons are shown in Map 106. Generally, the weighted large spawner groundfish hotspots are clustered in Closed Area II during the spring, primarily from haddock and yellowtail flounder (Map 107). Closed Area II appears to be well sited to reduce the impacts on fishing on spawning haddock and yellowtail flounder, but since Scallop Framework Adjustment 25 this area is now open to fishing by scallop dredges. In the fall survey, large spawner hotspots were identified on the northern portion of Georges Bank and in the Cultivator Shoals Area east of Closed Area I (Map 106), almost entirely from windowpane flounder hotspots (Map 107). The timing of windowpane flounder spawning is not well-defined.

No large spawner groundfish hotspots were identified by the data from the summer dredge survey (Map 106), although if they occurred, non-zero weights would have applied to cod, witch flounder, redfish, Atlantic halibut, ocean pout, and windowpane flounder (Table 30). The lack of large spawner hotspots is probably the result of low catchability of large fish in the noisy and relatively narrow lined scallop dredge.

Hotspots were identified from winter survey data in the southern portion of the Great South Channel, south of Closed Area I and east of the Nantucket Lightship Area (Map 106). These hotspots were mainly the result of the presence of high biomass levels for windowpane flounder (MAP).

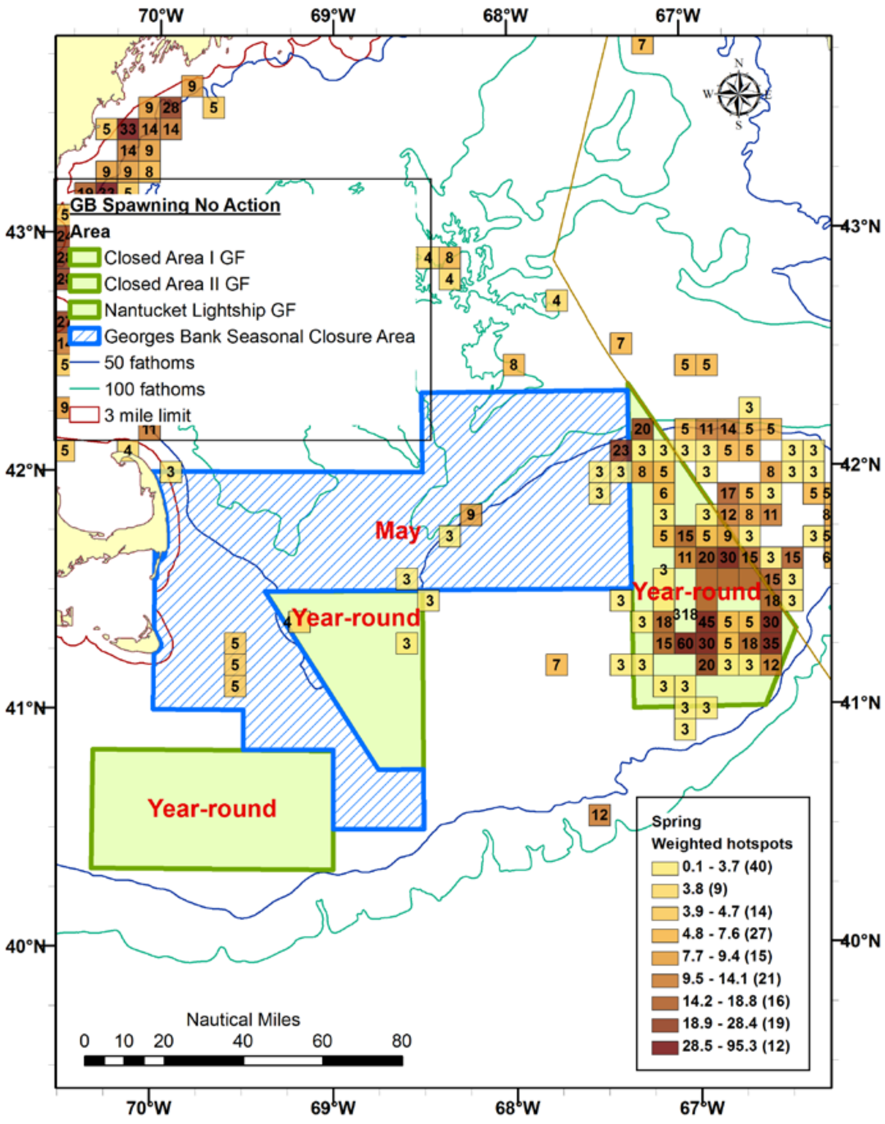
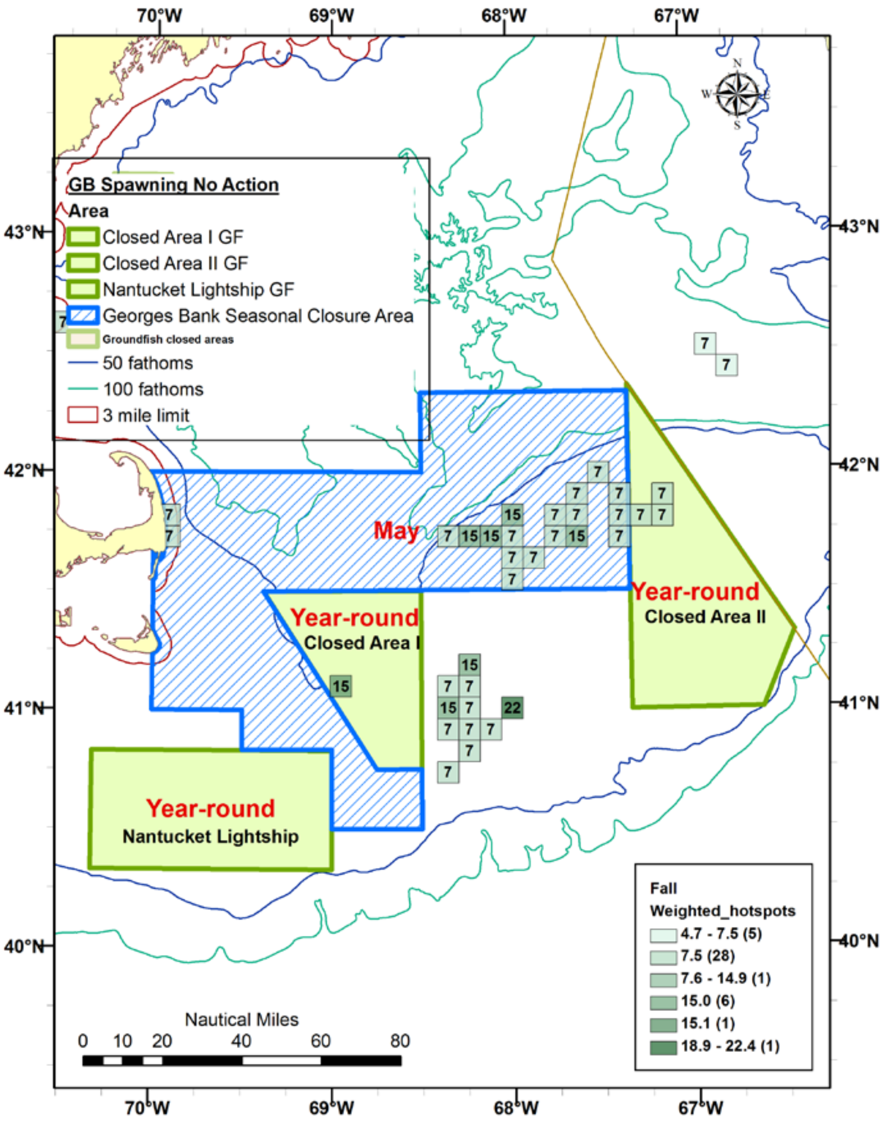
Hotspots in the Georges Bank/Southern New England region for other groundfish species were relatively sparse, including hotspots from cod catches. Only two cod hotspots were identified on the northern edge (Map 107), although a broader distribution of mature size cod are caught in the spring survey (Map 108). Although there are relatively few hotspots located in Closed Area I, there are large cod and haddock caught there by surveys, particularly in portions overlapping the Great South Channel and in the deeper water in the northern half of Closed Area I (Map 108). Past observations indicated that cod and haddock spawn in this area during the spring and were the basis for the original Closed Area I (and Closed Area II) designations. During the spring surveys, few developing and ripe cod were caught on Georges Bank, except in the southern part of Closed Area I (Map 109, top). A considerable proportion of haddock were however in developing or ripe condition during the spring surveys in most areas of Eastern Georges Bank and in the northern 2/3rds of Closed Area I (Map 109, bottom).

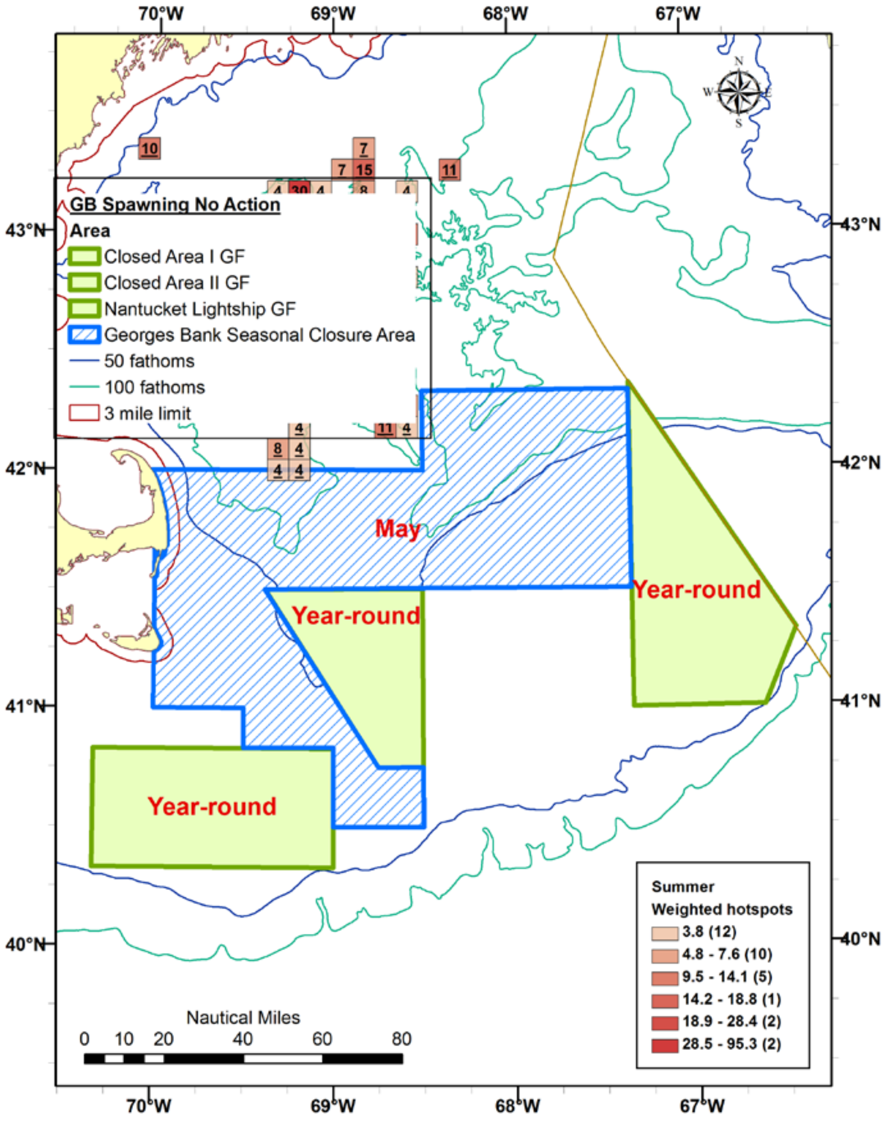
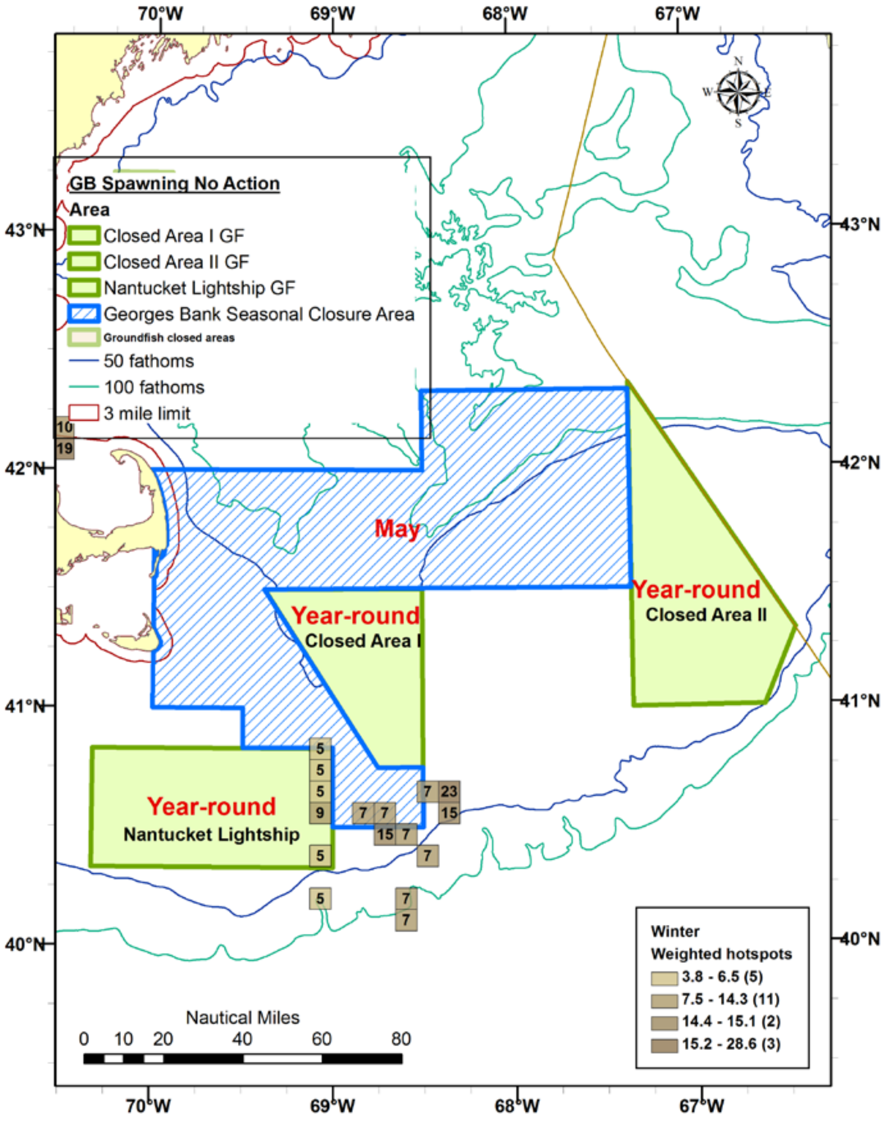
Table 30 – Total number of large spawner hotspots by species, management area, and survey season in the Georges Bank/Southern New England region.



	Acadian redfish	American plaice	Atlantic herring	Cod	Goosefish	Haddock	Ocean pout	Red hake	Silver hake	Windowpane flounder	Winter flounder	Yellowtail flounder	Grand Total
Georges Bank/Southern New England													
Groundfish closure	2	1	1	1		84	1	8	6	10	23	96	233
Closed Area I GF	2	1	1			8	1	7	6		14		40
Spring	1					1							2
Summer						1					14		15
Fall	1	1	1			6	1	7	6				23
Closed Area II GF				1		74		1		4	9	96	185
Spring				1		66				1	2	46	116
Summer											7	17	24
Fall						5		1		3		33	42
Winter						3							3
Nantucket Lightship GF						2				6			8
Summer						2							2
Winter										6			6
Spawning area	15	5	41	1	1	15		119	44	25	3		269
Georges Bank Seasonal Closure Area	15	5	41	1	1	15		119	44	25	3		269
Spring		5	5	1		8		21					40
Summer	2				1	2		2			3		10
Fall	13		36			5		96	44	23			217
Winter										2			2

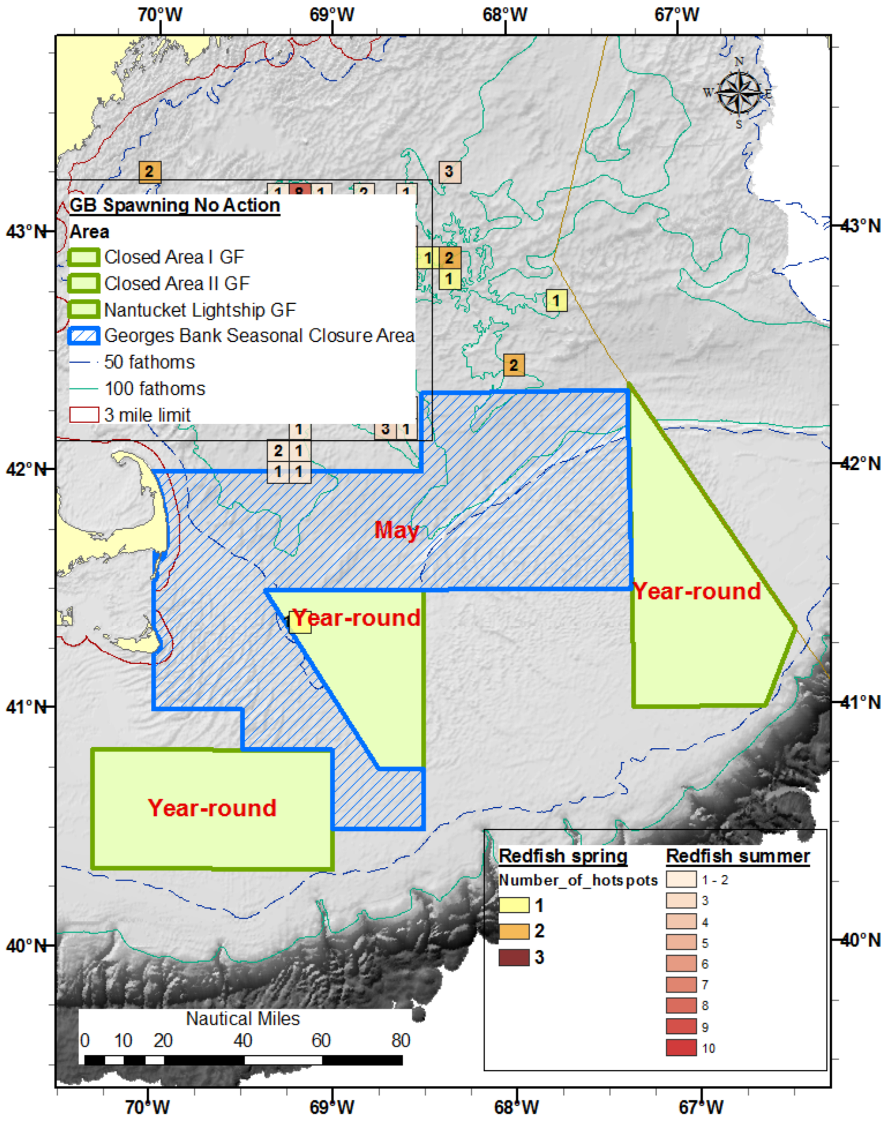
Map 106 – Distribution of weighted large spawner groundfish hotspots in the Georges Bank/Southern New England region by season, derived from 2002-2012 NMFS, MADMF, and IBS survey data. Continued on the next page.

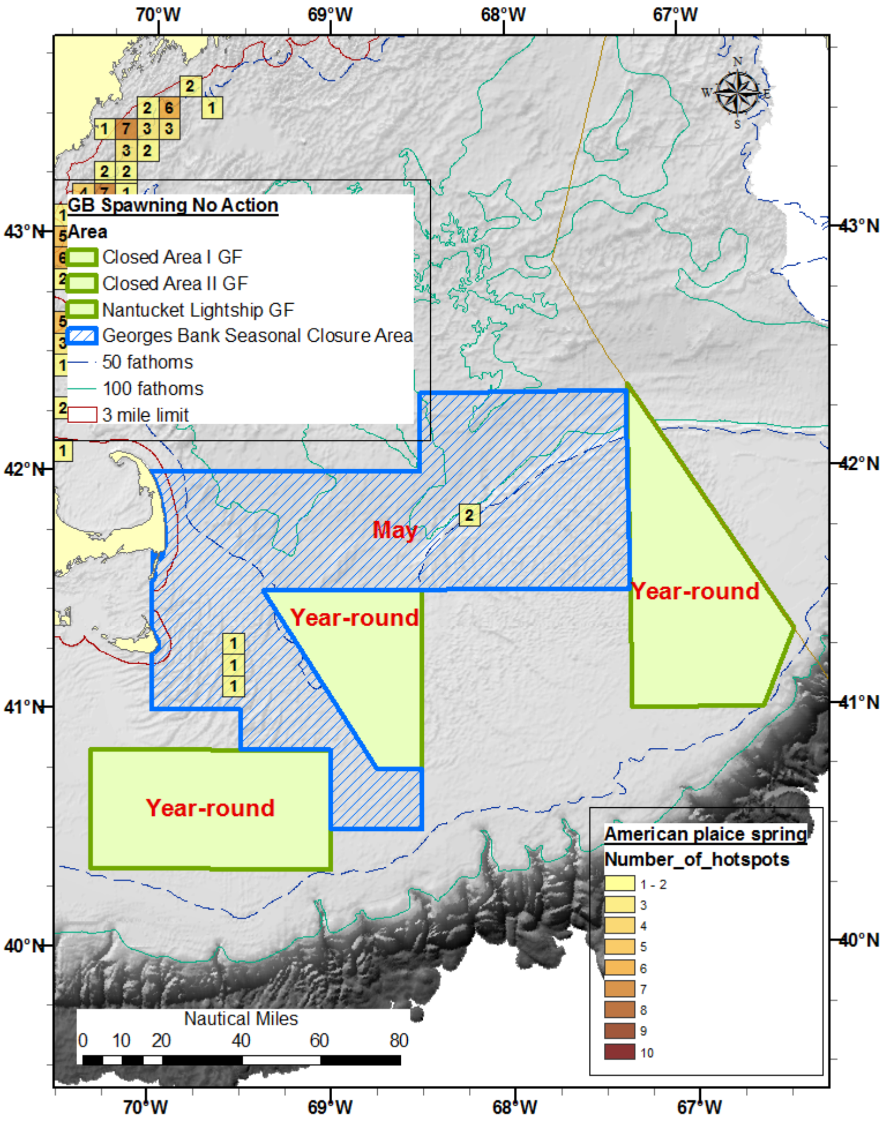
Spring	Fall
	

Summer	Winter
	

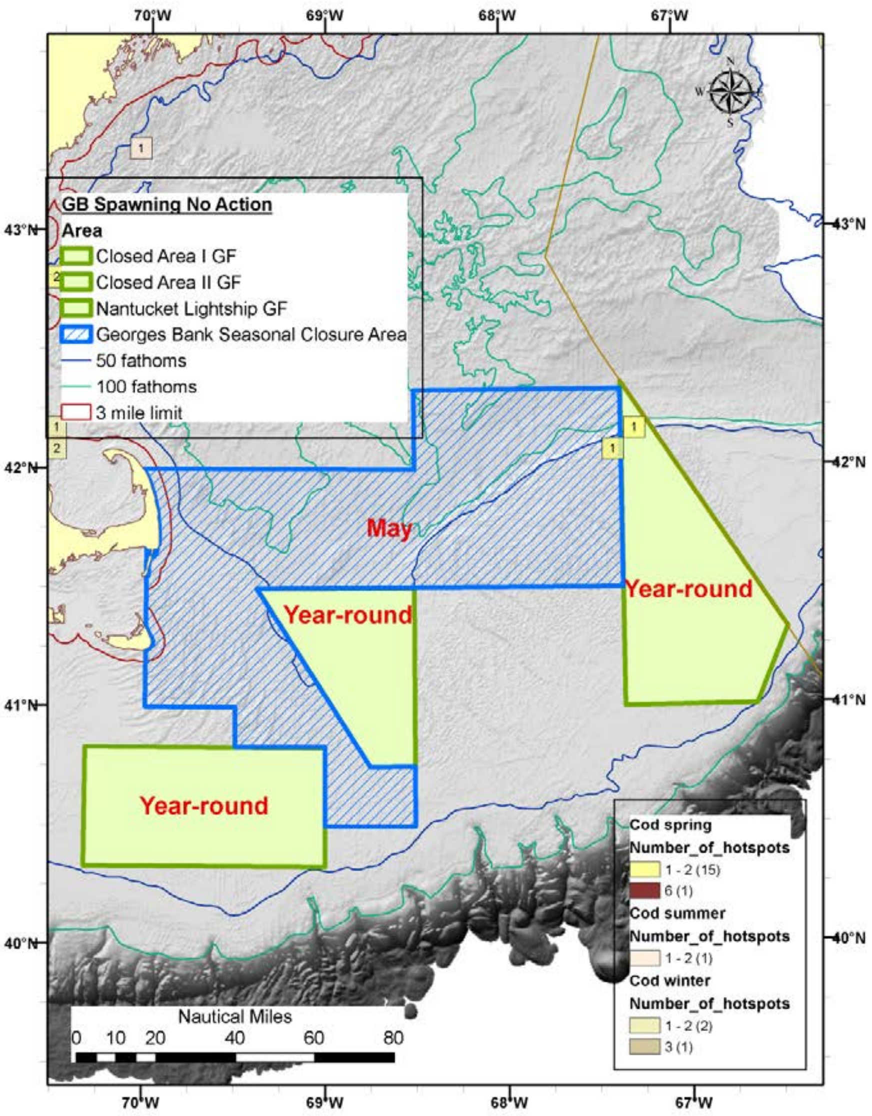
Map 107 – Seasonal distribution of large spawner hotspots for individual groundfish species in the Georges Bank/Southern New England region identified from 2002-2012 NMFS, MADMF, ME-NH, and IBS trawl surveys. Continued on the following 6 pages.

Acadian redfish	American plaice

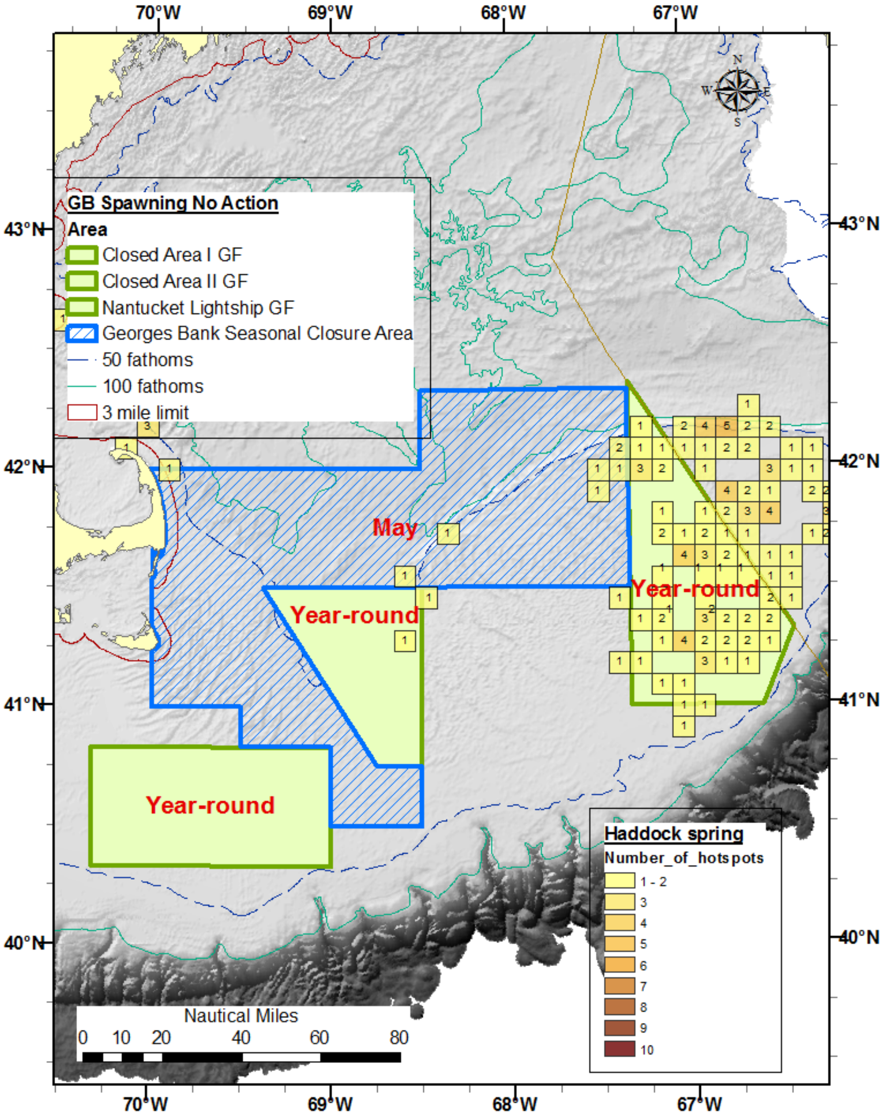




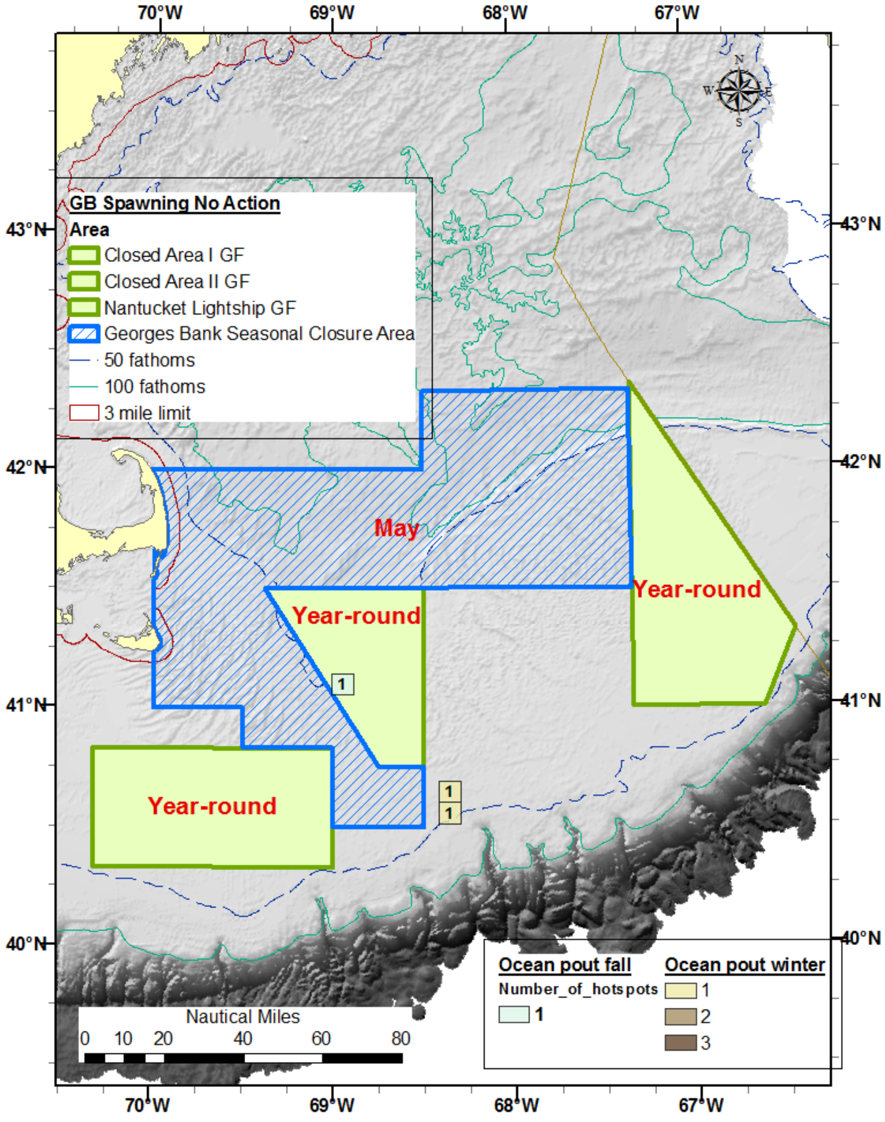
Cod


70°W
69°W
68°W
67°W
43°N
42°N
41°N
40°N
N
S
W
GB Spawning No Action
Area
Closed Area I GF
Closed Area II GF
Nantucket Lightship GF
Georges Bank Seasonal Closure Area
50 fathoms
100 fathoms
3 mile limit
May
Year-round
Year-round
Year-round
Nautical Miles
0 10 20 40 60 80
Cod spring
Number_of_hotspots
1 - 2 (15)
6 (1)
Cod summer
Number_of_hotspots
1 - 2 (1)
Cod winter
Number_of_hotspots
1 - 2 (2)
3 (1)

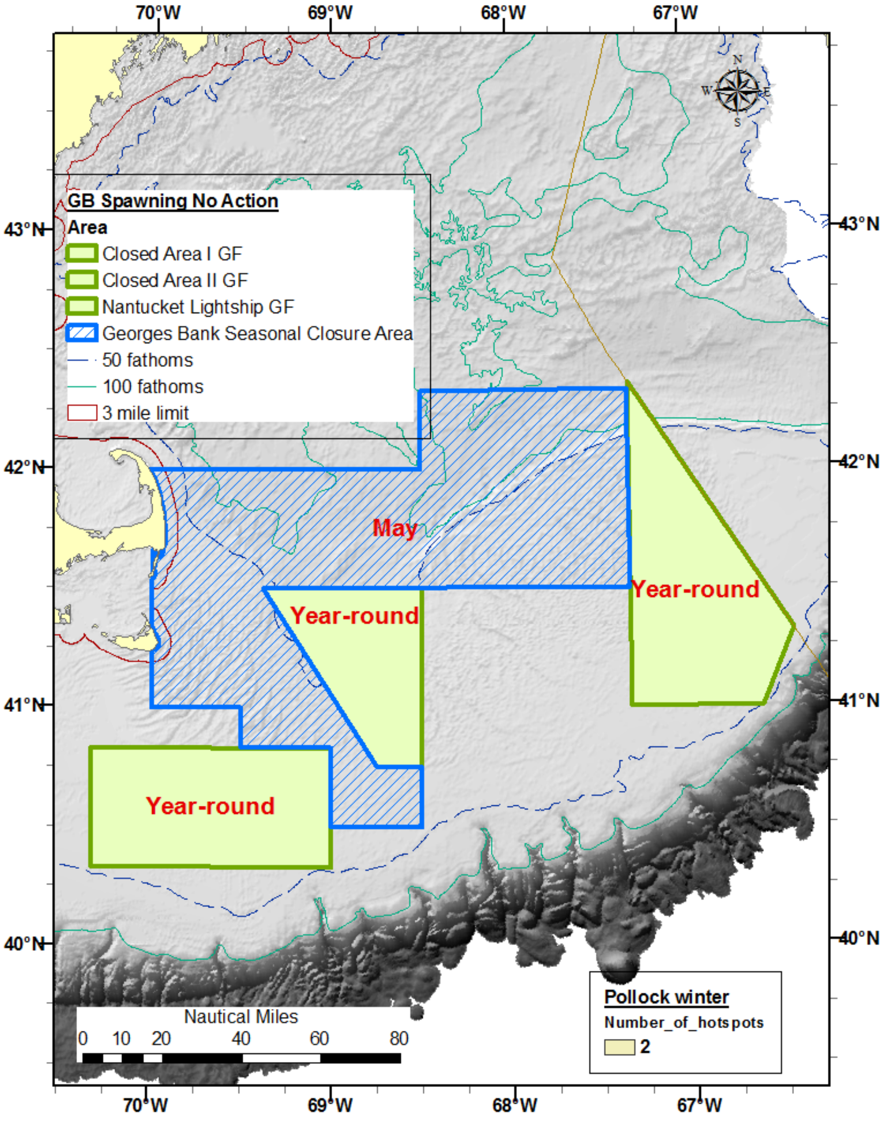
Haddock


70°W
69°W
68°W
67°W
43°N
42°N
41°N
40°N
N
S
W
E
GB Spawning No Action
Area
Closed Area I GF
Closed Area II GF
Nantucket Lightship GF
Georges Bank Seasonal Closure Area
50 fathoms
100 fathoms
3 mile limit
May
Year-round
Year-round
Year-round
Nautical Miles
0 10 20 40 60 80
Haddock spring
Number_of_hotspots
1 - 2
3
4
5
6
7
8
9
10

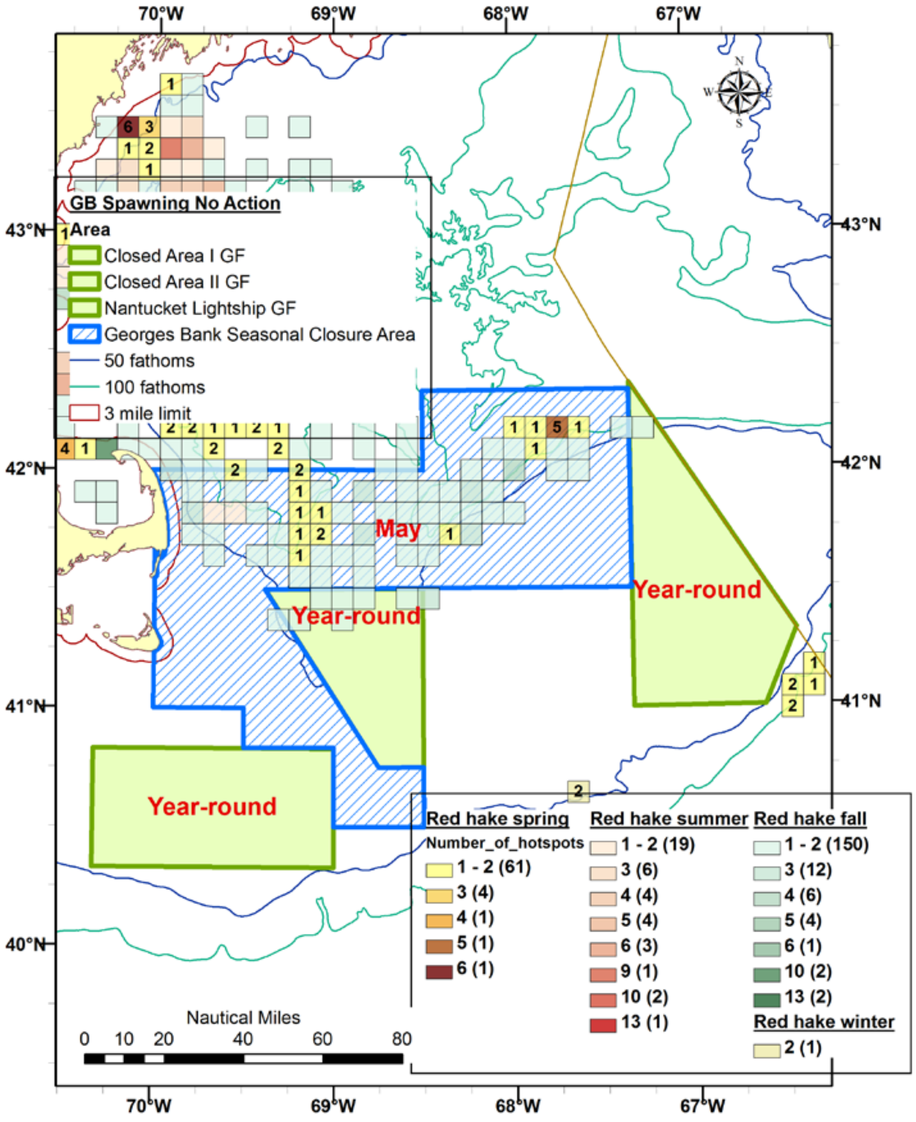
Ocean pout



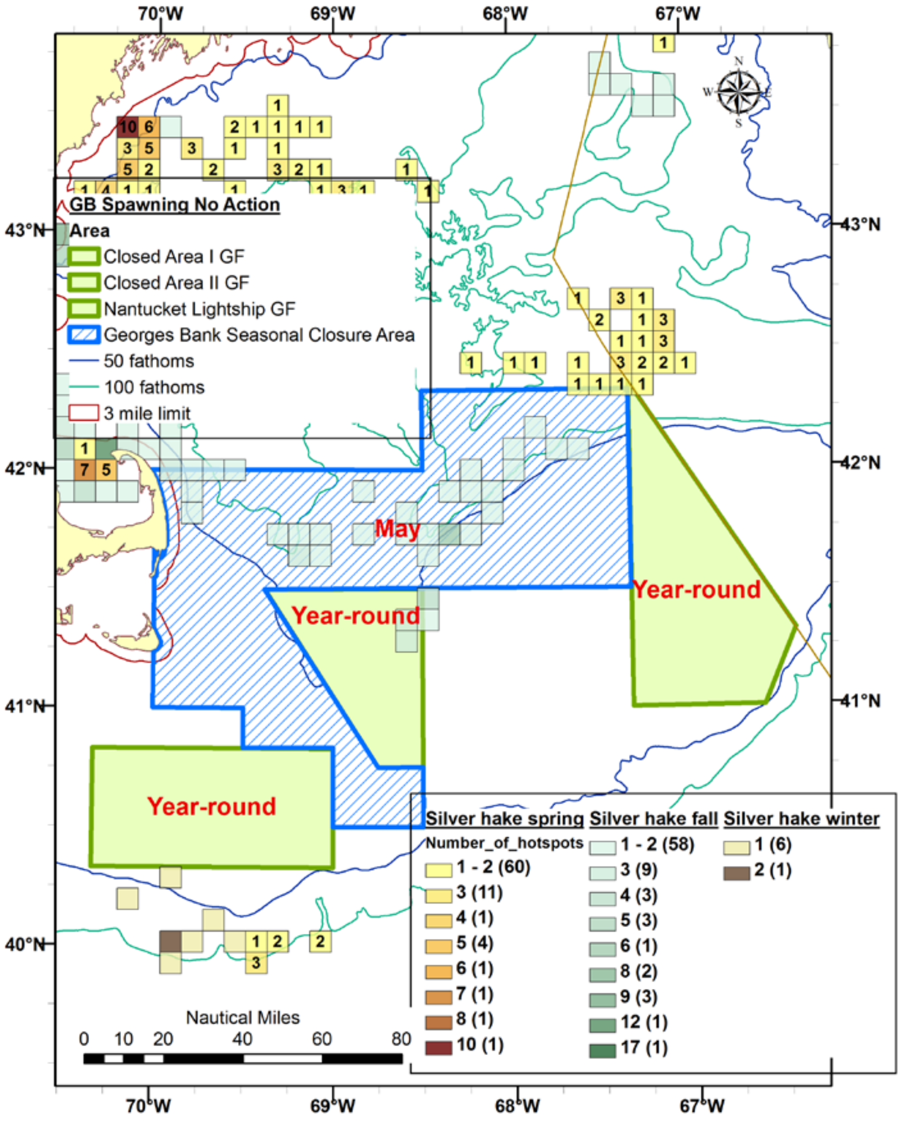
Pollock

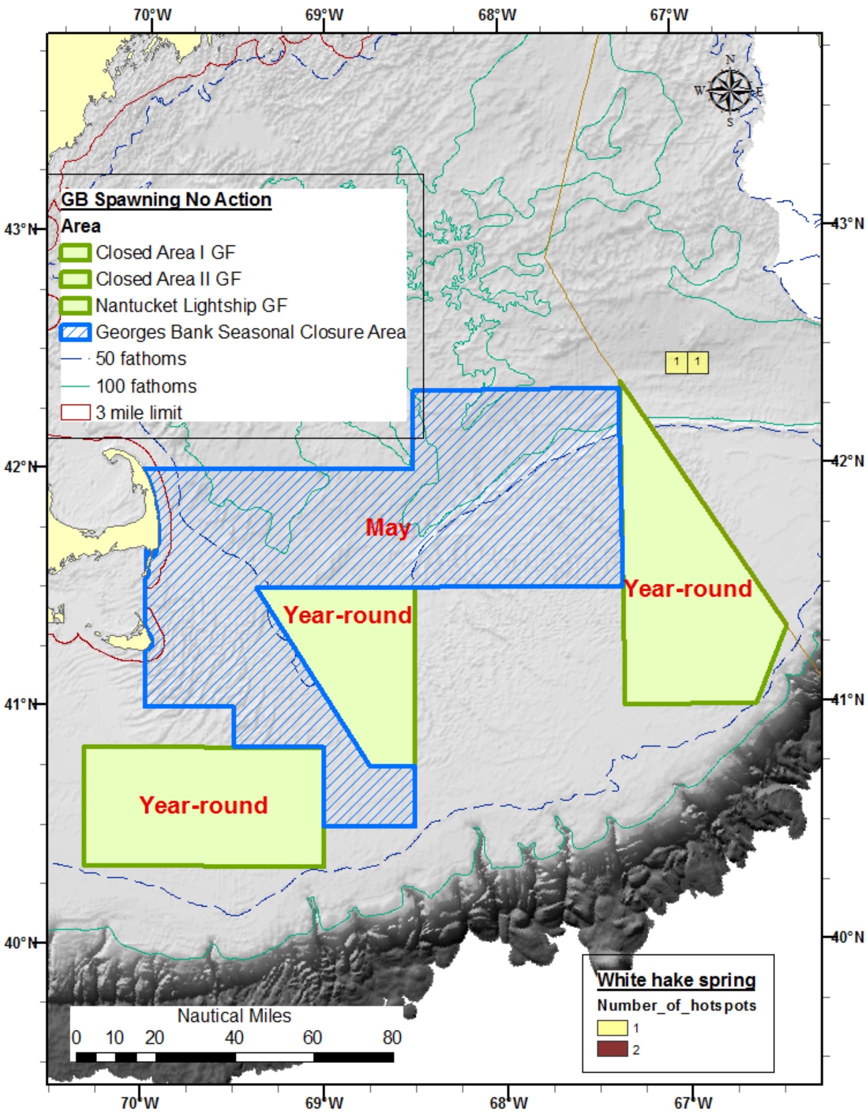
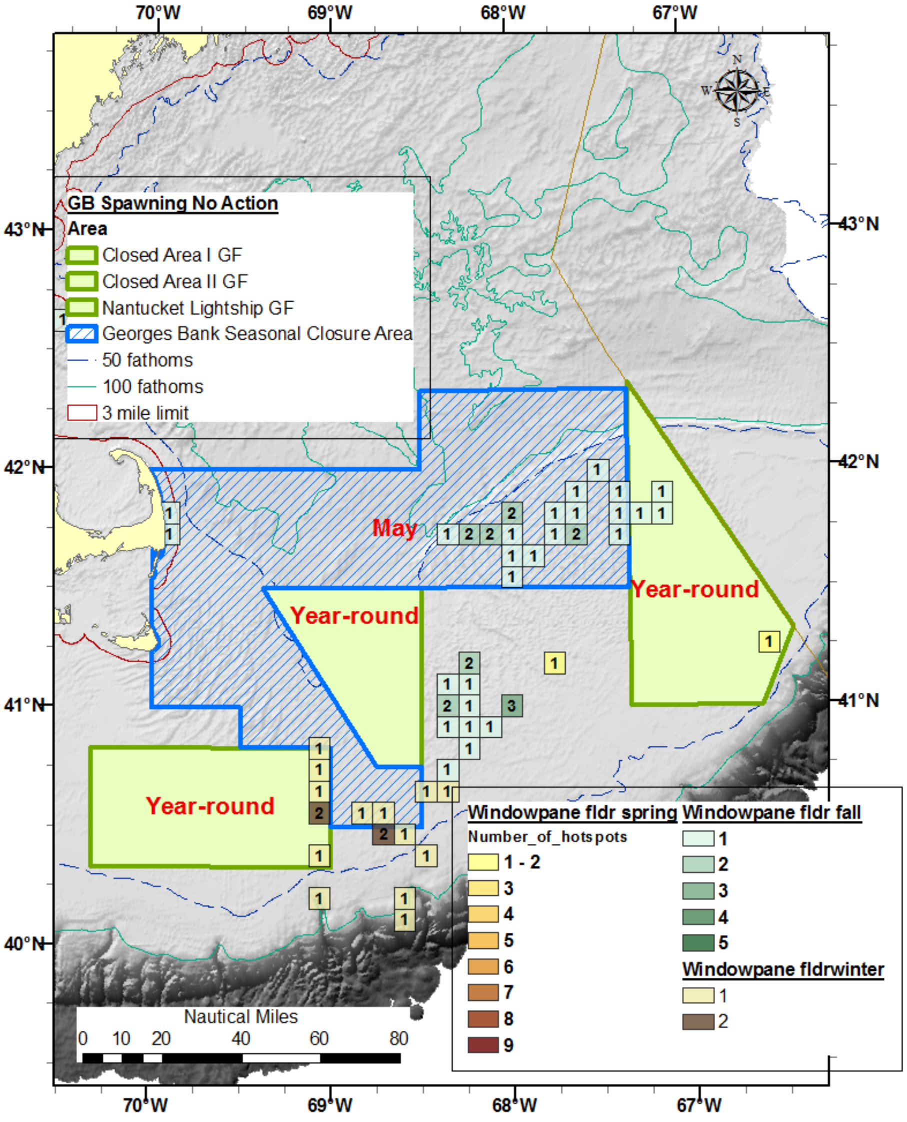


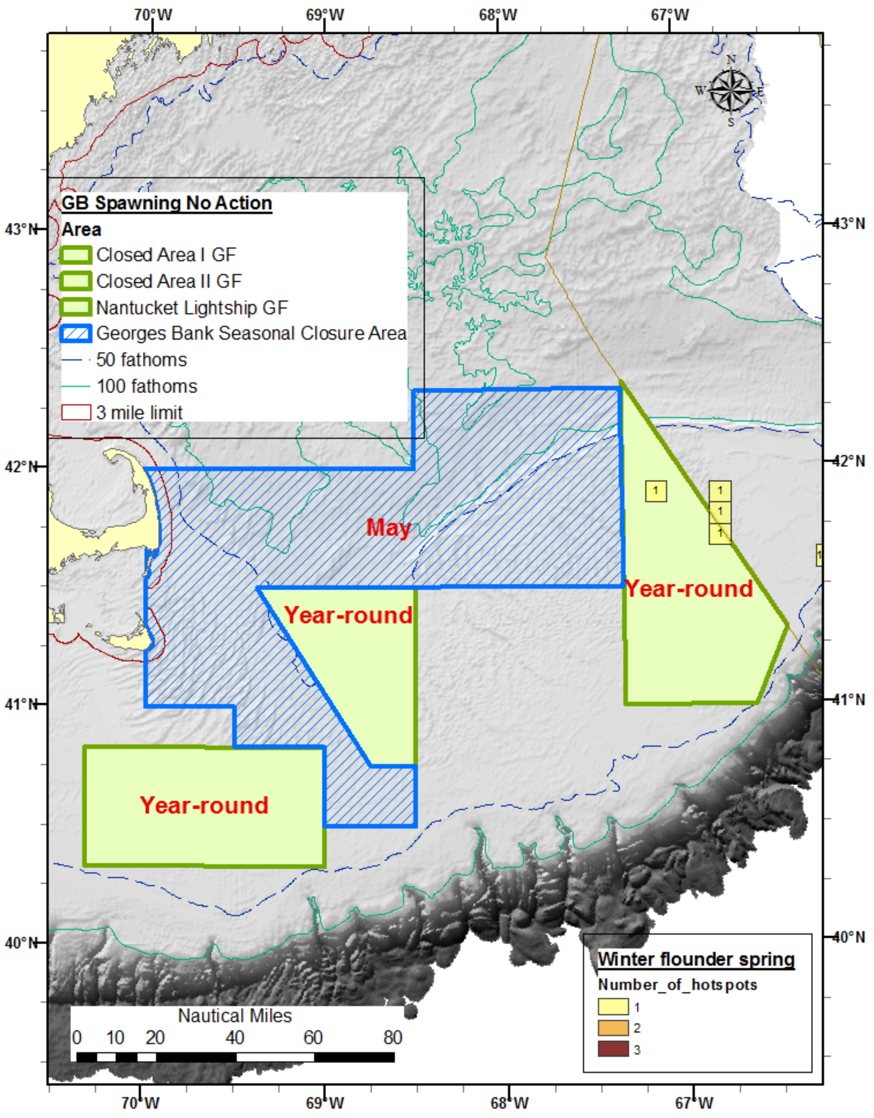
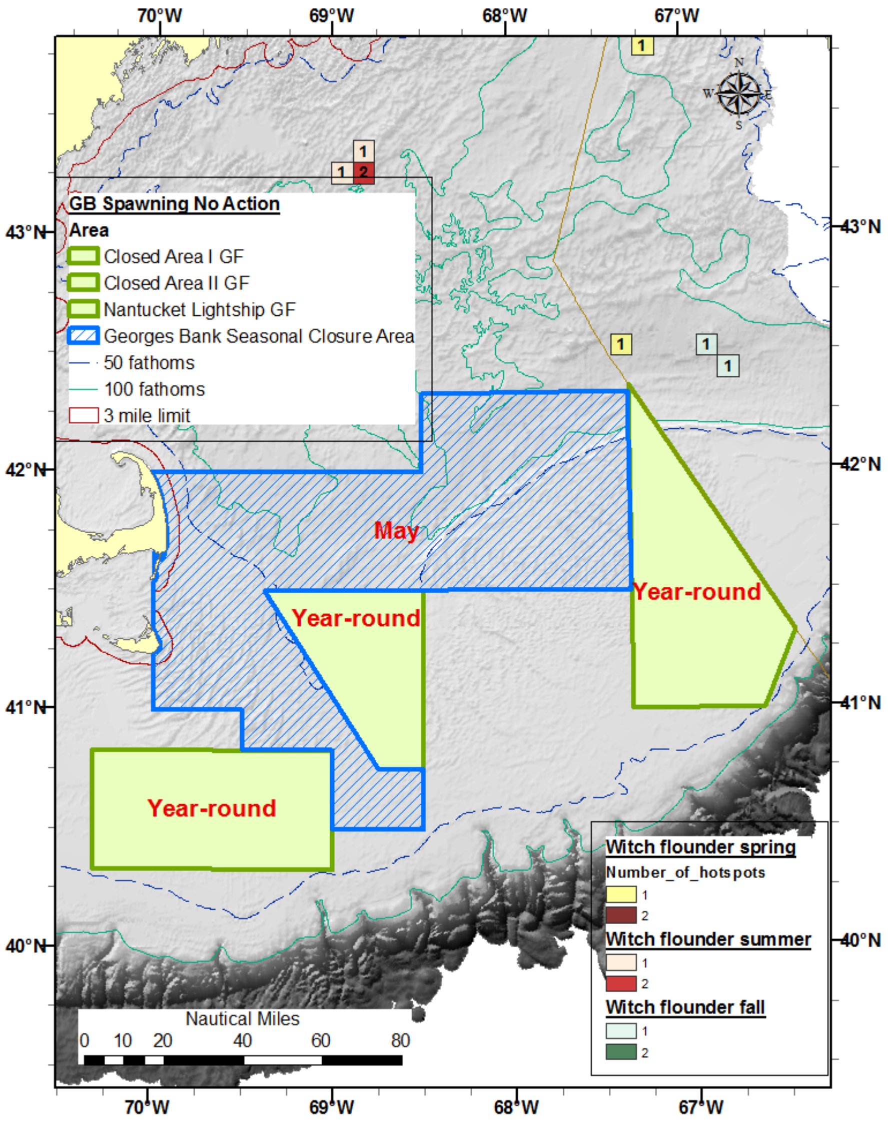
Red hake



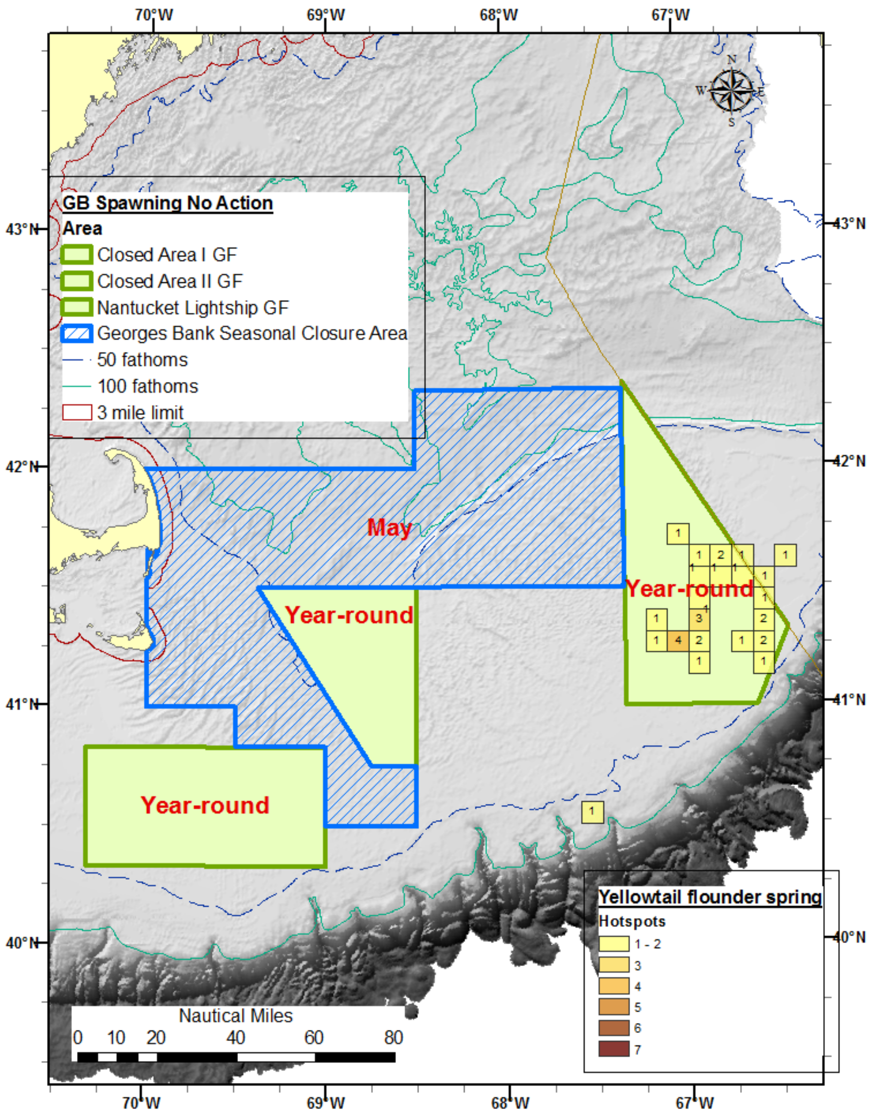
Silver hake



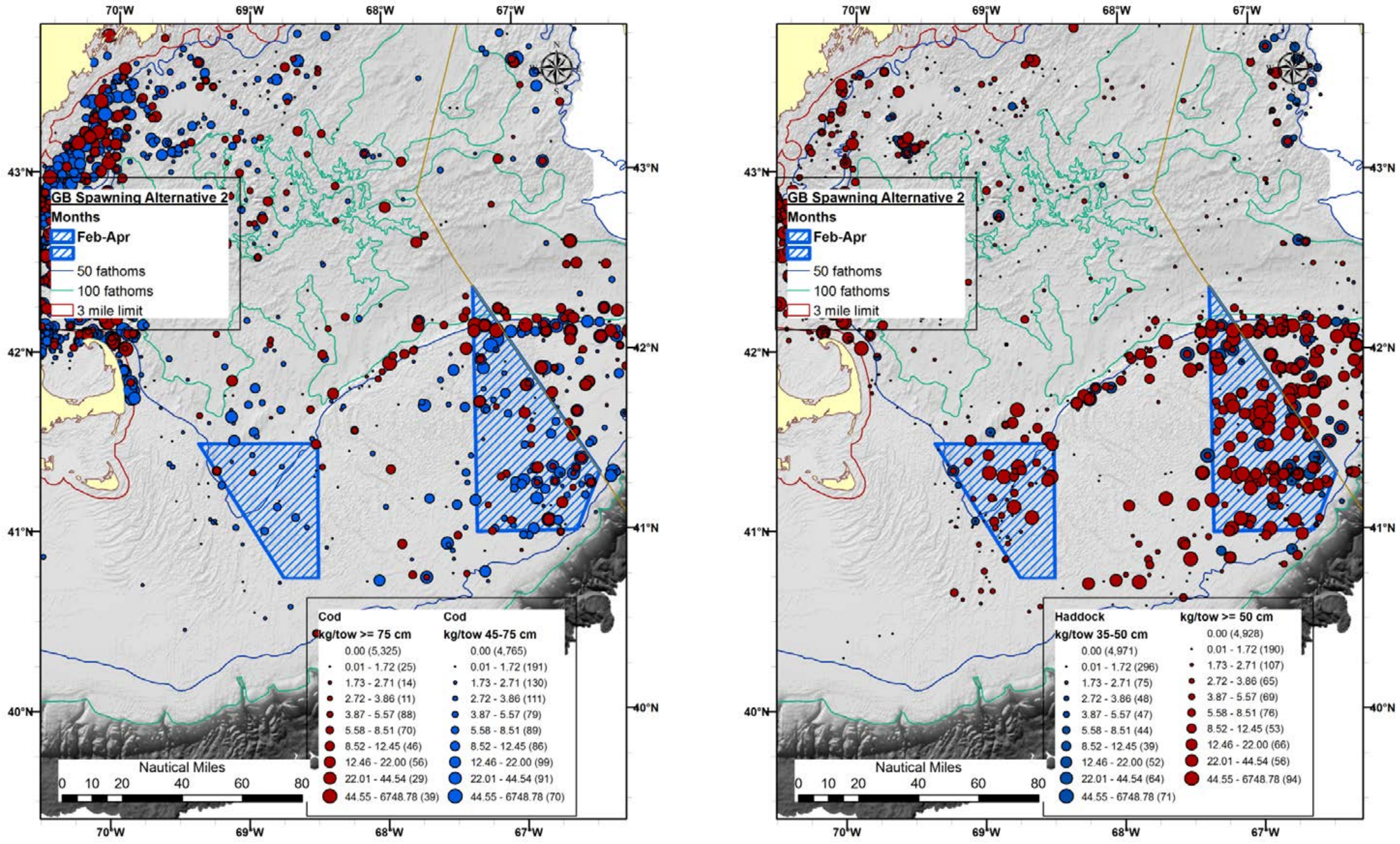
White hake	Windowpane flounder
	

Winter flounder	Witch flounder
	

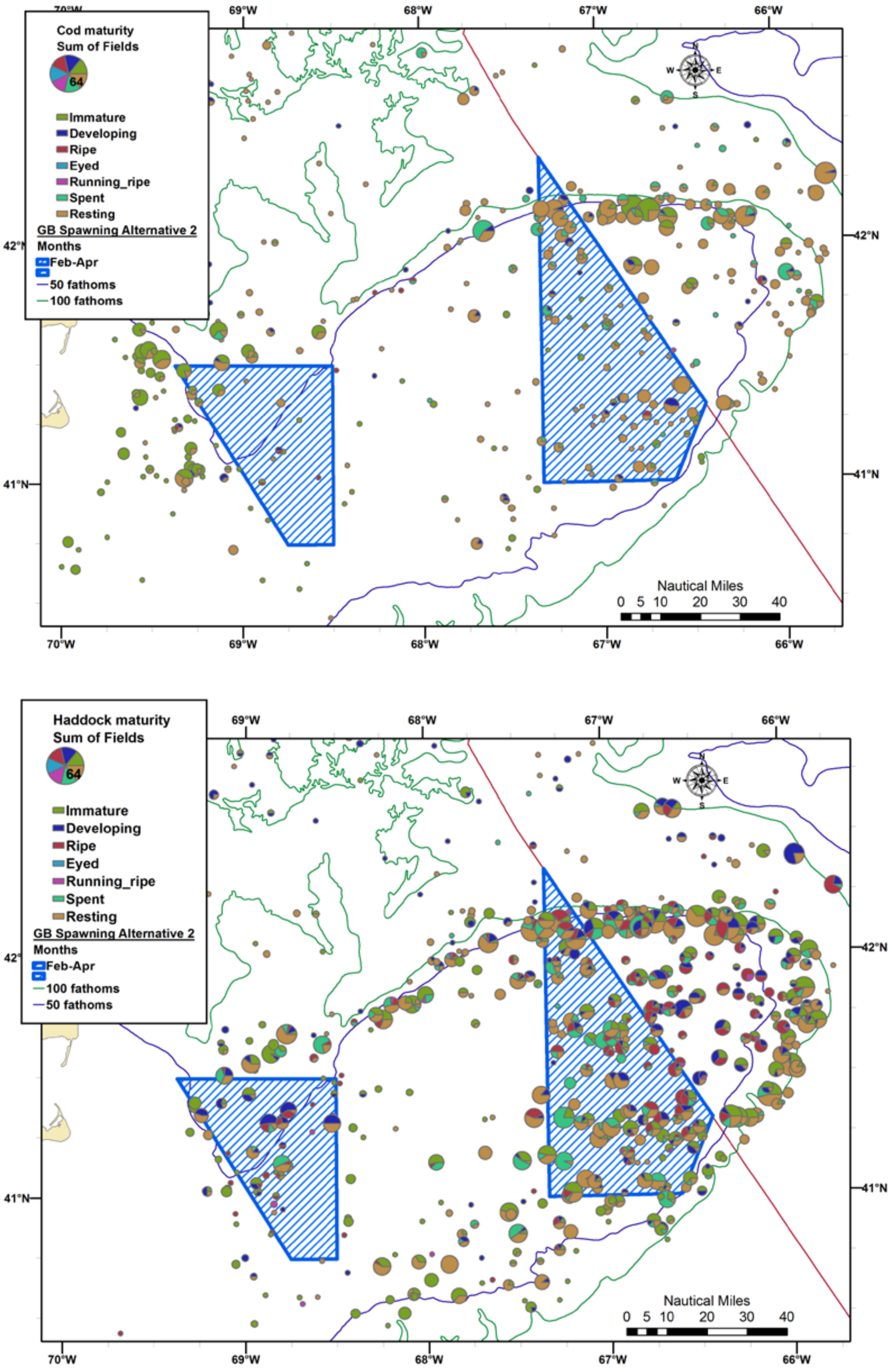
Yellowtail flounder	



Map 108 – Distribution of cod (left) and haddock (right) by small and large mature fish size classes during spring and summer surveys of Georges Bank during 2002-2011.



Map 109 – Distribution of cod (top) and haddock (bottom) by maturity stage during 2002-2011 surveys.



4.3 Human communities and the fishery

4.3.1 Fisheries and fishery management plans

The purpose of this section is to describe the major fisheries, managed by NEFMC or another authority, that operate within the NEFMC region, and could be affected by adjustments made in this action to areas managed or regulations for those areas. This section is intended to describe the basics of the management approach and summarize current conditions in the fisheries, including geographic scope, seasonality, target species (see section 4.1.2), and methods of fishing. This information provides context for the impacts analysis, and will help the reader of the amendment to understand why particular areas and measures may have an impact on specific fisheries. Detailed information about each fishery can be obtained from the descriptions of the affected environment provided in recent FMP documents specific to each plan.

Table 31 – Gear types used in the Northeast region, by FMP

Gear type	NEGEAR	NEGEAR2	Bottom tending gear?	Mobile gear?	FMP in which this gear is used	Notes
Dredge, ocean quahog and surfclam	400	40	Yes	Yes	Surfclam ocean quahog	Includes hydraulic and dry dredges
Dredge, sea scallop	132	13	Yes	Yes	Atlantic sea scallop	
Dredge, sea scallop w/chain mat	132	13	Yes	Yes	Atlantic sea scallop	
Gill net, runaround	500	50	Yes	No	?	
Gill net, sink	100	10	Yes	No	Northeast multispecies; Monkfish; Spiny dogfish	
Handline/rod and reel	20	2	Both	No	Northeast multispecies; Bluefish; Summer flounder, scup, and black sea bass	
Longline, bottom	10	1	Yes	No	Northeast multispecies; Spiny dogfish; Golden Tilefish	
Otter trawl, haddock separator	57	5	Yes	Yes	Northeast multispecies	
Otter trawl, scallop	52	5	Yes	Yes	Atlantic sea scallop	
Otter trawl, bottom fish	50	5	Yes	Yes	Northeast multispecies; Monkfish; Bluefish; Atlantic herring; Atlantic mackerel, squid, and butterfish; Spiny dogfish; Summer flounder, scup, and black sea bass	
Otter trawl, midwater	370	37	No	No	Atlantic herring; Atlantic mackerel, squid, and butterfish	

Gear type	NEGEAR	NEGEAR2	Bottom tending gear?	Mobile gear?	FMP in which this gear is used	Notes
Otter trawl, bottom, other	59	5	Yes	Yes	Northeast multispecies; Monkfish; Bluefish; Atlantic herring; Atlantic mackerel, squid, and butterfish; Spiny dogfish; Summer flounder, scup, and black sea bass	
Otter trawl, Ruhle	54	5	Yes	Yes	Northeast multispecies	
Otter trawl, bottom shrimp	58	5	Yes	Yes	Northern shrimp	
Pair trawl, bottom	56	5	Yes	Yes	?	
Pot, crab	300	30	Yes	No	Deep-sea red crab	
Pot, fish	181	18	Yes	No	Northeast multispecies; Summer flounder, scup, and black sea bass	
Pot, lobster	200	20	Yes	No	American lobster	
Pair trawl, midwater	170	17	No	No	Atlantic herring	
Pot, shrimp	190	19	Yes	No	Northern shrimp	
Seine, purse	120	12	Yes	No	Atlantic herring	
Trap	80	8	Yes	No	?	

Table 32 – Species associated with each FMP

Species	NESPP_3	FMP	Notes
Acadian redfish	240	Northeast multispecies large mesh	
American plaice	124	Northeast multispecies large mesh	
Atlantic cod	81	Northeast multispecies large mesh	
Atlantic halibut	159	Northeast multispecies large mesh	Not allocated to sectors
Atlantic wolffish	512	Northeast multispecies large mesh	Not allocated to sectors
Haddock	147	Northeast multispecies large mesh	
Ocean pout	250	Northeast multispecies large mesh	Not allocated to sectors; only large mesh species that is not a "regulated species"
Pollock	269	Northeast multispecies large mesh	
White hake	153	Northeast multispecies large mesh	
Windowpane flounder	125	Northeast multispecies large mesh	Not allocated to sectors
Winter flounder	120	Northeast multispecies large mesh	
Witch flounder	122	Northeast multispecies large mesh	
Yellowtail flounder	123	Northeast multispecies large mesh	
Silver hake	509	Northeast multispecies large mesh	
Offshore hake	508	Northeast multispecies large mesh	Likely to be rare in catches
Red hake	152	Northeast multispecies small mesh	
Monkfish	13	Monkfish	

Species	NESPP_3	FMP	Notes
Smooth skate	369	Skates	
Thorny skate	370	Skates	
Barndoor skate	368	Skates	
Little skate	366	Skates	Most landings little or winter
Winter skate	367	Skates	Most landings little or winter
Clearnose skate	372	Skates	
Rosette skate	364	Skates	
Unclassified skate or skate wing	365	Skates	Many landings will fall into this category
Atlantic sea scallop	800	Atlantic sea scallop	
Atlantic herring	168	Atlantic herring	
Deep-sea red crab	710	Deep-sea red crab	
Surfclam	769	Surfclam and ocean quahog	
Ocean quahog	754	Surfclam and ocean quahog	
Northern shrimp	736	Northern shrimp	
American lobster	727	American lobster	
Atlantic bluefish	23	Atlantic bluefish	
Atlantic mackerel	212	Atlantic mackerel, squid, and butterfish	
Longfin squid	801	Atlantic mackerel, squid, and butterfish	
Shortfin squid	802	Atlantic mackerel, squid, and butterfish	
Butterfish	51	Atlantic mackerel, squid, and butterfish	
Spiny dogfish	352	Spiny dogfish	
Summer flounder	121	Summer flounder, scup, and black sea bass	
Scup	329	Summer flounder, scup, and black sea bass	
Black sea bass	335	Summer flounder, scup, and black sea bass	
Golden tilefish	446	Tilefish	

4.3.1.1 Northeast multispecies (large mesh)

The Northeast Multispecies Fishery Management Plan developed by the NEFMC regulates catches of both large mesh and small mesh groundfish. Although managed under a single plan, the large mesh and small mesh groundfish fisheries operate differently and the regulations for large mesh and small mesh are generally developed by separate NEFMC oversight committees and via separate FMP amendments, framework adjustments, and specifications packages. A brief history specific to spatial management measures in the multispecies fishery is provided in the management background section of this document (section 3.3.2).

Large mesh species include the following (some species are assessed and allocated by stock):

- Acadian redfish
- American plaice
- Atlantic cod (GOM, GB)
- Atlantic halibut*
- Atlantic wolffish*
- Haddock (GOM, GB)
- Ocean pout*
- Pollock
- White hake
- Windowpane flounder (Northern, Southern)*
- Winter flounder (GOM, GB, SNE/MA)
- Witch flounder
- Yellowtail flounder (CC/GOM, GB, SNE/MA)

** Stock is not allocated to sectors as an Annual Catch Entitlement, bycatch only fishery*

In 1986, the NEFMC implemented the Northeast Multispecies FMP with the goal of rebuilding stocks. Since Amendment 5 in 1994, the multispecies fishery has been administered as a limited access fishery managed through a variety of effort control measures including DAS, area closures, trip limits, minimum size limits, and gear restrictions. Landings decreased throughout the latter part of the 1980’s until reaching a more or less constant level of around 40,000 tons (36,287 mt) annually since the mid 1990’s.

Over a ten year period, the fishery has gradually transitioned to a management system where most commercial fishermen participate in sectors. In 2004, the final rule implementing Amendment 13 to the Northeast Multispecies FMP allowed for self-selecting groups of limited access groundfish permit holders to form sectors. These sectors developed a legally binding operations plan and operated under an allocation of GB cod. While approved sectors were subject to general requirements specified in Amendment 13, sector members were exempt from DAS and some of the other effort control measures that tended to limit the flexibility of fishermen. The 2004 rule also authorized implementation of the first sector, the GB Cod Hook Sector. A second sector, the GB Cod Fixed Gear Sector, was authorized in 2006.

Amendment 16 (implemented 2010) expanded the sector program substantially. In addition, Amendment 16 brought the FMP into compliance with the catch limit requirements and stock rebuilding deadlines of the 2006 reauthorization of the Magnuson-Stevens Act. This amendment included Annual Catch Limits for all 20 stocks in the groundfish complex. Since Amendment 16, sectors are allocated subdivisions of Annual Catch Limits called Annual Catch Entitlements based on the sector’s members collective catch history, and became exempt from many of the effort controls previously used to manage the fishery. During fishing year 2013, sectors received Annual Catch Entitlements for 10 of 13 groundfish species (14 stocks + quotas for Eastern U.S./Canada cod and haddock; 16 catch entitlements in total) in the FMP. Non-sector vessels fish in a “common pool” subject to a shared Annual Catch Limit.

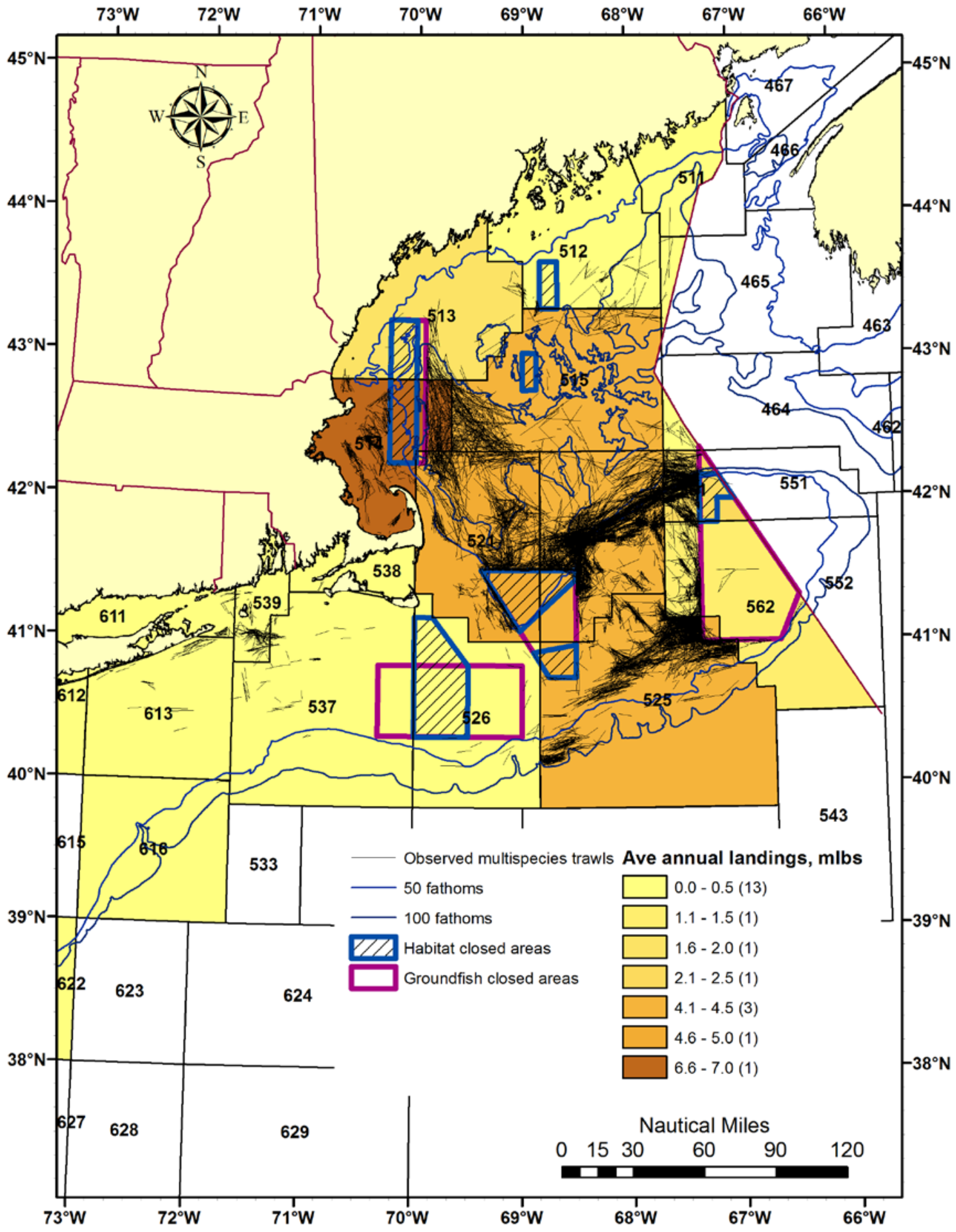
During the 2010 fishing year, seventeen sectors operated, each establishing its own rules for using its allocations. Vessels with limited access permits that joined sectors were allocated 98% of the total commercial groundfish sub-Annual Catch Limit, based on their collective level of historical activity in the groundfish fishery. Approximately half (46%) of the limited access groundfish permits opted to remain in the common pool. Common pool vessels act independently of one another, with each vessel constrained by the number of DAS it can fish, by trip limits, and by all of the time and area closures. These restrictions help ensure that the groundfish catch of common pool vessels does not exceed the common pool's portion of the commercial groundfish sub- Annual Catch Limit for all stocks (about 2% for 2010) before the end of the fishing year.

In 2011, the second year of sector management, 58% of limited access permits participated in one of 16 sectors or one of two lease-only sectors. From 2010 to 2011, the number of groundfish limited access eligibilities belonging to a sector increased by 66, while the number of these permits in the common pool decreased by 85. At the start of the 2011 fishing year, vessels operating within a sector were allocated about 98% of the total groundfish sub-Annual Catch Limit, based on historical catch levels. Those vessels that opted to remain in the common pool were given access to about 2% of the groundfish sub-Annual Catch Limit based on the historic catch. The same effort controls employed in 2010 were again used in 2011, to ensure the groundfish catch made by common pool vessels did not exceed the common pool's portion of the commercial groundfish sub-Annual Catch Limit.

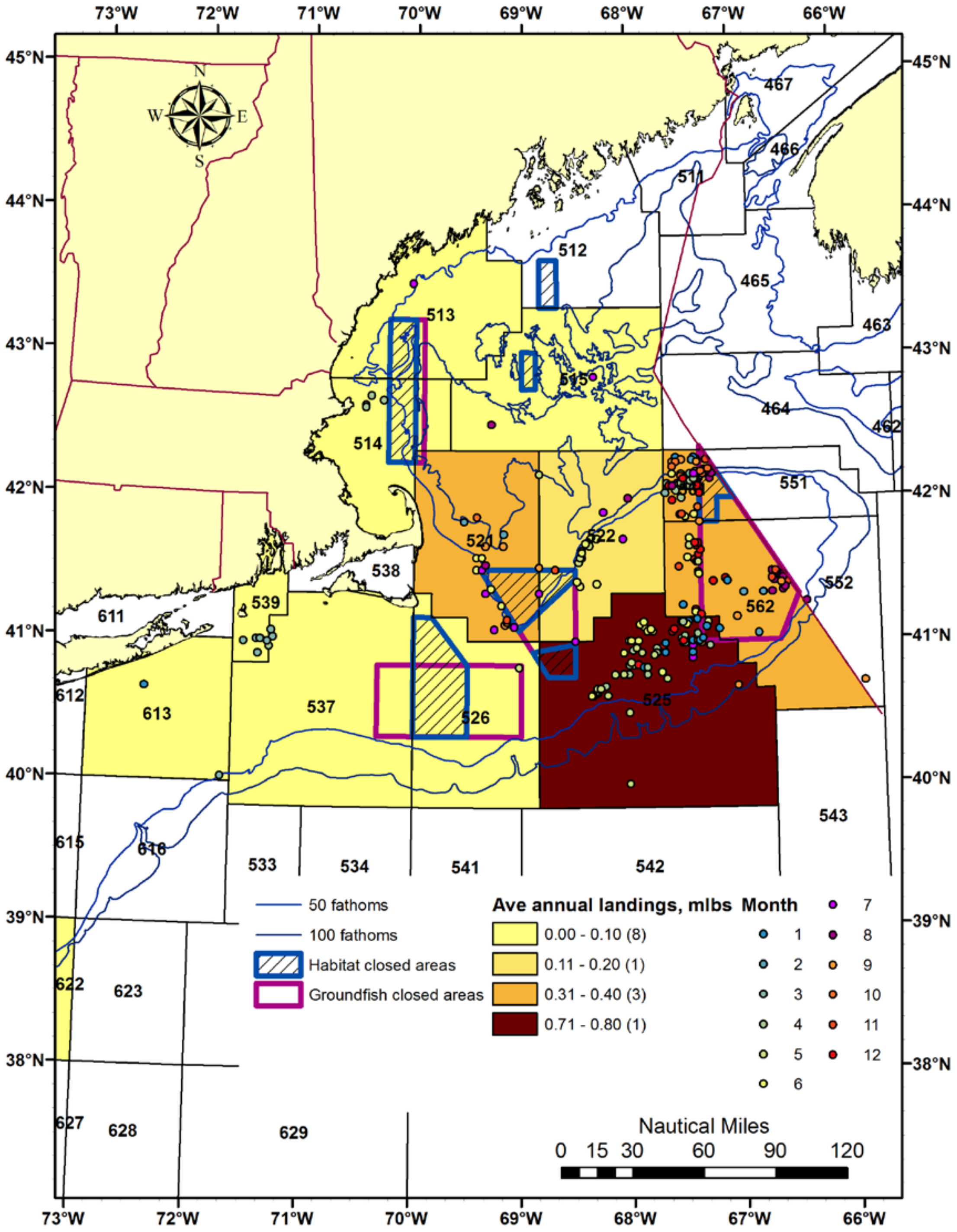
The commercial groundfish fishery operates throughout the Gulf of Maine, on Georges Bank, and in southern New England using a variety of fishing gears depending on the location and target species. Otter trawls are the primary gear type used for all species (Map 110) and flatfish are caught almost exclusively with otter trawls. Based on fishing vessel trip report data for 2007-2011, gillnets caught substantial fractions of the Atlantic cod, pollock, redfish, and white hake landings (Map 112). Separator trawls are used to target haddock (Map 111). Other gears identified in the fishing vessel trip report data associated with landings of groundfish include longlines (Map 113), handlines, and fish pots.

Recreational fishing for groundfish is focused primarily Atlantic cod, pollock, haddock, red hake, and winter flounder, although based on comments made during August 2013 informational meetings, redfish are increasingly important to the charter sector as well. Recreational vessels have a closed season from November through April 15, bag limits for some species, and minimum size limits by species. Recreational fishing is conducted by shore-based anglers and anglers with private boats, as well as by anglers aboard party/charter vessels. Amendment 16 to the Multispecies FMP (2009) includes a detailed description of this fishery through 2007. In the New England region, recreational groundfishing is concentrated in the western Gulf of Maine and off the Rhode Island coast (Map 114).

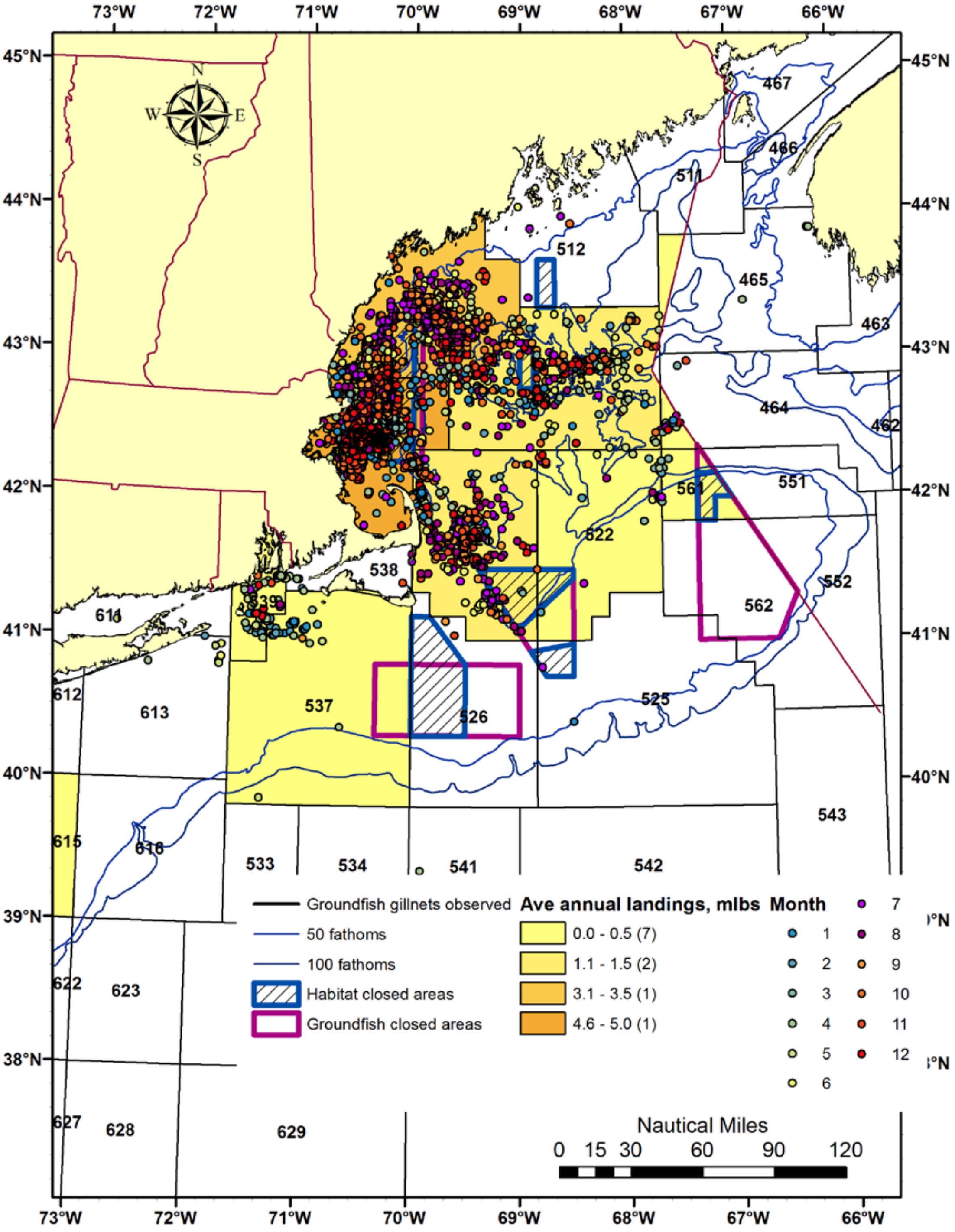
Map 110 – Large mesh demersal otter trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Black lines show start/end positions of hauls observed at sea.



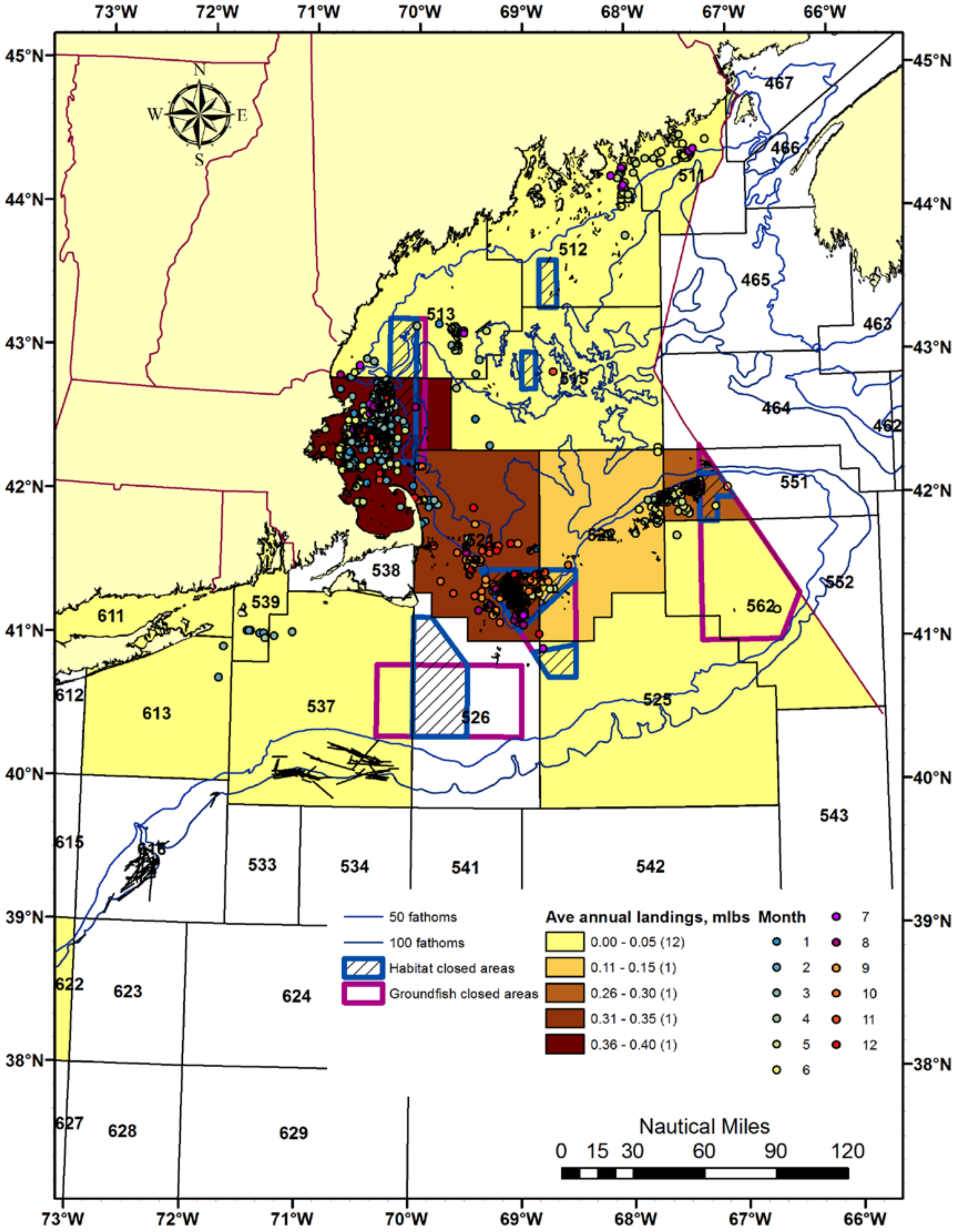
Map 111 – Large mesh multispecies separator trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



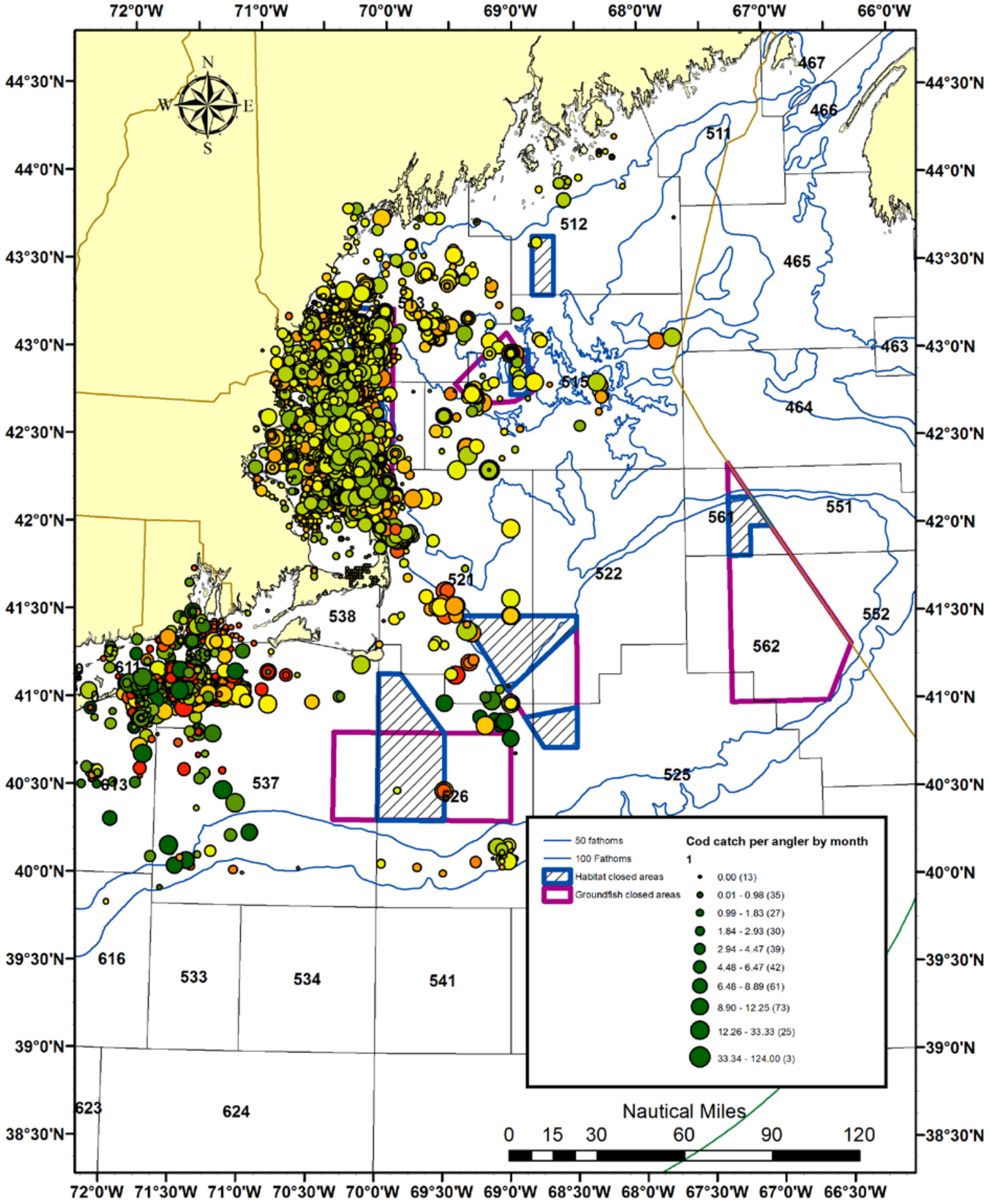
Map 112 – Large mesh multispecies gillnet effort, 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



Map 113 – Large mesh multispecies longline effort, 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red). Black lines show start/end positions of hauls observed at sea.



Map 114 – Trip location and cod catch per angler as reported on 2008-2012 Vessel Trip Reports. Increasing circle size indicates amount of catch, and circle color from dark green to red indicates month of the year, starting in January.



4.3.1.1.1 Groundfish bycatch analysis

Data describing the catch of groundfish by gear type is relevant to the question of which gears should be included or excluded from spawning closures. This section summarizes the proportion of catch by weight in various species categories by gear within the rolling closures, Closed Area I and Closed Area II. High proportions for a given species or mix of species are assumed to indicate the species or species grouping is being targeted with that gear type, while low percentages are assumed to indicate incidental catches.

The species groups analyzed are cod, large mesh groundfish, other regulated/managed species, and other. The species included in large-mesh groundfish are: Atlantic cod, haddock, yellowtail flounder, Acadian redfish, winter flounder, American plaice, windowpane flounder, white hake, pollock, Atlantic halibut, witch flounder and Atlantic wolffish. The species included in other managed/regulated species are: spiny dogfish, barndoor skate, winter skate, clearnose skate, rosette skate, little skate, smooth skate, thorny skate, Atlantic herring, offshore hake, silver hake, red hake, summer flounder, Atlantic mackerel, butterfish, black sea bass, tautog, monkfish, American lobster, northern shrimp, sea scallop, shortfin squid and longfin inshore squid. Any species that was not included within large-mesh groundfish or managed/regulated species was listed under “other”.

Rolling closures

Catch on trips in the sector rolling closures from March-June during 2010-2013 is summarized in Table 33. Portions of these areas are closed during April, May, and June on a rolling south to north basis, so these data represent fishing with exempted gears, or fishing with restricted gears in open months/locations. Proportion of cod catch is highest on trips using anchored-floating gillnets, making up 51% of total catch. Groundfish catch makes up the large majority of catch on trips using bottom trawl gear, indicating that gear is being used to target groundfish. Anchored-floating gillnets and bottom trawl gears are not exempted from the rolling closures. Total catch on trips using lobster pots/trap and scallop dredges is made up almost entirely of other managed/regulated species. These are exempted gear types in the rolling closures.

Table 33 – Summary of catch on trips inside the rolling closures from March-June in 2010-2013. Catch of each species group is averaged as a proportion of total catch for each gear type.

	Cod	LM Groundfish	Regulated Species	Other Species	Trips
Large mesh					
TRAWL,OTTER,BOTTOM,HADDOCK SEPARATOR	39.2%	82.1%	14.2%	3.6%	10
LONGLINE, BOTTOM	37.7%	77.4%	18.1%	4.5%	671
TRAWL,OTTER,BOTTOM,FISH	26.6%	68.9%	25.5%	5.6%	2482
GILL NET, DRIFT-SINK, FISH	14.7%	53.2%	44.4%	2.4%	67
GILL NET, ANCHORED-FLOATING, FISH	-	-	-	-	2
GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	22.3%	47.1%	49.5%	3.4%	3366
POT/TRAP, LOBSTER OFFSH NK	0.3%	0.9%	94.4%	4.7%	137
DREDGE, SCALLOP,SEA	0.0%	0.9%	78.0%	21.1%	207
Small Mesh					
GILL NET, FIXED OR ANCHORED,SINK, OTHER/NK SPECIES	-	-	-	-	1
TRAWL,OTTER,BOTTOM,SHRIMP	0.0%	2.3%	8.8%	88.9%	12
TRAWL,OTTER,MIDWATER PAIRED	-	-	-	-	1

Closed Area I and II

Catch on trips in Closed Area I from February-April during 2010-2013 is summarized in **Error! Reference source not found.**. Only a single trip occurred in Closed Area I with each of the noted trawl gears. Hagfish pots and traps appear to be used to target solely other species. Very few trips occurred in Closed Area II with the bottom ruhle and fish trawl gear.

Table 34 - Summary of catch on trips inside Closed Area I from February-April in 2010-2013. Catch of each species group is averaged as a proportion of total catch for each gear type.

	Cod	LM Groundfish	Regulated Species	Other Species	Trips
Large mesh					
TRAWL,OTTER,BOTTOM,FISH	-	-	-	-	1
TRAWL,OTTER,BOTTOM,HADDOCK SEPARATOR	-	-	-	-	1
POTS + TRAPS, HAGFISH	0.0%	0.0%	0.0%	100.0%	22
Small mesh					
TRAWL,OTTER,MIDWATER PAIRED	-	-	-	-	1

4.3.1.2 Northeast multispecies (small mesh)

As described above, the following small mesh groundfish species are managed as part of the northeast multispecies FMP by the NEFMC:

- Silver hake
- Offshore hake
- Red hake

The NEFMC developed Amendment 19 to bring the small-mesh multispecies portion of the Northeast Multispecies FMP into compliance with the Annual Catch Limit and accountability measure requirements of the reauthorized Magnuson-Stevens Act. Development of Amendment 19 was delayed for several reasons, so NMFS implemented Annual Catch Limits and Accountability Measures for the small-mesh multispecies in 2012 through a Secretarial Amendment. The Council continued development of Amendment 19 in order to adopt the Annual Catch Limit framework used by the Secretarial Amendment, as well as to modify other management measures for the small-mesh multispecies fishery. The measures in both actions included an incidental trip limit trigger to prevent the Annual Catch Limit from being exceeded, a year-round trip limit for red hake, and the potential to implement a quarterly quota system in the southern area, should landings increase rapidly. Because these species are caught incidentally in many fisheries, landings are never prohibited if a quota is projected to be reached, just reduced to an incidental limit to discourage directed fishing.

In general, small-mesh multispecies are managed using mesh-size-dependent trip limits for whiting (silver and offshore hake, combined), a new year-round trip limit for red hake, and area restrictions on small-mesh use, which are implemented as a series of exemptions from the NE multispecies FMP (Map 115). The small mesh fishery is prosecuted using otter trawls. The

Northeast Multispecies FMP requires that a fishery can routinely catch less than 5% of regulated multispecies (i.e. large mesh species and ocean pout described in the previous section) to be exempted from the minimum mesh size. In the Gulf of Maine and Georges Bank Regulated Mesh Areas (Map 115), there are six exemption areas, which are open seasonally (Table 35).

Table 35 – Small mesh exemption area seasons.

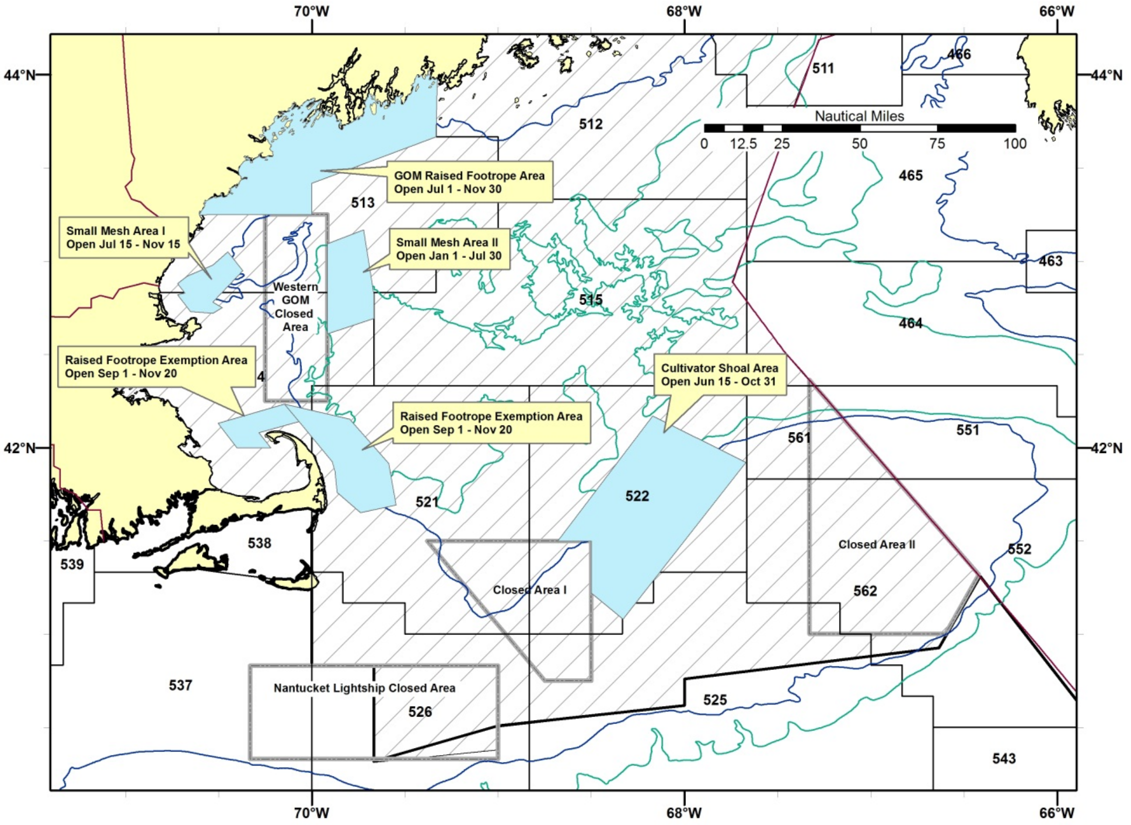
Area name	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Cultivator Shoals Exemption Area		Jun 15 – Oct 31										
GOM Grate Raised Footrope Area			Jul 1 – Nov 30									
Small Mesh Area I			Jul 15 – Nov 30									
Small Mesh Area II	Jan 1 –Jun 30								Jan 1 –Jun 30			
Cape Cod Raised Footrope Trawl – western area					Sep 1 – Nov 20							
Cape Cod Raised Footrope Trawl – eastern area					Sep 1 – Dec 31							

The exemption areas were implemented as part of several different amendments and framework adjustments to the Northeast Multispecies FMP. In 1991, Amendment 4 incorporated silver and red hake and established an experimental fishery on Cultivator Shoal. Framework Adjustment 6 (1994) was intended to reduce the catch of juvenile whiting by changing the minimum mesh size from 2.5 inches to 3 inches. Small-mesh Areas I and II, off the coast of New Hampshire, were established in Framework Adjustment 9 (1995). The New England Fishery Management added offshore hake to the plan in Amendment 12 (2000). The Raised Footrope Trawl Area off of Cape Cod was established in Framework Adjustment 35 (2000). A modification to Framework Adjustment 35 in 2002 adjusted the boundary along the eastern side of Cape Cod and extended the season to December 31 in the new area. Framework Adjustment 37 modified and streamlined some of the varying management measures to increase consistency across the exemption areas. In 2003, Framework Adjustment 38 established the Grate Raised Footrope Exemption Area in the inshore Gulf of Maine area.

The Gulf of Maine Grate Raised Footrope area requires the use of an excluder grate on a raised footrope trawl with a minimum mesh size of 2.5 inches. A raised footrope trawl is required in Small-mesh Areas I and II, and the trip limits are mesh size dependent. Cultivator Shoal Exemption Area requires a minimum mesh size of 3 inches. The Raised Footrope Trawl Exemption Areas around Cape Cod require a raised footrope trawl, with a minimum mesh size of 2.5-inch square or diamond mesh. The Southern New England and Mid-Atlantic Regulated Mesh Areas are open year-round and have mesh size dependent possession limits for the small-mesh multispecies. The mesh size dependent possession limits are: smaller than 2.5” - 3,500 lb; larger than 2.5”, but smaller than 3.0”, - 7,500 lb; equal to or greater than 3.0”- 30,000 lb.

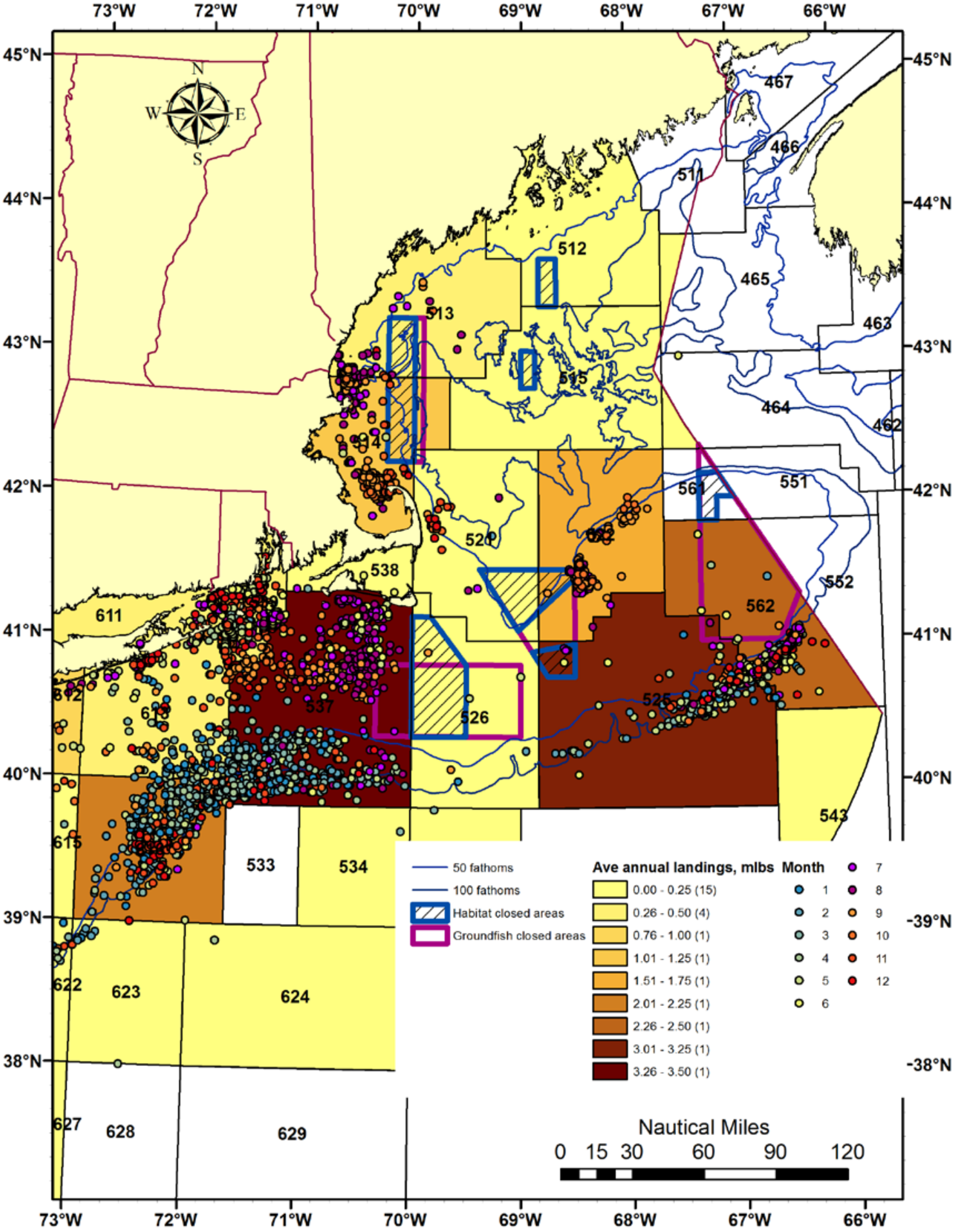
Vessels participating in any of the exemption areas must have a Northeast Multispecies limited access or open access category K permit and must have a letter of authorization from the Regional Administrator to fish in Cultivator Shoal and the Cape Cod Raised Footrope areas. All of the exemption areas, including the Mid-Atlantic and Southern New England regulated mesh areas, have a 5,000 lb possession limit for red hake.

Map 115 – Small-mesh exemption areas in the Gulf of Maine and on Georges Bank.



The general distribution of effort and landings in the small mesh multispecies fishery is shown on Map 116.

Map 116 – Small mesh multispecies trawl effort, 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).

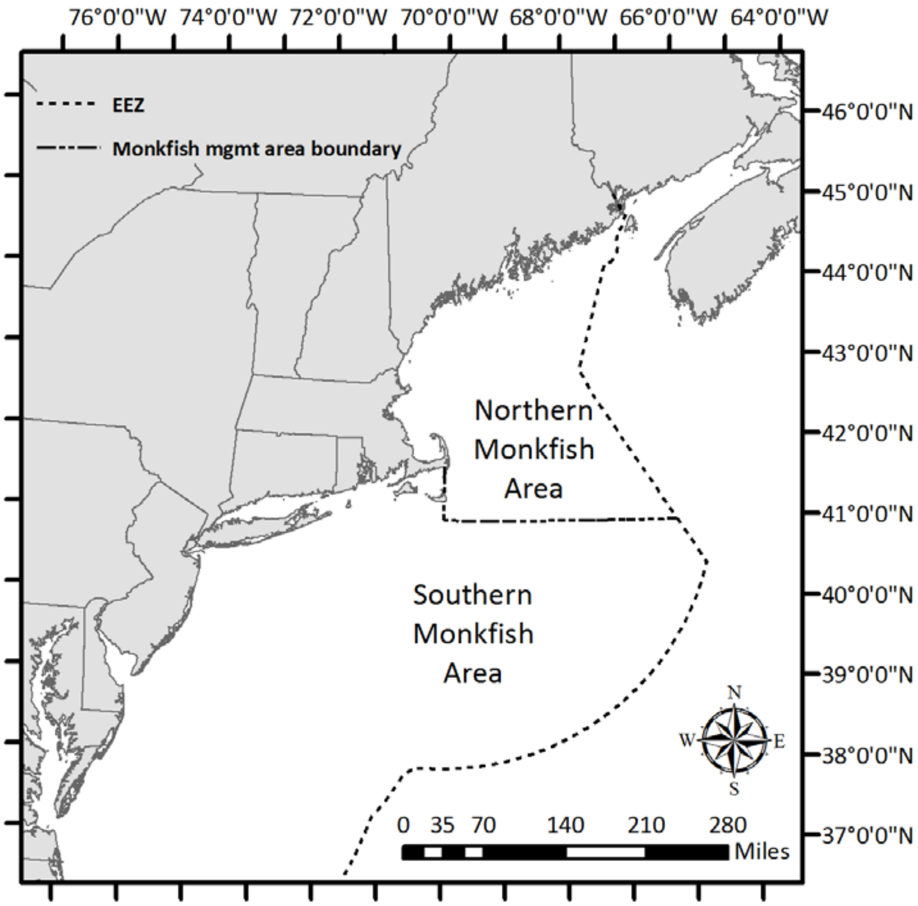


4.3.1.3 Monkfish

Monkfish have a large, bony head and are harvested for their livers and the tender meat in their tails. During the early 1990s, fishermen and dealers in the monkfish fishery addressed both the New England and Mid-Atlantic Councils with concerns about the increasing amount of small fish being landed, the increasing frequency of gear conflicts between monkfish vessels and those in other fisheries, and the expanding directed trawl fishery. In response, the Councils developed a joint FMP that was implemented in 1999. Since the implementation of the FMP, vessels are more commonly landing large, whole monkfish for export to Asian markets.

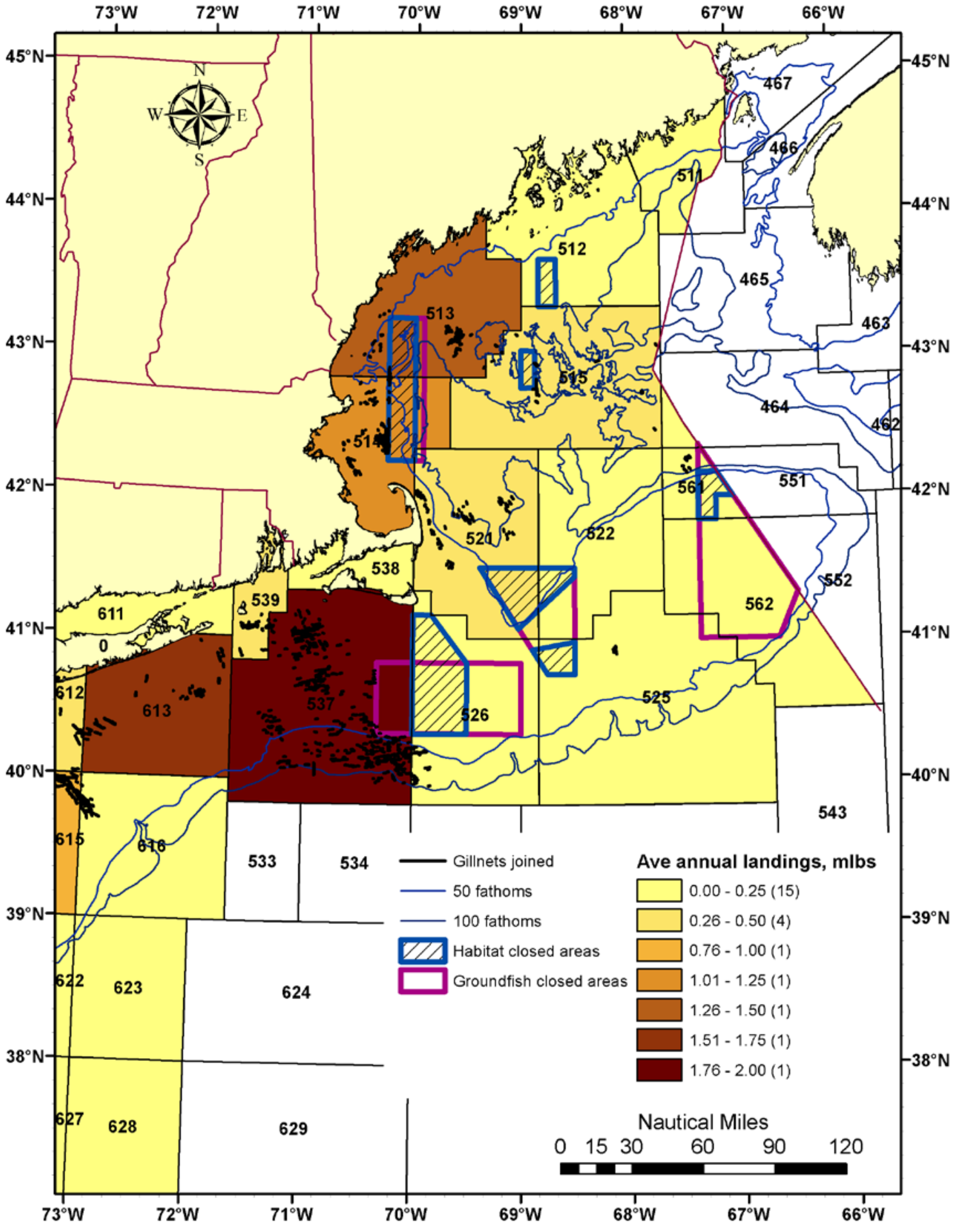
For management purposes, the monkfish fishery is divided into two areas, the Northern and Southern Management Areas (Map 117). While scientific evidence for two biological stocks is uncertain, and additional research, including archival tagging, is ongoing, fisheries in the two areas are clearly distinct. Stock assessments are done on the two areas separately to be able to support the management plan. The NMA monkfish fishery is closely integrated with the northeast multispecies fishery, and is primarily a trawl fishery, while the SMA fishery is primarily a gillnet fishery targeting monkfish almost exclusively. These differences have resulted in some differences in management measures, such as trip limits and DAS allocations, between the two areas.

Map 117 – Monkfish management areas

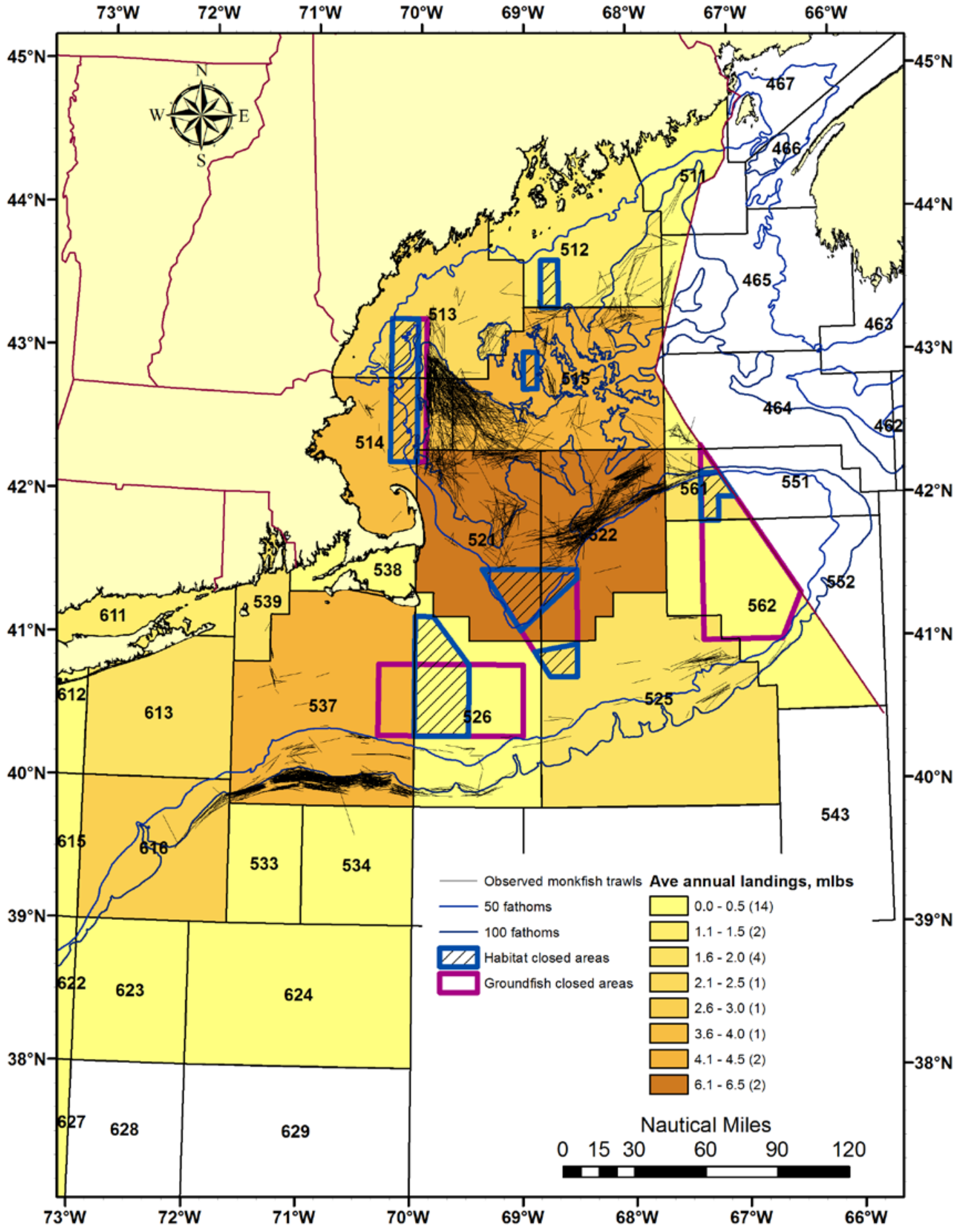


According to 2007-2011 vessel trip reports, the majority of landings are made using gillnets (67 percent, Map 118) with another 26 percent landed by otter trawls (Map 119). Scallop dredges also catch monkfish, but in much smaller amounts (7 percent of reported landings, 2007-2011). No other gear types account for more than trace landings of monkfish, and there is no recreational component to this fishery. Revenues have generally increased since the mid-1980s and the relative value of monkfish is currently at its highest point since 1996.

Map 118 – Monkfish gillnet effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Black lines show start/end positions of hauls observed at sea.



Map 119 – Monkfish trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Black lines show start/end positions of hauls observed at sea.



4.3.1.4 Skates

The NEFMC manages seven species as part of the Northeast skate complex:

- Barndoor skate
- Little skate
- Winter skate
- Rosette skate
- Clearnose skate
- Thorny skate
- Smooth skate

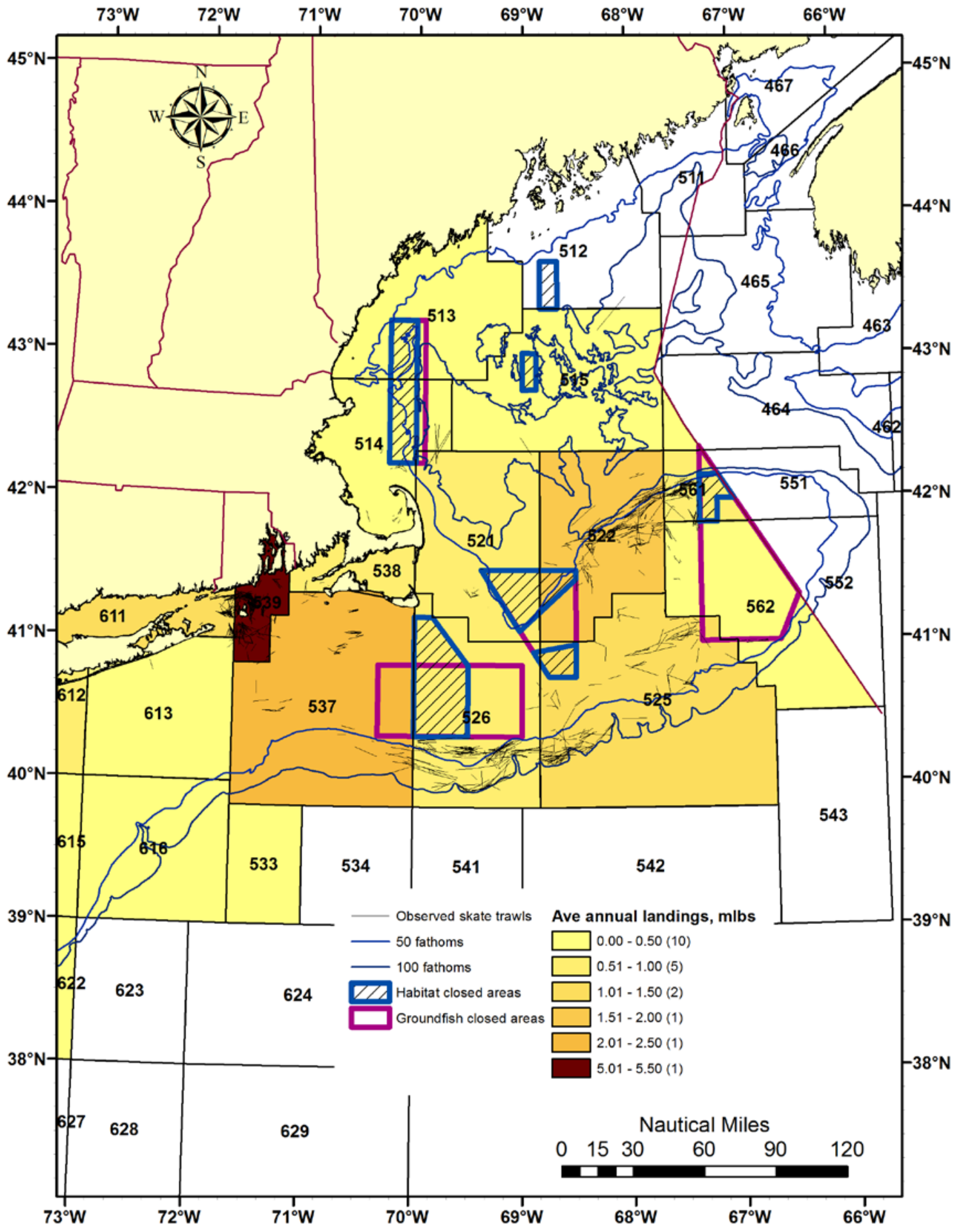
Amendment 3 to the Skate FMP was implemented in 2010, to establish Annual Catch Limits and Accountability Measures for the skate complex as required by the 2006 reauthorization of the Magnuson-Stevens Act, and to implement measures to rebuild overfished skate stocks. Amendment 3 implemented a stock complex Annual Catch Limit for skates, but created separate landing quotas for the skate wing and bait fisheries, and reduced the skate wing and bait possession limits. The skate bait fishery annual Total Allowable Landings were divided into three separate seasonal quotas to maintain year-round supply of bait. Framework Adjustment 1 to the Skate FMP was subsequently implemented in 2011, to further reduce the skate wing possession limits, and adjust the in-season trigger of the incidental possession limit.

Skates are harvested for two very different commercial markets—one market supplies whole skates to be used as bait in the lobster fishery, and one market supplies skate wings for human consumption. The skate bait fishery is a directed fishery and is more traditional, involving vessels primarily from southern New England ports that target a combination of little skates (>90 percent) and, to a much lesser extent, juvenile winter skates (<10 percent). The vessels supplying skates for the bait market tend to make dedicated trips targeting skates and land large quantities of skates per trip.

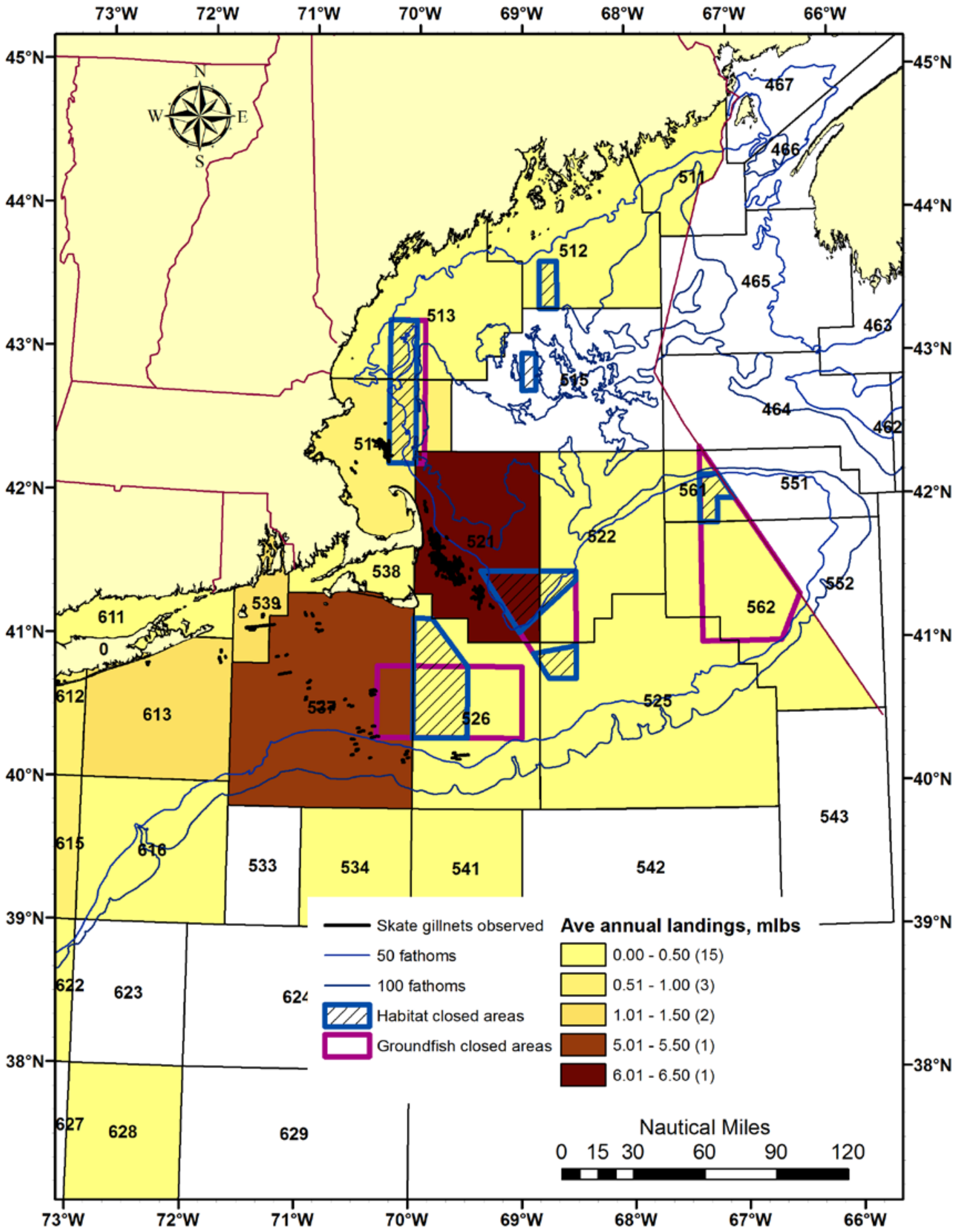
The skate wing fishery developed in the 1990s when skates were promoted as “underutilized species,” and fishermen shifted effort from groundfish and other fisheries to skates and spiny dogfish. The wing fishery is largely an incidental catch fishery that involves vessels that also participate in the groundfish and/or monkfish fisheries. Although some vessels will make trips specifically targeting winter skates for the wing market, most skates caught for this market are retained by vessels engaged in other fisheries.

Most skates are caught using an otter trawl (according to the Fishing Vessel Trip Report database for 2007-2011, almost 65 percent of landings were from an otter trawl), although gillnets are also used (the remaining 35 percent of 2007-2011 landings were from gillnets). Small amounts of landings are associated with hook and line gear and scallop dredges. Although some skates are caught by recreational fishermen, recreational landings of skates are negligible both in the context of all recreational fisheries and in the context of the overall skate fisheries. Even though skates are now managed under a Federal FMP, reported landings remain incomplete at the species level.

Map 120 – Skate trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Black lines show start/end positions of hauls observed at sea.



Map 121 – Skate gillnet effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Black lines show start/end positions of hauls observed at sea.



4.3.1.5 Atlantic sea scallop

Sea scallops are managed by the NEMFC in collaboration with the MAFMC. The Atlantic Sea Scallop FMP, prepared by the New England Council, was implemented in 1982 to restore adult scallop stocks and reduce year-to-year fluctuations in stock abundance caused by variation in recruitment. One of the foundations of the Scallop FMP is its area rotational management programs, established in 2004 under Amendment 10. Under this program, areas are defined and closed and reopened to fishing on a rotational basis, depending on the condition and size of the scallop resource in the areas. As a result of Amendment 10, controls on scallop effort differ depending on whether a fishing trip occurs in an access area or in an open area. Vessels either fish in access areas under allocated trips, or in open areas under DAS. Amendment 11, implemented in 2008, included measures to control capacity and mortality in the general category scallop fishery. Primary measures included a limited entry program for general category vessels, as well as other permit provisions including an individual fishing quota (IFQ) program. The most recent amendment, Amendment 15, introduced Annual Catch Limits and accountability measures to the Scallop FMP in 2011, as required by the Magnuson-Stevens Act.

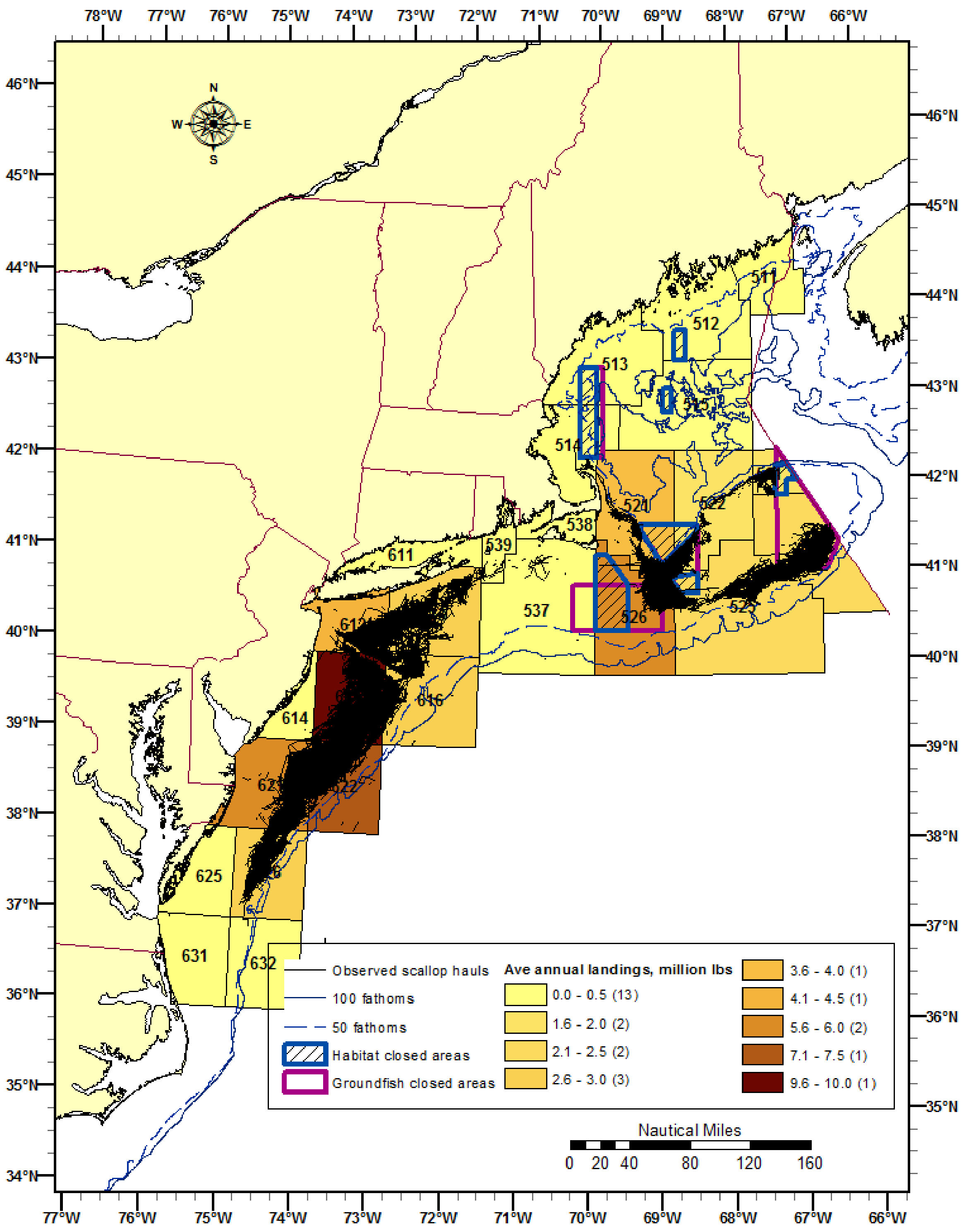
Under current regulations, the scallop fleet can be differentiated by vessel permit category: limited access (LA) vessels that are subject to area-specific days at sea controls and trip allocations; and limited access general category (LAGC) vessels that are not subject to days at sea controls, but are subject to a possession limit per fishing trip. There are three types of LAGC permits: individual fishing quota permits with a possession limit of 600 lb per trip; Northern Gulf of Maine permits with a possession limit of 200 lb per trip; and incidental permits with a possession limit of 40 lb. per trip. The limited access and LAGC scallop fleets receives a total allocation of 94.5 percent and 5 percent, respectively, of the scallop fishery's Annual Catch Limit, with the remaining 0.5 percent allocated to IFQ permits on vessels that have both LAGC IFQ and limited access scallop permits. There are no open access permits in this fishery.

Most limited access effort is from vessels using scallop dredges, including small dredges. The number of vessels using scallop trawl gear has decreased continuously and has been at 11 full-time trawl vessels since 2006. In comparison, there has been an increase in the numbers of full-time and part-time small dredge vessels after 2002. About 80% of the scallop pounds are landed by full-time dredge and about 13% landed by full-time small dredge vessels since the 2007 fishing year (Section 1.1.6 of Appendix I to Framework Adjustment 24).

Most LAGC effort is, and has been, from vessels using scallop dredge and other trawl gear. The percentages of scallop landings show that landings made with a scallop dredge in 2012 continue to be the highest compared to other general category gear types (Table 18 and Table 22, Appendix I to Framework Adjustment 24). The majority of limited access vessels are based in Massachusetts, Virginia, New Jersey, and North Carolina, and the primary scallop ports are located in New Bedford, Massachusetts, Cape May, New Jersey, and Newport News, Virginia.

In the fishing years 2003-2011, the landings from the northeast sea scallop fishery stayed above 50 million pounds, surpassing the levels observed historically. The recovery of the scallop resource and consequent increase in landings and revenues was striking given that average scallop landings per year were below 16 million pounds during the 1994-1998 fishing years, less than one-third of the present level of landings. The increase in the abundance of scallops coupled with higher scallop prices increased the profitability of fishing for scallops by the general category vessels. As a result, general category landings increased from less than 0.4 million pounds during the 1994-1998 fishing years to more than 4 million pounds during the fishing years 2005-2009, peaking at 7 million pounds in 2005 or 13.5% of the total scallop landings. The landings by the general category vessels declined after 2009 as a result of the Amendment 11 implementation that restricts Total Allowable Catch for the limited access general category fishery to 5.5% of the total Annual Catch Limit. However, the landings by limited access general category IFQ fishery increased in 2011 from its levels in 2010 due to a higher projected catch and a higher Annual Catch Target for all permit categories. Recent dredge landings and the distribution of observed dredge hauls are shown on Map 122.

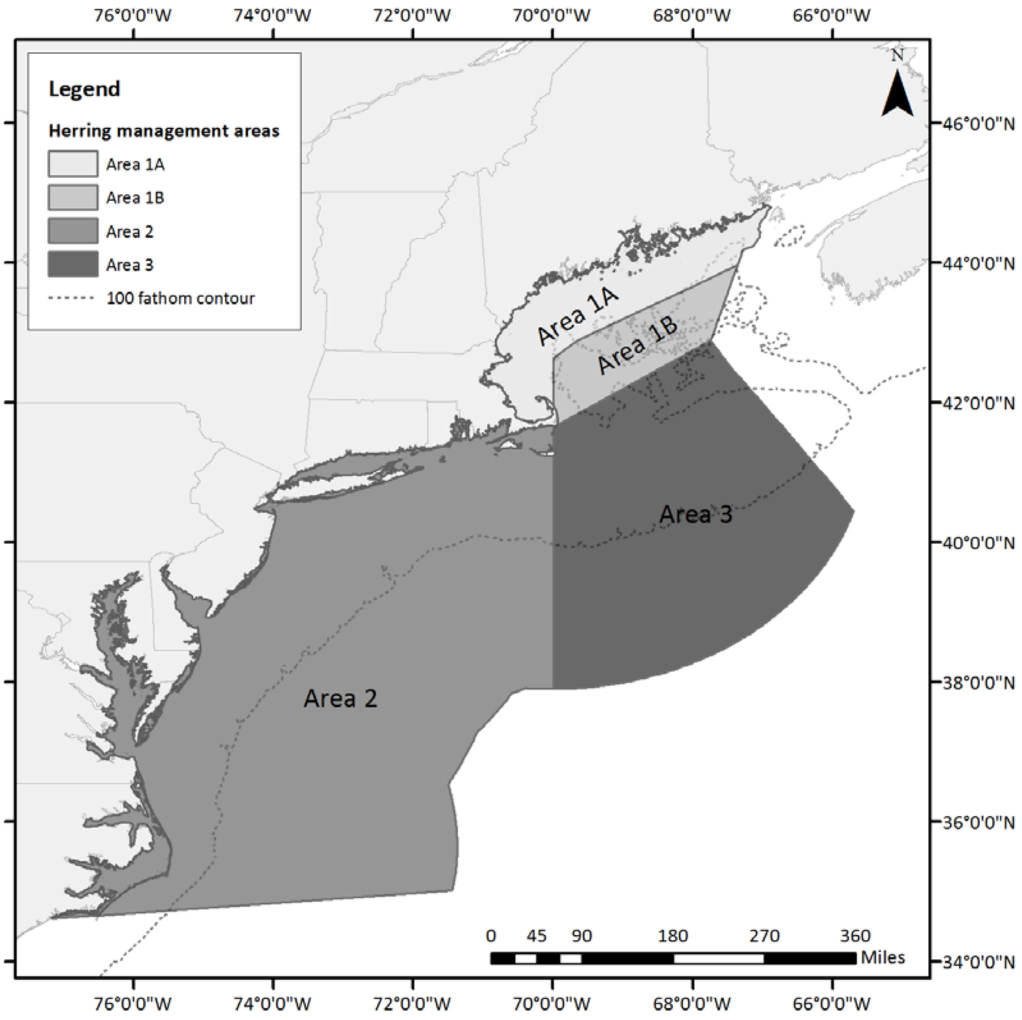
Map 122 – Sea scallop dredge effort 2008-2012. Yellow to brown shading shows average annual landings (meat weight) by statistical area from the dealer tables. Black lines show start/end positions of hauls observed at sea.



4.3.1.6 Atlantic herring

Atlantic herring are managed by the NEFMC. The fishery management plan (2000) established total allowable catches for each of four management areas (Map 123). The FMP established requirements for vessel, dealer, and processor permits, as well as reporting requirements and restrictions on the size of vessels that can catch herring. Amendment 4 (2011) implemented a process for establishing Annual Catch Limits and accountability measures in the herring fishery. Amendment 5 (which is currently undergoing NMFS review for 2014 implementation), focuses on establishing a comprehensive catch monitoring program for the limited access herring fishery, addressing river herring bycatch, establishing criteria for midwater trawl vessel access to groundfish closed areas, and adjusting other aspects of the fishery management program to keep the Herring FMP in compliance with the Magnuson-Stevens Act and ensure sustainable long-term management. Additional measures to implement river herring catch caps in the Atlantic herring fishery are currently under development by the NEFMC.

Map 123 – Atlantic herring management areas



Although some herring are caught incidentally in recreational fisheries for Atlantic mackerel and silver hake, this is limited to coastal New Jersey, and almost all herring are caught for commercial purposes. Commercially-caught herring are primarily used as bait in the lobster or tuna fisheries, or as a food fish for the export market.

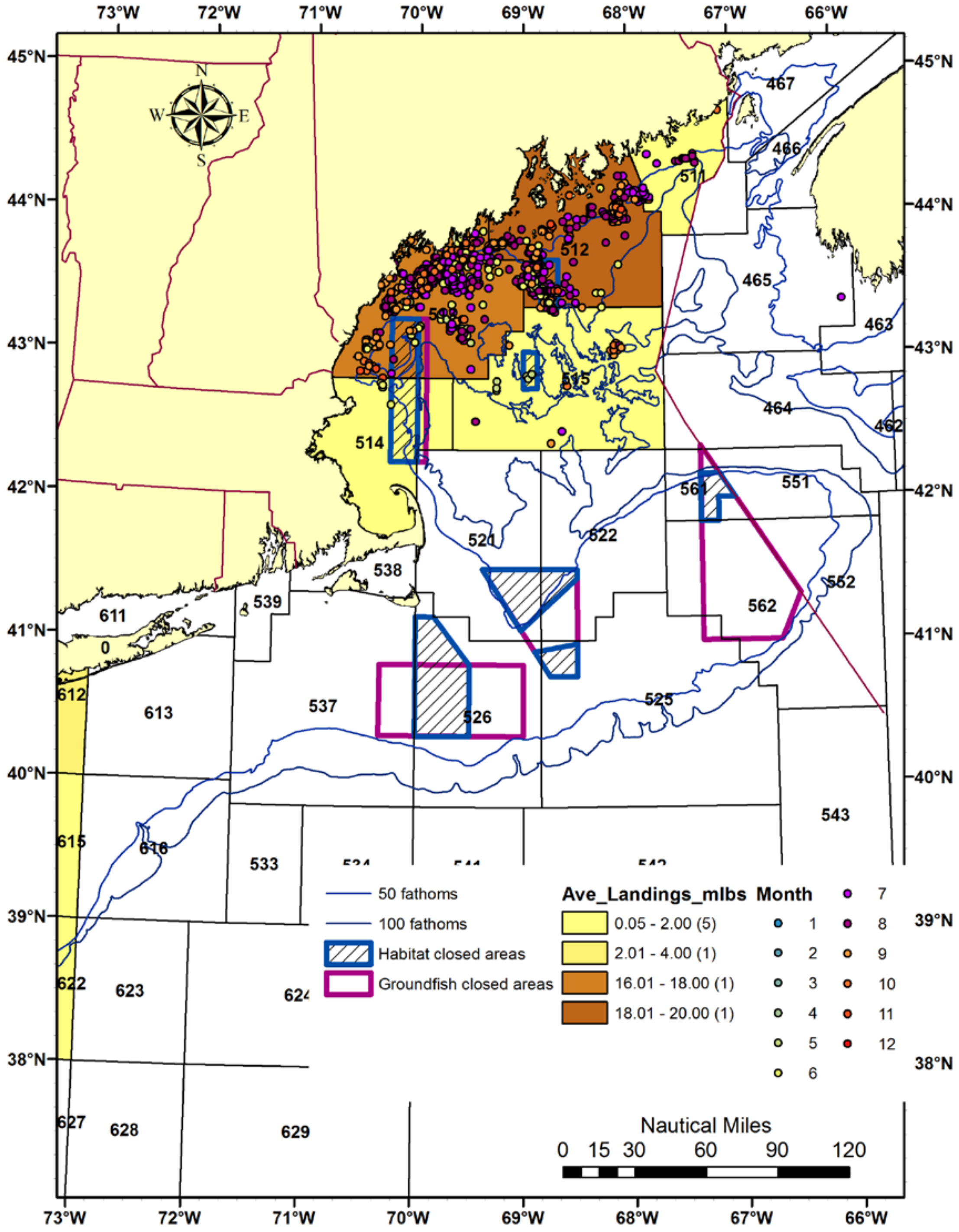
The U.S. Atlantic Herring fishery occurs over the Mid-Atlantic shelf region from Cape Hatteras to Maine, including an active fishery in the inshore Gulf of Maine and seasonally on Georges Bank. The Atlantic herring winter fishery is generally prosecuted south of New England in management Area 2 during the winter (January-April), and oftentimes as part of the directed mackerel fishery. There is significant overlap between the herring and mackerel fisheries in Area 2 and in Area 3 during the winter months, although catches in Area 3 tend to be relatively low. The herring summer fishery (May-August) is generally prosecuted throughout the Gulf of Maine in Areas 1A, 1B and in Area 3 (Georges Bank) as fish are available. Restrictions in Area 1A have pushed the fishery in the inshore Gulf of Maine to later months (late summer). The midwater trawl (single and paired) fleet is restricted from fishing in Area 1A in the months of January through September because of the Area 1A split that is currently enforced through ASMFC days-out measures (0% January-May) and the purse seine-fixed gear only area (all of Area 1A) that is effective June-September. Fall fishing (September-December) tends to be more variable and dependent on fish availability; the Area 1A quota is always fully utilized, and the inshore Gulf of Maine fishery usually closes sometime around November. As the 1A and 1B quotas are taken, larger vessels become increasingly dependent on offshore fishing opportunities (Georges Bank, Area 3) when fish may be available.

Atlantic herring vessel permit categories are: Category A limited access, all management areas; Category B limited access, Areas 2 and 3 only; Category C limited access, incidental catch of 25 mt per trip; and Category D open access, incidental catch of 3 mt per trip. Category A and B vessels comprise the majority of the directed herring fishery. Many of the Category A, B, and C vessels are also active in the Atlantic mackerel fishery

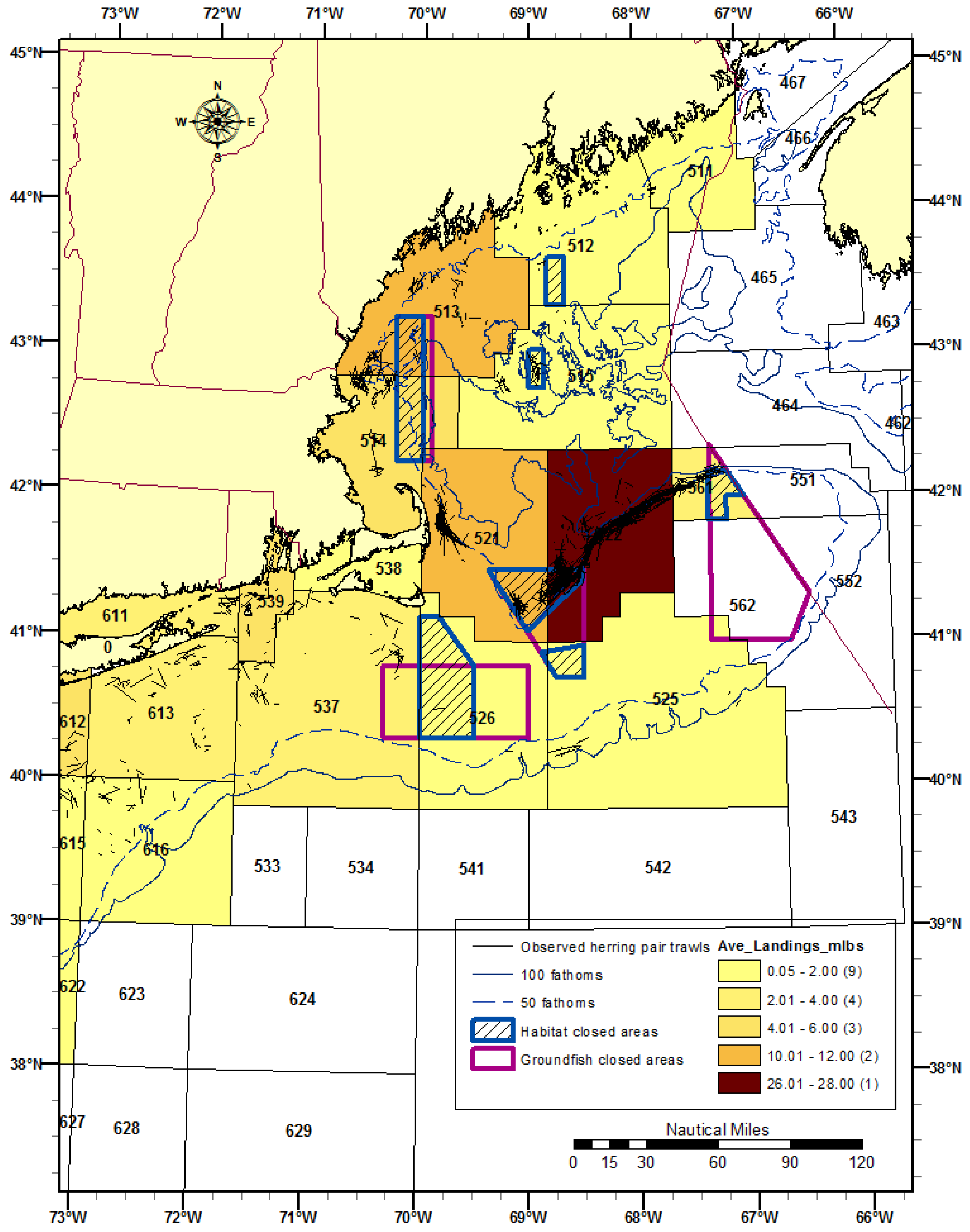
Atlantic herring vessels fish with purse seines (Map 124), or single or paired midwater trawls (Map 125), with the midwater pair trawl fleet harvesting the majority of landings from 2008 to 2011 (65% according to July 2013 specifications document). Some herring vessels use multiple gear types during the fishing year. Single and pair trawl vessels generally fish in all areas (October-December in Area 1A). The purse seine fleet fishes in the inshore Gulf of Maine (Area 1A and, to a lesser extent, Area 1B) and in Area 2. The single midwater trawl has been most active in Area 3. Small mesh bottom trawl vessels represented 4% of herring landings over the time series; other gear types (e.g. pots, traps, shrimp trawls, hand lines) comprise less than 1% of the fishery.

Atlantic herring harvested from Areas 1A and 1B are landed in fishing communities in Maine, New Hampshire, and Massachusetts, whereas herring from Areas 2 and 3 are landed in a wider range of ports. Communities in Rhode Island and New Jersey fish in Area 2 for herring almost exclusively. Portland, Rockland, Gloucester, and New Bedford are ports with the most herring landings in recent years. Within New Jersey, Cape May is the most active landing port.

Map 124 – Atlantic herring purse seine effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



Map 125 – Atlantic herring single and paired midwater trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



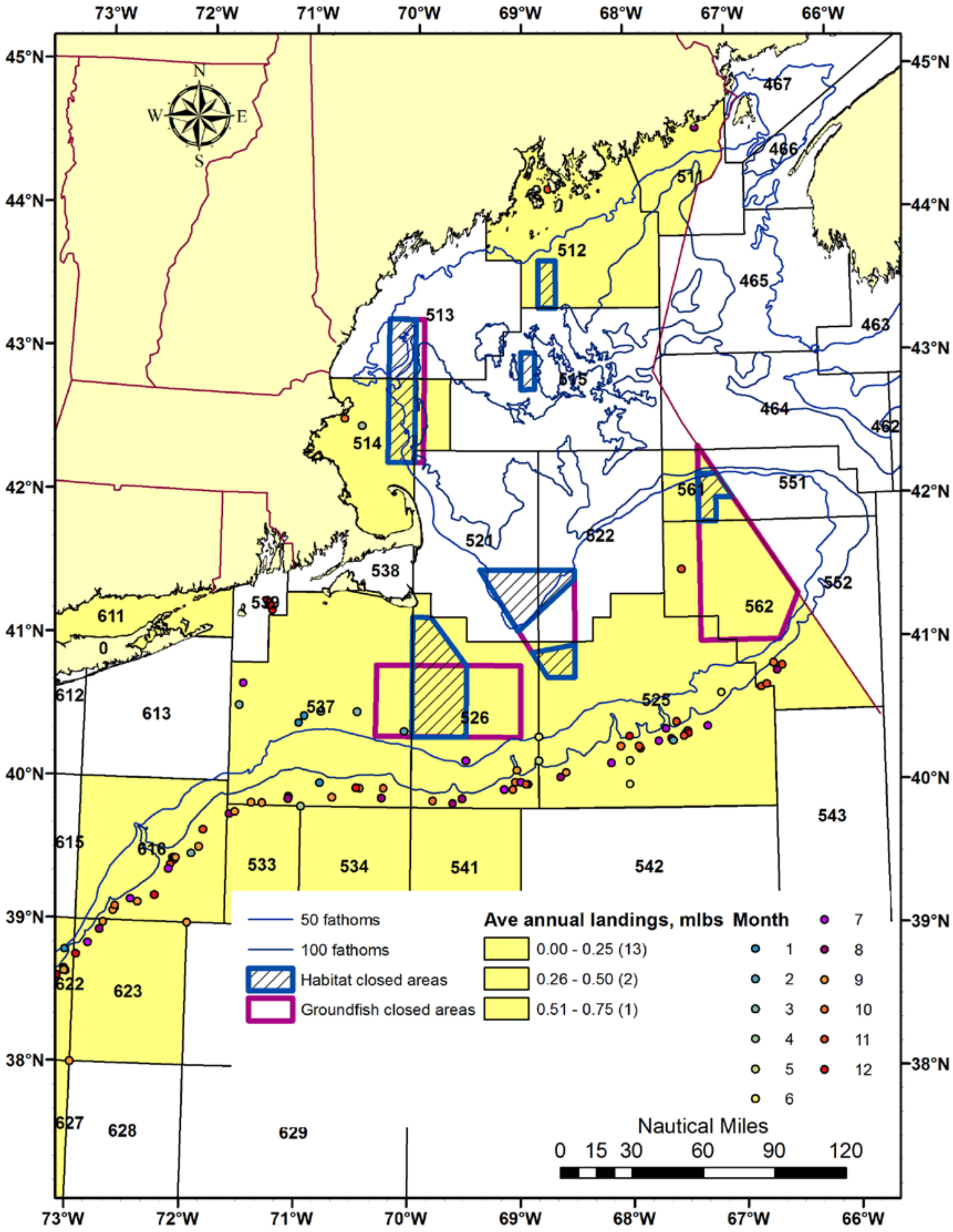
4.3.1.7 Deep-sea red crab

There has been a small directed fishery off the coast of New England and in the Mid-Atlantic for deep-sea red crab since the early 1970s. Though the size and intensity of this fishery has fluctuated, it has remained consistently small relative to more prominent New England fisheries such as groundfish, sea scallops, and lobster. In 1999, at the request of members of the red crab fishing industry, the NEFMC began development of an FMP to prevent overfishing of the red crab resource and address a threat of overcapitalization of the red crab fishery. The FMP was implemented in 2002.

The primary management control was to establish a limited access permit program for qualifying vessels with documented history in the fishery. Other measures included days at sea limits, trip limits, gear restrictions, and limits on processing crabs at sea. Amendment 3 was implemented in 2011 to bring the FMP into compliance with the revised Magnuson-Stevens Act by implementing Annual Catch Limits and accountability measures. Amendment 3 also revised the management measures, by eliminating DAS and the vessel trip limit.

The directed, limited access red crab fishery is a male-only fishery, that is currently managed with a “hard” quota (i.e., the fishery is closed when the quota is reached), gear restrictions, and limits on processing crabs at sea. Although there is an open access permit category, the small possession limit of 500 pounds per trip has kept this sector of the fishery very small. The directed red crab fishery is limited to using parlor-less crab pots (Map 126), and is considered to have little, if any, incidental catch of other species. There is no known recreational fishery for deep-sea red crab. Landings of red crab varied somewhat before the implementation of the FMP, but have stabilized since. All vessels with limited access permits now fish out of Fall River, Massachusetts.

Map 126 – Deep-sea red crab trap effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



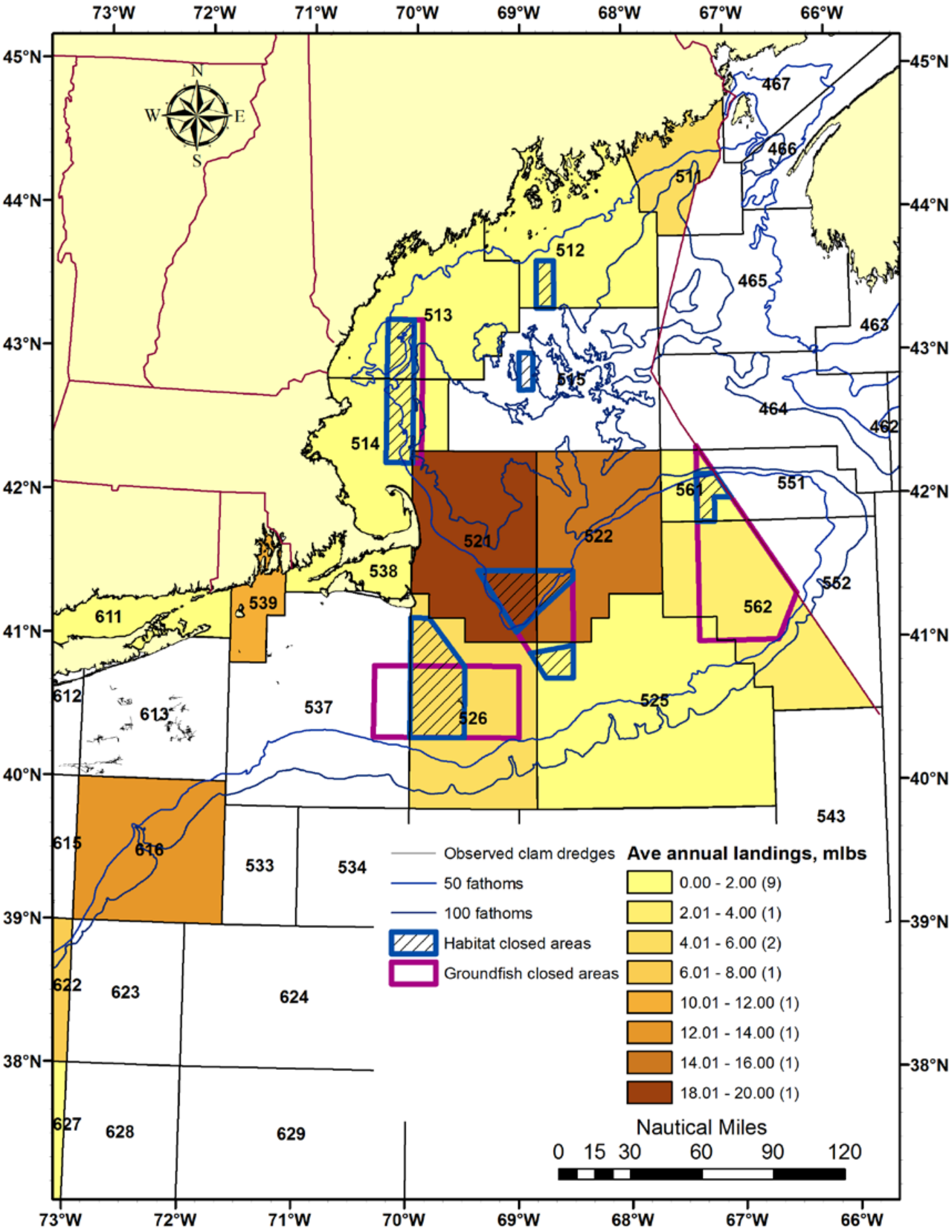
4.3.1.8 Surfclam and ocean quahog

The Mid-Atlantic Council developed the FMP in the mid 1970's and it was implemented in 1977. Amendment 8 to the FMP, implemented in 1990, established an individual transferable quota (ITQ) system for the fisheries. Quota shareholders are allowed to purchase, sell, or lease quota to and from other shareholders. Amendment 10 incorporated management measures for ocean quahogs (mahogany clams) in Maine; a separate portion of the quota is set aside for this area, which is shown in green on Map 128. A framework adjustment in 2007 implemented a requirement to use VMS for all vessels participating in the surfclam or ocean quahog fisheries.

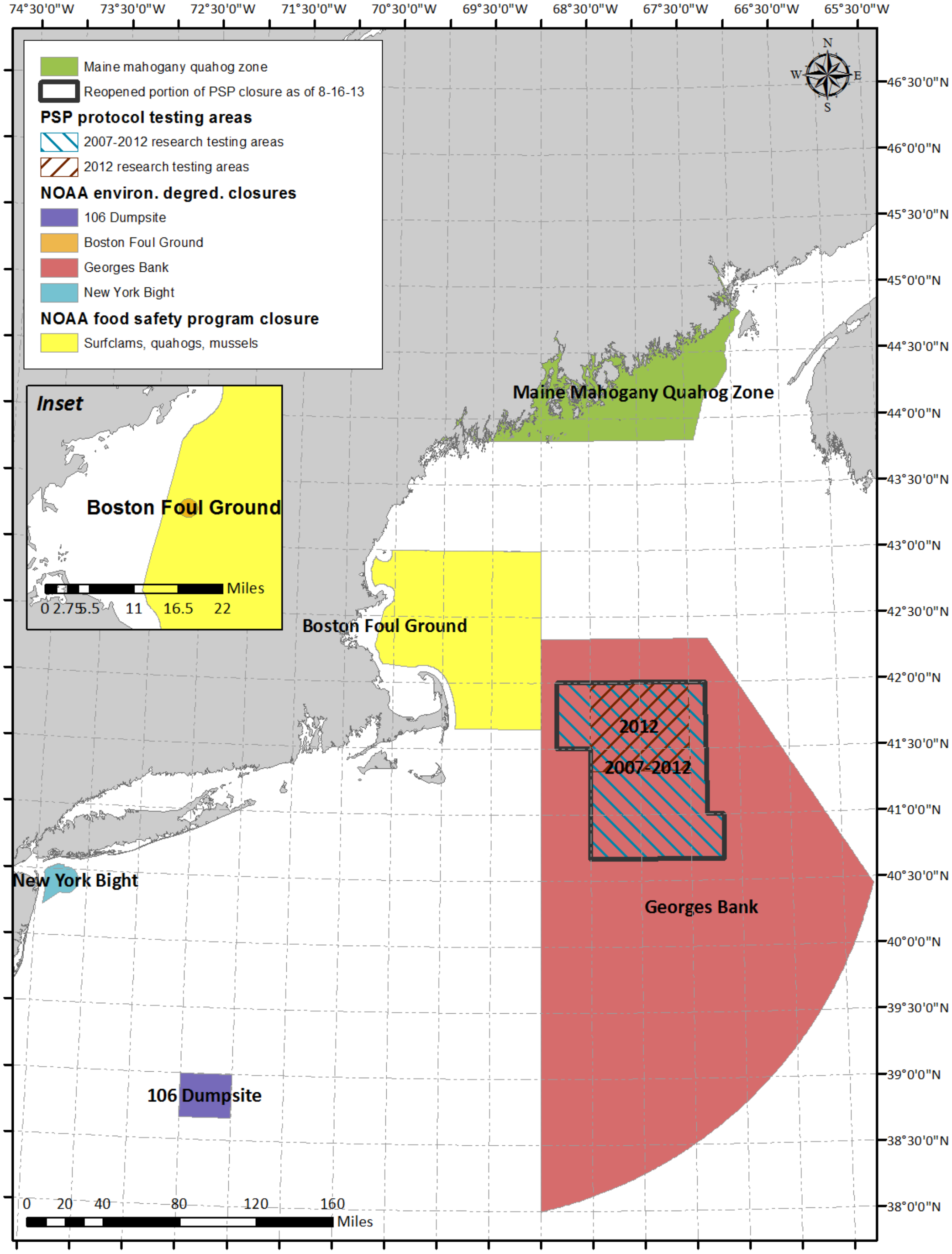
There is no recreational fishery for either species. Most of the landings of quahogs and almost all landings of surfclams are associated with the hydraulic clam dredge (see description in SASI appendix). The relatively small Maine mahogany quahog fishery uses a non-hydraulic dredge. These dredges rely on 6-inch teeth along the leading edge to rake the seabed and lift quahogs into the cage (Stevenson et al 2004). They are fished from small 30-40 ft vessels in areas of sand and sandy mud between bedrock outcrops (Stevenson et al 2004). The state of Maine caps the width of these dredges at 36" (24" between the Spurwink River in Scarborough and Fletcher's Neck in Biddeford Pool). Landing by both types of dredges are shown on Map 127.

Waters of the Gulf of Maine and Georges Bank are subject to intermittent harmful algal blooms, or "red tide," caused by the dinoflagellate *Alexandrium fundyense*, which produces a toxin known to cause paralytic shellfish poisoning (PSP) in people consuming contaminated clams. Because of a history of harmful algal blooms and limited testing in the area, eastern Georges Bank has been closed to the harvest of clams since 1990. In 2013 a portion of Georges Bank (grey outlined area shown on Map 128) was opened for the harvest of surfclams and ocean quahog by vessels using a new PSP testing protocol. This area was accessible to vessels developing the PSP testing protocol during 2007-2012 (hatched areas shown on Map 128). Other areas in the Gulf of Maine and western Georges Bank have been closed since 2005 due to an outbreak of *A. fundyense* in these areas (yellow area shown on Map 128).

Map 127 – Clam dredge effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Black lines show start/end positions of hauls observed at sea.



Map 128 – Management areas relevant to the clam fishery.



4.3.1.9 Northern shrimp

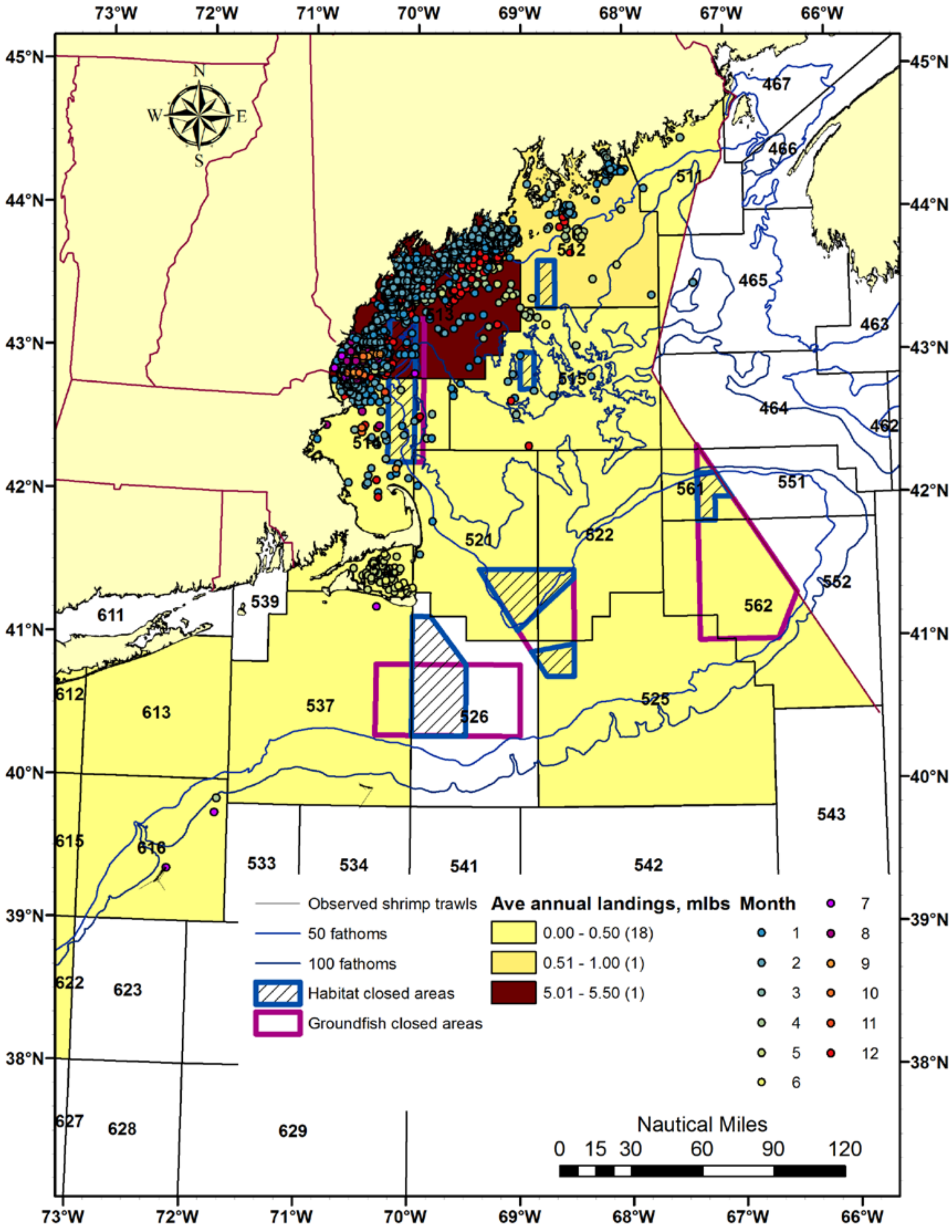
The northern shrimp fishery is managed by the states of Maine, New Hampshire, and Massachusetts, through ASFMC. The first Interstate Fishery Management Plan was approved in October 1986, and Amendment 1 (2004) established biological reference points.

The northern shrimp fishery is seasonal, targeting female shrimp when they come inshore to spawn. When the annual total allowable catch has been harvested, the fishery closes. Both the 2009/2010 and 2010/2011 seasons were relatively short (156 days and 90 days, respectively). Delays in reporting landings resulted in short notice of the early closures during these seasons, and the total allowable catches were exceeded in both years. As a result, Amendment 2 implemented trip limits, trap limits, and days out of the fishery, in an effort to slow down catch rates and extend the season. Despite these changes, the 2011/2012 season was also brief, opening on January 2, 2012 for trawls and February 1 for traps, and closing on February 17.

Addendum I to Amendment 2 allocated 87% of the Total Allowable Catch to the trawl fishery (Map 129) and 13% to the trap fishery. Shrimp trawl gear is described in the Appendix D. Trawl vessels must use a Nordmore grate, which is intended to eliminate most of the bycatch of finfish. Addendum I to Amendment 2 authorized the use of a double Nordmore or compound grate which minimizes retention of small shrimp. Most trawling occurs inshore, defined as shallower than 55 fathoms in the assessment document. In 2012, 235 Maine trawl fishermen interviews placed 92% of their trips inshore and 8% offshore. The trawl fleet includes 30-46’ lobster vessels that re-rig for shrimping, 40-56’ stern trawlers, and larger 56-79’ vessels. ASFMC reports “a trend in recent years towards the use of heavier, larger roller and/or rockhopper gear. These innovations, in concert with substantial improvements in electronic equipment, have allowed for much more accurate position and towing in formerly unfishable grounds, thus greatly increasing the fishing power of the Gulf of Maine fleet” (ASMFC 2011).

The most recent assessment indicates collapse of the stock (see section 4.2.1.8), and future prospects look bleak. In December 2013, the Atlantic States Marine Fisheries Commission’s Northern Shrimp Section approved a moratorium for the 2014 northern shrimp fishing season.

Map 129 – Northern shrimp trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



4.3.1.10 American lobster

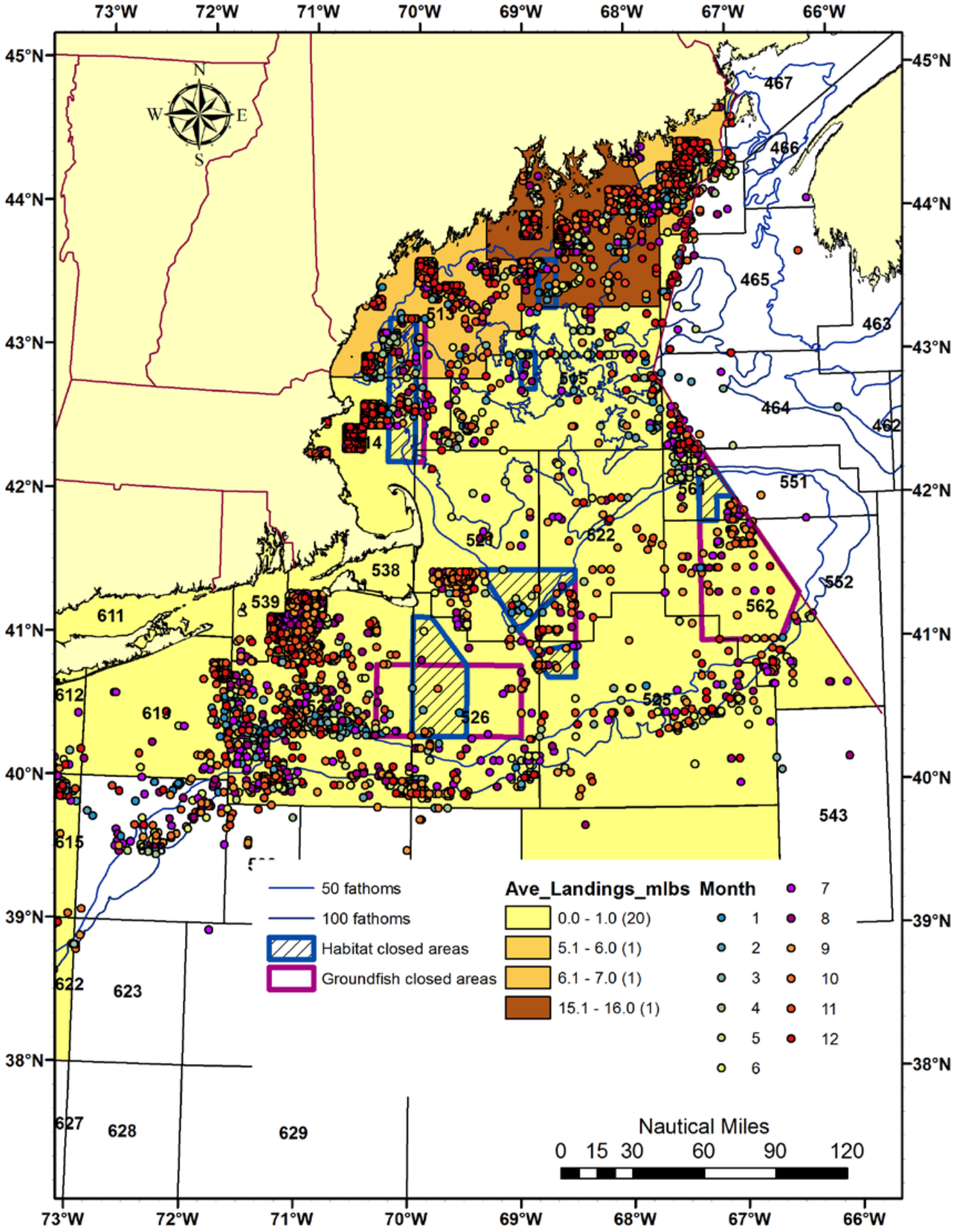
The lobster fishery is managed by ASMFC, with measures developed by Lobster Conservation Management Teams specific to seven management areas. The most relevant areas to this action are Area 1 (inshore GOM), Outer Cape Cod, Area 2 (south of MA and RI), and Area 3 (offshore GOM, GB, and MAB to the EEZ). Management measures include minimum and maximum sizes; trap limits and configuration requirements; prohibitions on possessing egg-bearing females or v-notched lobsters, lobster meat, or lobster parts; prohibitions on spearing lobsters; and limits on non-trap landings. The vast majority of landings coast-wide comes from Area 1, and are taken with traps (Map 130). Trawls and other commercial gears account for a small fraction of the commercial landings. Recreationally, lobsters are harvested with traps and by hand while SCUBA diving, but the magnitude of recreational landings is unknown.

The Gulf of Maine fishery is prosecuted mainly with small, 22-42’ vessels that conduct day trips within about 12 miles of shore. There are some larger vessels that fish offshore in the GOM. Maine vessels account for most of the fishing effort, and the number of traps fished increased substantially between 1993 and 2002, and has remained at over 3.5 million since then. Trap effort in NH and MA are much smaller in magnitude compared to ME; since 1989 effort in NH has increased and GOM effort in MA has declined.

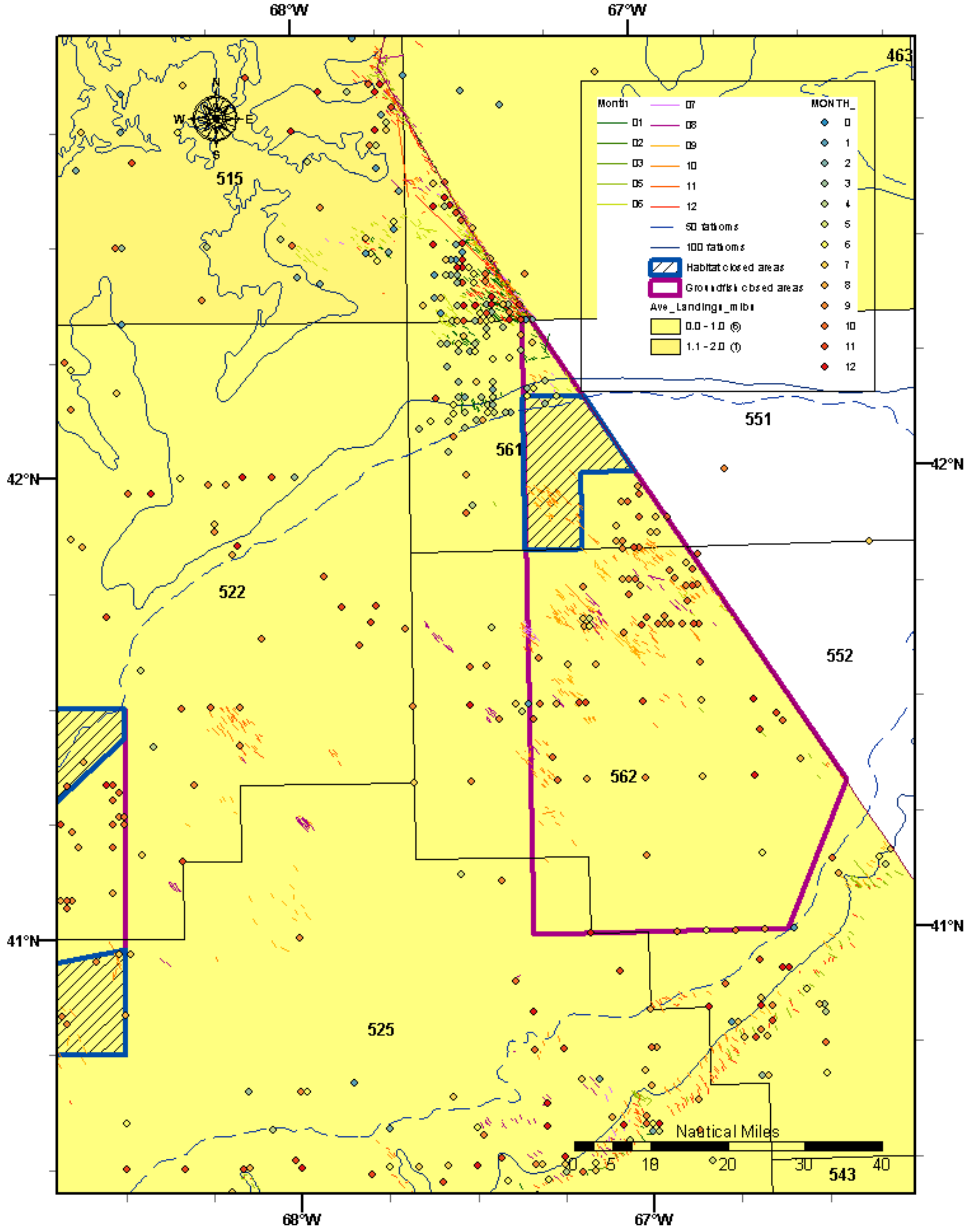
On Georges Bank, most of the effort (Map 131) is on multi-day trips taken using larger, 55-75’vessels. There is day trip fishery in the Outer Cape Cod area. According to the 2009 assessment, the number of traps fishing on Georges Bank is “not well characterized, due to a lack of mandatory reporting, and/or a lack of appropriate resolution in the reporting system” (ASMFC 2009, p 42). Data from Massachusetts, which constitutes a large fraction of the Georges Bank fishery, indicate that number of traps remained relatively stable between 1994 and 2007.

In Southern New England, there is a nearshore, small vessel day boat fleet as well as an offshore fleet that takes multi-day trips to the canyons along the edge of the continental shelf.

Map 130 – Lobster trap effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



Map 131 – Lobster trap effort on eastern Georges Bank 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored lines show the distribution of observed hauls from January (blue) to December (red).

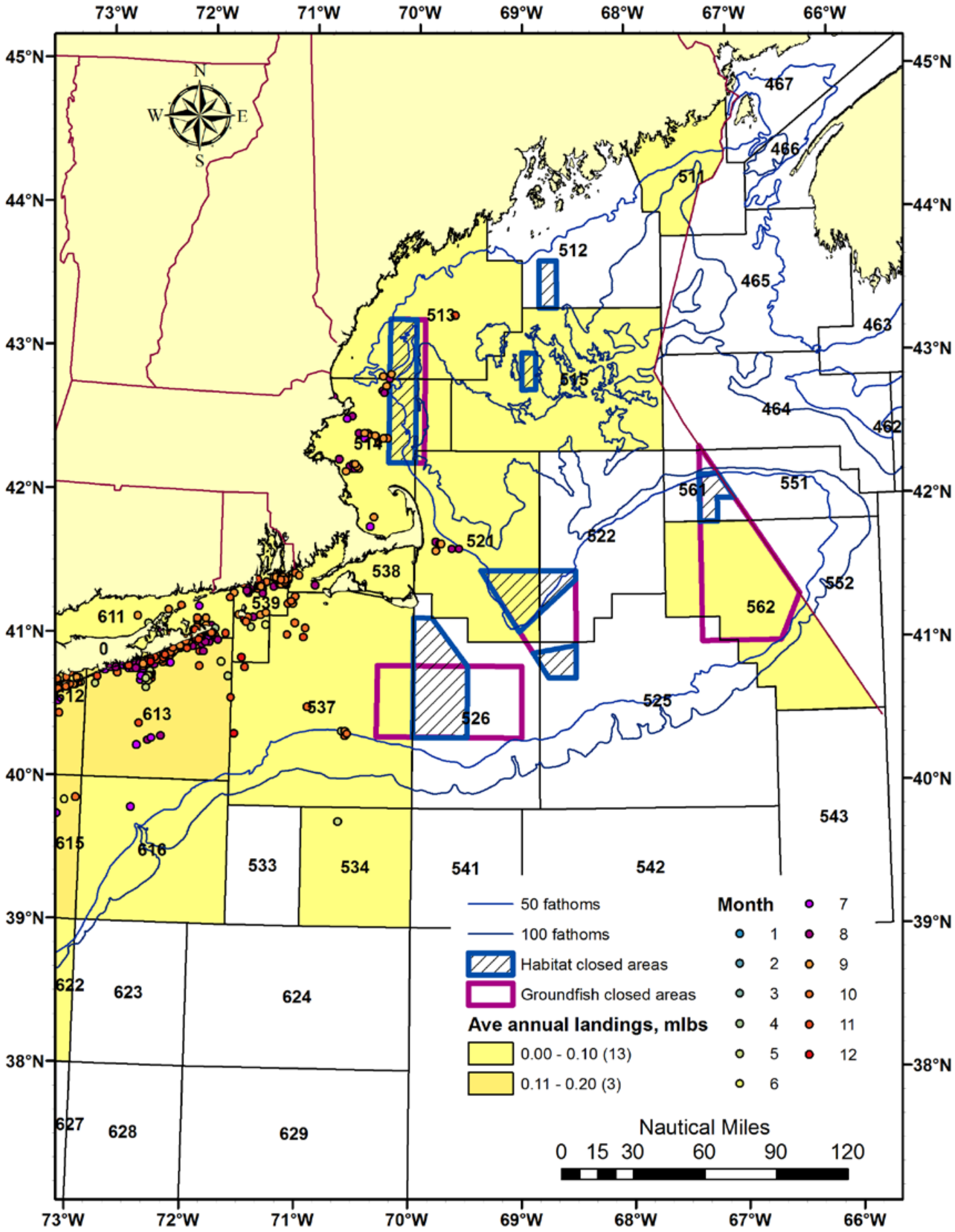


4.3.1.11 Atlantic bluefish

The Mid-Atlantic Council began developing the Atlantic Bluefish FMP in 1979 in response to a petition by concerned fishermen reacting to developments in international markets for bluefish. The final FMP was adopted as a joint plan between the Council and ASMFC in 1989 and was implemented in 1990. The FMP established a state-by-state commercial quota system and a coast-wide recreational harvest limit. The MAFMC and the ASMFC decide annually on a total allowable landings level that is divided between the commercial and recreational sectors. The commercial quota is then further allocated to the states from Maine through Florida based on percentage shares specified in the FMP. The FMP calls for 83 percent of the total allowable landings to be allocated to the recreational sector and 17 percent allocated to the commercial sector, but provides for a transfer of quota to the commercial sector from the recreational sector within certain limits.

The primary gear types used in the commercial fisheries that land bluefish include gillnets (Map 132), rod and reel, and otter trawls, although there are small localized fisheries, such as the beach seine fishery that operates along the Outer Banks of North Carolina that also catch bluefish. Recreational fishing, which dominates the catch of bluefish, is almost exclusively rod and reel, and includes shoreside recreational anglers, party/charter boats, and private recreational boats. There is a lot of seasonality to both the commercial and recreational fisheries for bluefish due to the migratory nature of the species.

Map 132 - Bluefish gillnet effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



4.3.1.12 Atlantic mackerel, squid, and butterfish

The mackerel, squid, and butterfish fisheries are all managed by directly controlling harvest under an FMP developed by the MAFMC in 1983. The directed mackerel fishery can be closed when landings are projected to reach 95 percent of the total domestic harvest. The mackerel incidental catch fishery can be closed when landings are projected to reach 100 percent of the total domestic harvest. The directed longfin squid fishery is managed via trimester quota allocations and the directed fishery is closed when 90 percent of the trimester quota allocations or 95 percent of the total domestic harvest is projected to be landed. There is also a cap on butterfish discards in the longfin squid fishery that is allocated by trimester, and closes the longfin squid fishery to directed harvest once it has been exceeded. The directed *Illex* fishery closes when 95 percent of the total domestic harvest is projected to be landed. Finally, butterfish is managed using a phased system. The system triggers butterfish possession limit reductions at different points to ensure quota is available for directed harvest throughout the fishing year. During closures of the directed longfin squid, *Illex*, or butterfish fisheries, incidental catch fisheries for these species are permitted.

Although 1.5 percent of butterfish landed from 2007-2011 were reported as caught with gillnets, and trace amount of these species were reported as caught with a variety of fishing gears, more than 98 percent of reported landings of all four species during this period were caught with otter trawls (midwater and bottom). Management measures implemented under this FMP restrict only the commercial fishing sectors, although there is a recreational fishery for Atlantic mackerel. Fishing for Atlantic mackerel occurs year-round, although most fishing activity occurs from January through April. The *Illex* squid fishery occurs largely from June through October, although this can vary somewhat from year to year. In some years, the longfin squid fishery remains relatively consistent throughout the year, but in most years, landings peak during October through April. Butterfish are landed year-round, with no apparent seasonal patterns.

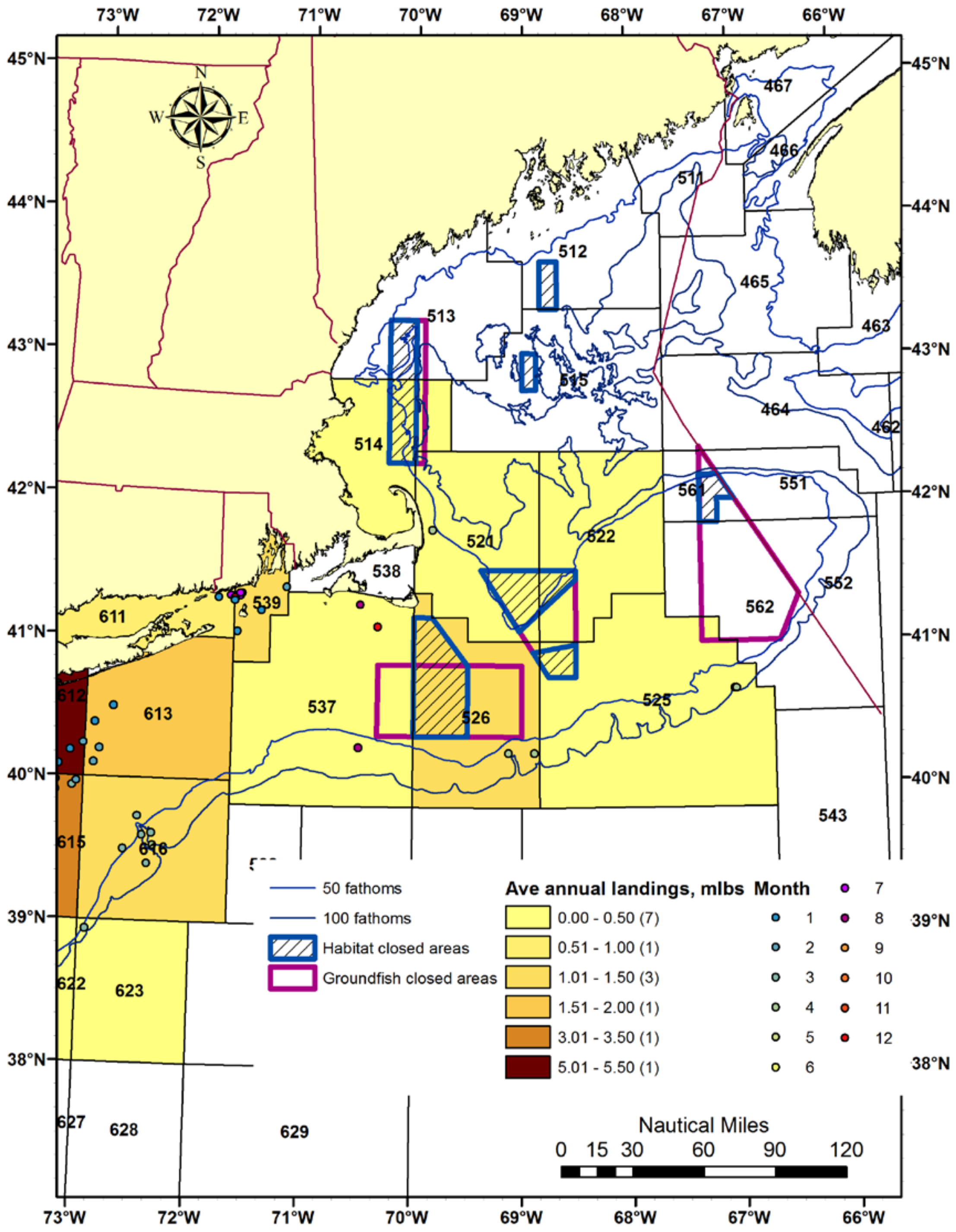
Mackerel harvest has declined since about the mid-2000s and the fishery has harvested at most about 50% of the quota since that time.

Butterfish had been landed domestically from the late 1800s, and in the 1960s and 1970s there was a substantial increase in catch, mostly by foreign vessels. After extended jurisdiction was implemented, domestic landings expanded but then declined in the 1990s due to lower abundance and market conditions. As of January 2013, a limited domestic fishery has been reestablished, although landings have been low so far. In general discards represent a significant fraction of the catch.

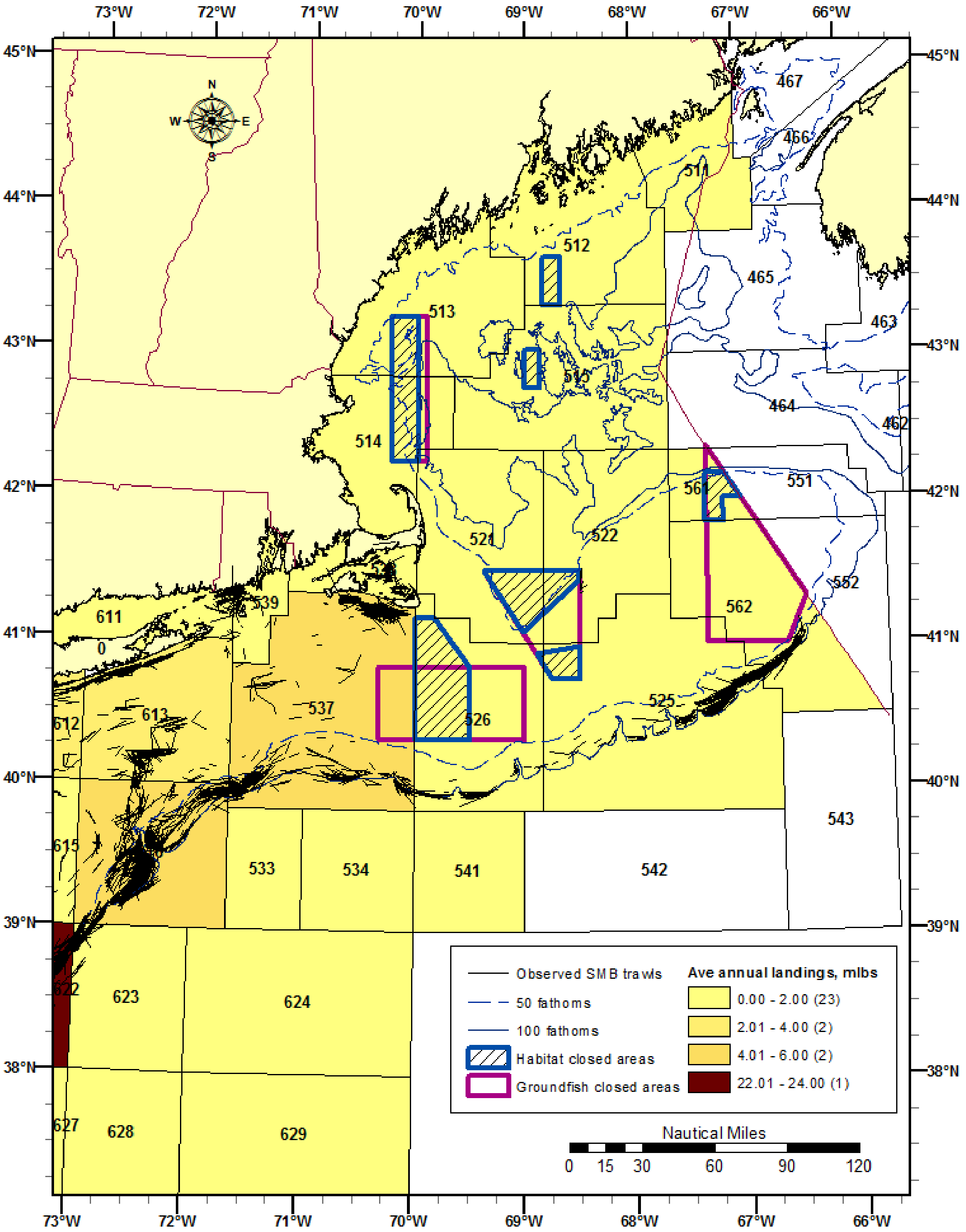
Like butterfish, *Illex* were also subject to substantial foreign fishing from the 1960s to the 1980s. Domestic harvest increased as foreign fishing mortality was reduced in the 1980s, and have remained between 10,000 and 20,000 mt per year since the mid-2000s. Longfin were fished domestically in the 1960s and 1970s, while foreign fishing occurred on this squid when they were offshore. An offshore US fishery developed in the late 1980s. Currently, offshore fishing occurs between October and March and inshore fishing occurs from April through September. There has been a slight downward trend in longfin squid landings since the late 1980s, although 2011 and 2012 show an upward trend.

Landings for all species in mid-water and bottom trawls are shown on Map 133 and Map 134.

Map 133 – Atlantic mackerel, squid, and butterfish midwater trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



Map 134 – Atlantic mackerel, squid, and butterfish bottom trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Black lines show start/end positions of hauls observed at sea.

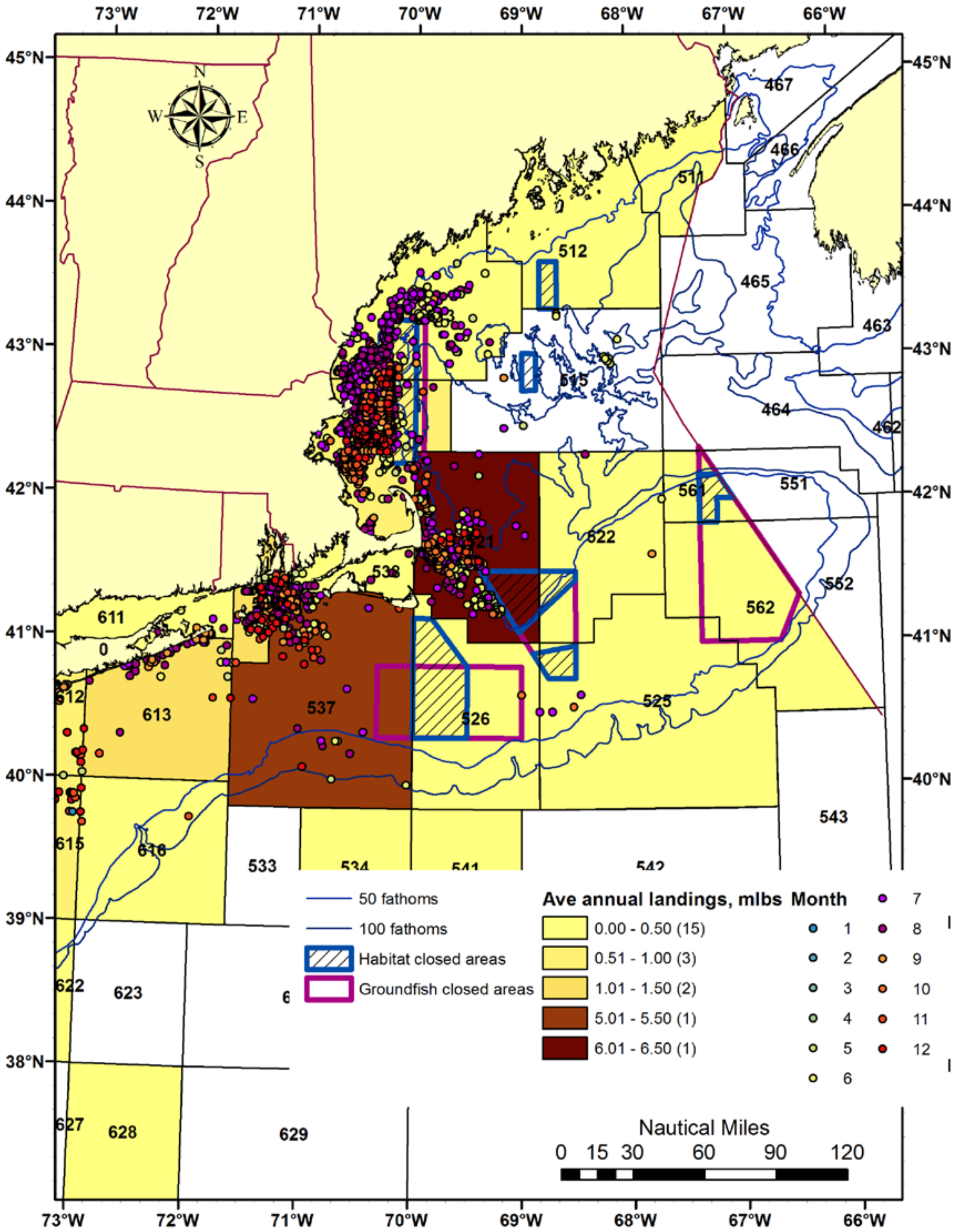


4.3.1.13 Spiny dogfish

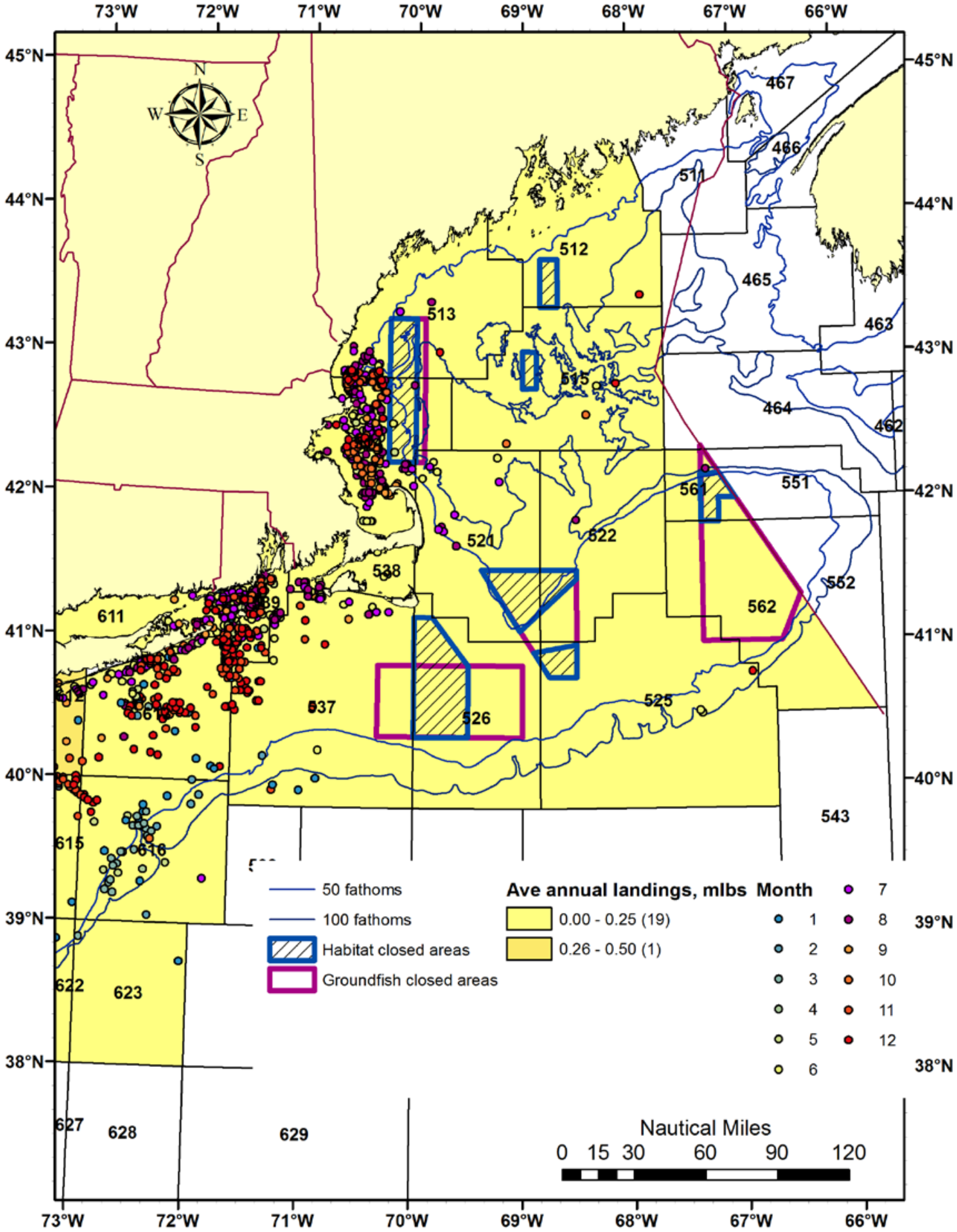
The Mid-Atlantic and New England Councils jointly developed an FMP for spiny dogfish, which was partially approved in 1999 and implemented in 2000. Management measures included an overall commercial quota, allocated into two semiannual periods; restrictive trip limits; a prohibition on finning; an annual quota adjustment process; and permit and reporting requirements. The Atlantic States Marine Fisheries Commission implements complementary management measures for spiny dogfish in state waters. The spiny dogfish stock was officially declared to be rebuilt in 2010, and commercial quotas have been significantly increased in recent years.

Most spiny dogfish landings are the result of commercial fishing activities, as reported recreational landings comprise less than 2 percent of the total catch. Sink gillnets (Map 135), bottom longlines, and bottom otter trawls (Map 136) are the primary commercial fishing gears that catch spiny dogfish and these three gear types accounted for 97 percent of all dogfish landed in 2007-2011. For fishing years 2007-2011 combined, the Massachusetts ports had the most commercial landings (42.5 percent), with another 19 percent made in Virginia, and 10 percent in New Hampshire.

Map 135 – Spiny dogfish gillnet effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



Map 136 – Spiny dogfish trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



4.3.1.14 Summer flounder, scup, and black sea bass

The ASMFC and the MAFMC work collaboratively to manage these three species. The federal FMP was developed by the Mid-Atlantic Council, initially just for summer flounder (fluke), and approved by the Secretary of Commerce in 1988. This original Summer Flounder FMP was based largely on the ASMFC plan. Amendment 2 (1993) established much of the current management regime, including a commercial quota allocated to the states, a recreational harvest limit, minimum size limits, gear restrictions, permit and reporting requirements, and an annual review process to establish specifications for the coming fishing year.

Although initially intended to be separate FMPs, work on the development of the Scup FMP and the Black Sea Bass FMP was folded into the Summer Flounder FMP, which was broadened to incorporate management measures for scup and black sea bass through Amendments 8 and 9, respectively. These amendments included management measures for scup and black sea bass such as commercial quotas and quota periods, commercial fishing gear requirements, minimum fish size limits, recreational harvest limits, and permit and reporting requirements. Both amendments were implemented in 1996.

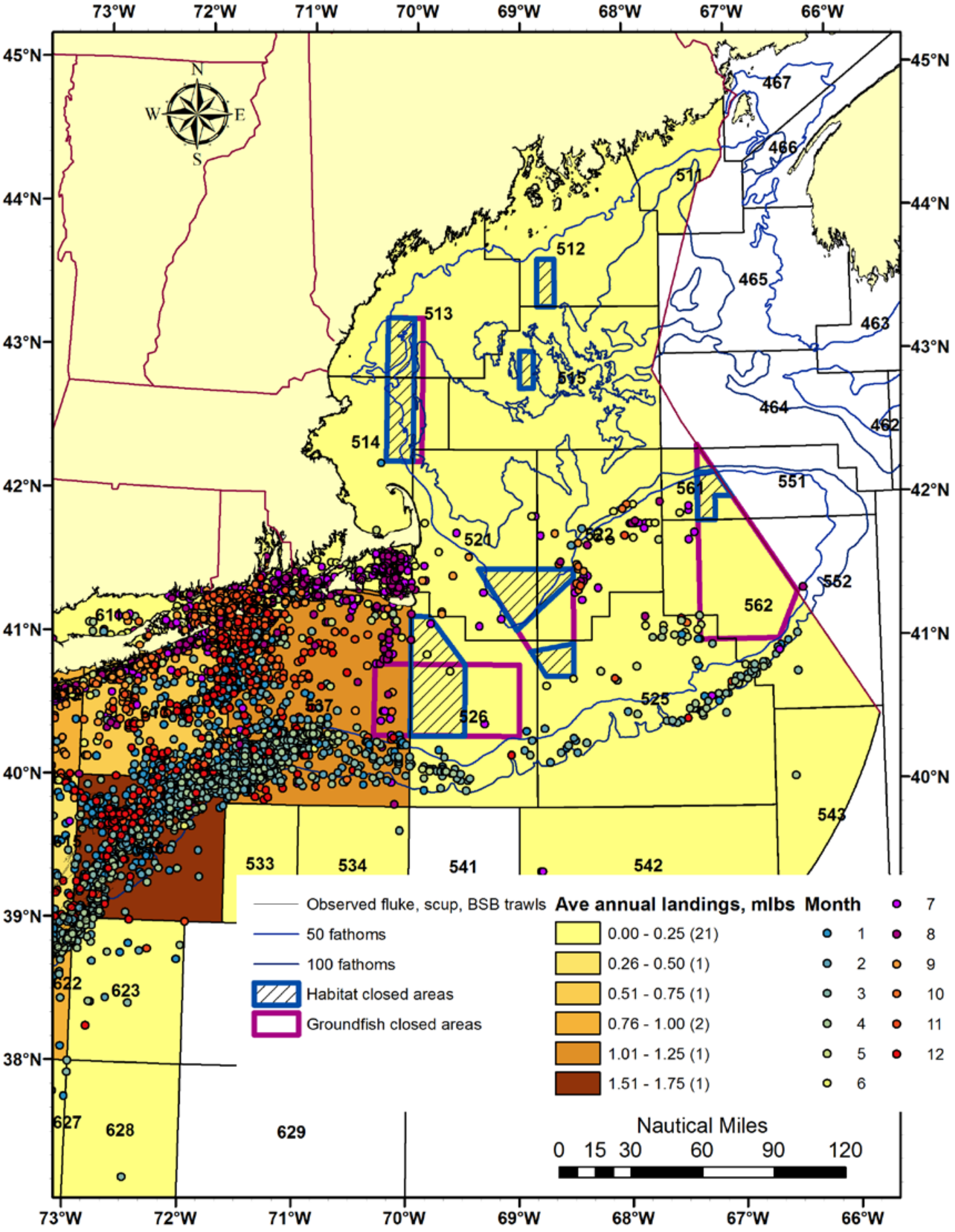
For each of these three species, an annual acceptable biological catch (ABC) is established by the MAFMC. The ABC is then divided, using percentages identified in the FMP, into a commercial Annual Catch Limit and a recreational Annual Catch Limit. The MAFMC then sets corresponding annual catch targets (ACT) for each fishing sector. The commercial quota and recreational harvest limit are the amount of landings remaining after deducting discards from the respective ACTs. The commercial fisheries for all three species are managed through a combination of limited access (moratorium) fishing vessel permits, annual quotas that result in closures of the fisheries upon reaching the quota, gear restrictions, and minimum fish sizes.

The recreational fisheries are not subject to a “hard” quota, but instead are subject to a set of management measures designed to constrain catch to a target level. Management measures used include minimum fish sizes, bag (possession) limits, and fishing seasons. Party/charter vessels operating in Federal waters are required to obtain Federal permits. Coast-wide management measures are established for the black sea bass and scup recreational fisheries operating in Federal waters. For summer flounder, however, the states have the option to develop state-by-state measures that, in sum, would achieve the equivalent level of conservation as would the coast-wide measures. All decisions regarding annual quotas and management measures for these commercial and recreational fisheries are made in conjunction with the ASMFC.

All three of these species support significant recreational as well as commercial fisheries. On average, commercial landings over the last several years accounted for slightly more than half to two-thirds of the total landings of summer flounder and scup, while black sea bass recreational landings typically exceed commercial landings. The primary gears used in the commercial fisheries for these species vary. Based on fishing vessel trip report data from 2007-2011, summer flounder are caught almost exclusively (95 percent) with bottom otter trawls; scup are caught primarily (92 percent) with bottom otter trawls, but handlines/rod and reel combined with pots, traps, and weirs accounted for another 6 percent; and black sea bass are caught in roughly equal amounts by bottom otter trawls (47 percent), and pots and traps (46 percent), and to a much lesser extent by handlines/rod and reel (5 percent). Recreational fishing for these species is enjoyed by shore-based anglers, private recreational boat anglers, and anglers on party and charter vessels.

Although the stock areas for these species are described as Maine through North Carolina, very little recreational or commercial catch is allocated to New Hampshire or Maine, and there are no dealers buying summer flounder, scup, or black sea bass in these states.

Map 137 – Summer flounder trawl effort 2008-2012. Yellow to brown shading shows average annual landings (live weight) by statistical area from the dealer tables. Colored circles show the locations of trips as reported on vessel trip reports, from January (blue) to December (red).



4.3.1.15 Golden tilefish

The Tilefish FMP (implemented 2001) was developed by the Mid-Atlantic Council to implement management measures for the tilefish fishery north of the Virginia/North Carolina border intended to address the overfished status of the species. Amendment 1 to the Tilefish FMP, implemented in 2009, eliminated the limited access permit categories and adopted an IFQ program. Initially, thirteen allocation holders received quota share based primarily on historical participation in the fishery. All vessels landing tilefish are required to have an open access permit, which authorizes a vessel to land up to 500 lb per trip. An IFQ allocation permit exempts the vessel from the possession limit. Each year, 95 percent of the total allowable landings are allocated to the IFQ fishery, and the remaining 5 percent is allocated to the incidental fishery.

The commercial tilefish fishery is relatively small, with only a dozen vessels participating in the IFQ fishery. Tilefish are primarily caught with bottom longlines (98 percent of landings reported in the fishing vessel trip report database from 2007-2011), and approximately 1.8 percent of landings are associated with bottom otter trawls. There is a minimal recreational fishery for this species, with less than 8,300 lb landed annually for the last 30 years and in only two years since 2000 does the MRIP database report trips with tilefish as the primary target species.

4.3.2 Fishing Communities

This amendment will impact communities and ports throughout the coastal northeast and mid-Atlantic. Consideration of the social impacts on these communities from proposed fishery regulations is required as part of the National Environmental Policy Act (NEPA) of 1969 and the Magnuson Stevens Fishery Conservation and Management Act (MSA), 1976. Before any agency of the federal government may take “actions significantly affecting the quality of the human environment,” that agency must prepare an Environmental Assessment (EA) that includes the integrated use of the social sciences (NEPA Section 102(2)(C)). National Standard 8 of the MSA stipulates that “conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities” (16 U.S.C. § 1851(a)(8)).

A “fishing community” is defined in the Magnuson-Stevens Act, as amended in 1996, as “a community which is substantially dependent on or substantially engaged in the harvesting or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and United States fish processors that are based in such community” (16 U.S.C. § 1802(17)). For detailed descriptions of the affected human communities and fisheries affected by the Omnibus Amendment refer to the respective FMPs available from NEFMC, MAFMC, and ASMFC.

Given the geographic scope of the Omnibus Amendment and the fact that it will influence fishing with various different gear types, these alternatives will impact numerous fishing communities. Identifying specific communities that will be impacted is difficult and uncertain, particularly for the communities which will be impacted by opening or modifying current area closures. Because these areas are currently closed and have been for some time, there is no baseline information regarding the recent history of effort in these areas and communities that are most likely to be impacted. Due to changes in behavior, fishing strategy and other adaptations that have occurred since the original implementations of these closures, it is unlikely that effort will revert to the original condition prior to the implementation of the closures. Additionally there are a number of potential issues with the confidential nature of the information used to narrow the focus to individual communities in the analysis of fishing dependence. There are privacy concerns with presenting the data in such a way that proprietary information (landings, revenue, etc.) can be attributed to an individual vessel or a small group of vessels. This is particularly difficult when presenting information on small ports and communities that may only have a small number of vessels and that information can easily be attributed to a particular vessel or individual.

The communities that are likely to experience significant impacts from the alternatives under consideration include those currently fishing in areas proposed to be closed, those fishing near current closed areas which are proposed to be opened, and those fishing with gear types that are allowed in currently closed areas that are proposed to be opened to other gear types. Given the scope of the Omnibus Amendment, these criteria identify more port groups than is practical to identify as *communities of interest* for this assessment. Additionally, it is difficult to determine which ports are likely to be most impacted by the opening of currently closed areas. For these reasons, the specific communities identified as communities of interest were identified through the economic analysis of vessel trips most likely to be impacted by the addition of new closed areas (see the economic impacts sections in Volume 3, Section 4). Communities listed in Table 36 are either the port of landing or the city where the permit is registered for trips by at least three vessels using mobile bottom tending gears in 2012 in areas that are proposed for closure in this amendment. It is important to note that this is not an exhaustive list of communities that will be impacted. It is necessary to consider the impacts of the proposed alternatives across all communities, particularly those identified as communities of interest in their respective FMPs.

Table 36 also includes Social Indicators of Fishing Community Vulnerability and Resilience for these communities. Social indicators are useful in understanding the context with which these communities will be affected by regulatory change. These indicators were developed for three categories of vulnerability: social, gentrification and fishing dependence. Within each category separate indices are calculated. These indices were selected based on literature and previous research and correspond to different components of vulnerability that will affect communities. Each indicator is scored from low to high vulnerability (1=Low, 2=Moderate, 3=High). These levels are calculated from the standard deviation of each community's individual vulnerability score. Standard deviations less than 0.499 are scored as low (1), standard deviations of 0.500-0.999 are scored as moderate (2) and standard deviations >1.000 above the mean are scored as high (3). For more information on the development and use of Social Indicators see Jepson and Colburn, 2013 or http://www.st.nmfs.noaa.gov/humandimensions/social-indicators/index.

In addition, snapshots of the Human Communities and Fisheries of the Northeast with the most recent data available for key indicators for Northeastern fishing communities related to dependence on fisheries and other economic and demographic characteristics can be found at http://www.nefsc.noaa.gov/read/socialsci/communitySnapshots.php . More detailed profiles providing in-depth information regarding the historic, demographic, cultural, and economic context for understanding a community's involvement in fishing can be found at http://www.nefsc.noaa.gov/read/socialsci/communityProfiles.html.

Table 36 – Communities (port of landing or city of registration) associated with mobile bottom tending gear trips by 3 or more vessels in 2012 in currently open areas potentially affected by new closure management alternatives. Some information is omitted due to privacy concerns (*).

	Level Affected		2012 Landings		Social Vulnerability Indices					Gentrification Indices				Commercial Fishing Dependence	
State, Community	**Port**	**City**	**Lbs**	**Value**	**Personal Disruption**	**Population Composition**	**Poverty**	**Labor Force Structure**	**Housing Characteristics**	**Housing Disruption**	**Retiree Migration**	**Urban Sprawl**	**Natural Amenities**	**Com. Fishing Reliance**	**Com. Fishing Engagement**
CT	**x**	**x**	**14,341,127**	**31,543,035**											
New London	x		7,494,255	11,825,904	3	3	3	1	2	1	1	1	2	1	2
Stonington	x		5,226,644	16,085,371	2	1	1	1	1	1	1	1	1	1	2
MA	**x**	**x**	**275,992,488**	**611,643,951**											
Barnstable	x		349,017	16,085,371	1	1	1	1	1	1	1	1	1	1	2
Boston	x	x	11,524,254	18,738,935	3	3	3	1	1	1	1	3	1	1	3
Chatham	x	x	10,743,546	16,622,422	1	1	1	3	1	3	3	2	3	3	3
Chilmark	x		198,738	904,057	1	1	1	3	1	1	1	3	3	3	2
Fairhaven	x	x	7,099,780	25,079,912	2	1	2	1	2	1	1	1	1	1	3
Falmouth	x		314,097	1,492,030	1	1	1	3	2	1	3	1	2	1	1
Gloucester	x	x	77,466,102	56,766,072	1	1	1	1	1	1	1	1	1	3	3
Harwich		x			1	1	1	1	1	2	2	1	1	1	1
Harwichport	x	x	1,049,430	4,369,782	1	1	1	3	2	1	3	1	3	2	1
Hyannis	x		469,493	1,782,784											
Marshfield	x	x	2,547,340	3113654	1	1	1	1	1	2	1	2	1	1	1
Mattapoisset	x				1	1	1	2	1	1	2	1	1	1	1
Nantucket	x		449,616	2,697,923	1	1	1	1	1	3	1	2	3	1	3
New Bedford	x	x	133,902,841	406,824,112	3	3	3	1	2	2	1	1	1	2	3
Newburyport	x		294,989	993,023	1	1	1	1	1	1	1	2	1	1	2
Peabody		x			1	1	1	1	1	1	1	2	1	1	1
Plymouth	x		1,831,055	4078916	2	1	1	1	1	1	1	1	1	1	3

	Level Affected		2012 Landings		Social Vulnerability Indices					Gentrification Indices				Commercial Fishing Dependence	
State, Community	**Port**	**City**	**Lbs**	**Value**	**Personal Disruption**	**Population Composition**	**Poverty**	**Labor Force Structure**	**Housing Characteristics**	**Housing Disruption**	**Retiree Migration**	**Urban Sprawl**	**Natural Amenities**	**Com. Fishing Reliance**	**Com. Fishing Engagement**
Provincetown	x		1,911,149	6,230,772	1	1	1	1	2	1	1	1	3	2	2
Rockport	x	x	233,431	821,618	1	1	1	2	1	1	2	1	3	1	2
Sandwich	x		2,792,307	5,273,595	1	1	1	1	1	2	1	1	1	1	2
Scituate	x		3,258,874	4,555,489	1	1	1	1	1	1	1	2	1	1	3
South Dartmouth[1]		x			1	1	1	1	1	1	1	1	1	1	1
Westport		x	2,046,220	2,579,805	1	1	1	1	1	1	1	1	1	1	3
Woods Hole	x	x	1,352,969	2,525,068	1	1	1	3	1	1	3	2	3	1	1
ME	**x**	**x**	**288,195,478**	**529,159,412**											
Beals		x	5,035,295	11,463,226	1	1	3	3	3	1	1	1	3	3	3
Boothbay Harbor	x		1,710,568	4,663,084	1	1	1	3	2	1	3	1	3	3	3
Bremen		x	1,307,048	3,335,316	1	1	1	2	3	1	2	1	3	3	1
Cundys Harbor[2]	x		2,278,264	5,265,619	1	1	3	3	1	1	3	1	3	3	3
Friendship	x	x	5,816,141	14,179,324	1	1	2	3	3	1	3	1	3	3	3
Harpswell[2]	x	x	1,291,800	3,751,017	1	1	3	3	1	1	3	1	3	3	3
Jonesport	x	x	17,800,051	12,673,990	2	1	3	3	3	1	1	1	3	3	3
New Harbor[3]	x		1,795,115	3,729,210	1	1	1	3	2	1	3	1	3	3	2
Port Clyde[4]	x	x	6,075,059	9,620,816	1	1	2	3	2	2	3	1	3	3	3
Portland	x	x	58,549,137	33,278,136	2	1	3	1	2	1	1	1	2	1	3
South Bristol	x	x	3,275,440	5,637,715	1	1	1	3	2	1	3	1	3	3	3
Westbrook		x			1	1	3	1	2	1	1	1	1	1	1
Winter Harbor		x	2,861,014	4,787,681	1	1	3	3	3	1	1	1	3	3	2
NC	x	x	20,629,590	30,767,814											
Bayboro		x			2	2	2	3	3	1	3	1	1	1	1
Beaufort	x		2,360,340	4,862,934	3	1	3	2	3	1	1	1	1	2	2

	Level Affected		2012 Landings		Social Vulnerability Indices					Gentrification Indices				Commercial Fishing Dependence	
State, Community	**Port**	**City**	**Lbs**	**Value**	**Personal Disruption**	**Population Composition**	**Poverty**	**Labor Force Structure**	**Housing Characteristics**	**Housing Disruption**	**Retiree Migration**	**Urban Sprawl**	**Natural Amenities**	**Com. Fishing Reliance**	**Com. Fishing Engagement**
Hobucken		x			1	1	1	3	3	1	3	1	2	3	1
New Bern		x			3	2	3	2	3	1	1	1	1	1	2
Newport		x			2	1	1	1	3	1	1	1	1	1	1
Oriental		x	682,007	1,873,922	1	1	1	3	1	2	3	1	2	3	2
Wanchese		x	9,035,097	13,393,751	1	1	1	1	3	1	2	1	1	3	3
NH	**x**	**x**	**11,368,326**	**22,438,709**											
Hampton		x	107,472	377,396	1	1	1	1	1	1	1	1	2	1	2
Portsmouth	x		2,753,324	5,673,327	1	1	1	1	1	1	1	1	1	1	3
Rye	x		1,834,759	2,011,107	1	1	1	1	1	1	1	2	3	1	2
Seabrook	x	x	1,877,559	2,165,924	1	1	1	1	3	1	1	1	1	1	2
NJ	**x**	**x**	**240,213,971**	**190,952,493**											
Barnegat/	x	x	6,443,597	29,364,254	1	1	1	1	1	3	1	1	1	1	1
Barnegat Light					1	1	1	3	1	1	3	2	3	3	3
Cape May	x	x	74,279,155	74,841,543	1	1	1	3	1	3	3	1	3	3	3
Cape May Courthouse		x			1	1	1	1	1	2	1	1	1	1	1
Manahawkin		x			1	1	1	1	1	2	1	1	1	1	1
Point Pleasant	x		25,062,004	28,614,510	1	1	1	1	1	1	1	1	1	1	3
NY	**x**	**x**	**28,241,505**	**43,088,494**											
Hampton Bays[5]		x	7,077,477	8,100,029	1	1	1	1	1	3	1	3	1	1	3
Montauk	x	x	14,426,305	22,800,411	1	1	1	2	1	3	1	2	3	3	3
RI	**x**	**x**	**81270384**	**78,107,593**											
Charlestown[6]		x	2,685	8,639	1	1	1	1	1	1	1	1	2	1	1
Newport	x		8,582,388	10,557,816	1	1	1	1	1	2	1	1	1	1	3
North Kingstown[7]		x	22,985,183	12,672,262	1	1	1	1	1	1	1	1	1	1	3

	Level Affected		2012 Landings		Social Vulnerability Indices					Gentrification Indices				Commercial Fishing Dependence	
State, Community	**Port**	**City**	**Lbs**	**Value**	**Personal Disruption**	**Population Composition**	**Poverty**	**Labor Force Structure**	**Housing Characteristics**	**Housing Disruption**	**Retiree Migration**	**Urban Sprawl**	**Natural Amenities**	**Com. Fishing Reliance**	**Com. Fishing Engagement**
Point Judith/ Narragansett[8]	x	x	43,912,140	42,311,380	1	1	1	2	1	1	1	1	1	1	1
South Kingstown		x	83,112	278,243	1	1	1	1	1	1	1	1	1	1	1
Wakefield[9]		x			1	1	1	1	1	1	1	1	1	1	3
West Kingston[10]		x			1	1	1	1	1	1	1	1	1	1	1
Westerly		x	108,609	239,920	1	1	1	1	1	1	1	1	3	1	1
VA	**x**	**x**	**453,871,072**	**176,155,223**											
Chincoteague	x		4,479,003	9,143,116	1	1	3	2	3	1	2	1	3	2	2
Gloucester[11]		x	4,663,168	4,344,250	1	1	2	3	1	1	3	1	1	1	1
Hampton	x	x	5,592,006	13,891,606	2	2	2	1	2	1	1	1	2	1	3
Newport News	x	x	5,527,009	30,628,642	2	2	2	1	2	1	1	1	1	1	3
Seaford[12]	x	x			1	1	1	1	1	1	1	1	1	1	3

[1] indicators were developed for Dartmouth, MA

[2] indicators were developed for Harpswell/Bailey Island, ME (Cundy's Harbor is a village within Harpswell)

[3] indicators were developed for Bristol/New Harbor/Pemaquid, ME

[4] indicators were developed for Saint George/Port Clyde-Tenants Harbor/Spruce Head, ME

[5] indicators were developed for Hampton Bays/Shinnecook, NY

[6] indicators were developed for Charlestown/Carolina, RI

[7] indicators were developed for North Kingstown/Saunderstown, RI

[8] indicators were developed for Narragansett Pier, RI

[9] indicators were developed for Wakefield-Peacedale, RI

[10] indicators were developed for South Kingstown, RI (West Kingstown is a village within the town of South Kingstown)

[11] indicators were developed for Gloucester Courthouse, VA

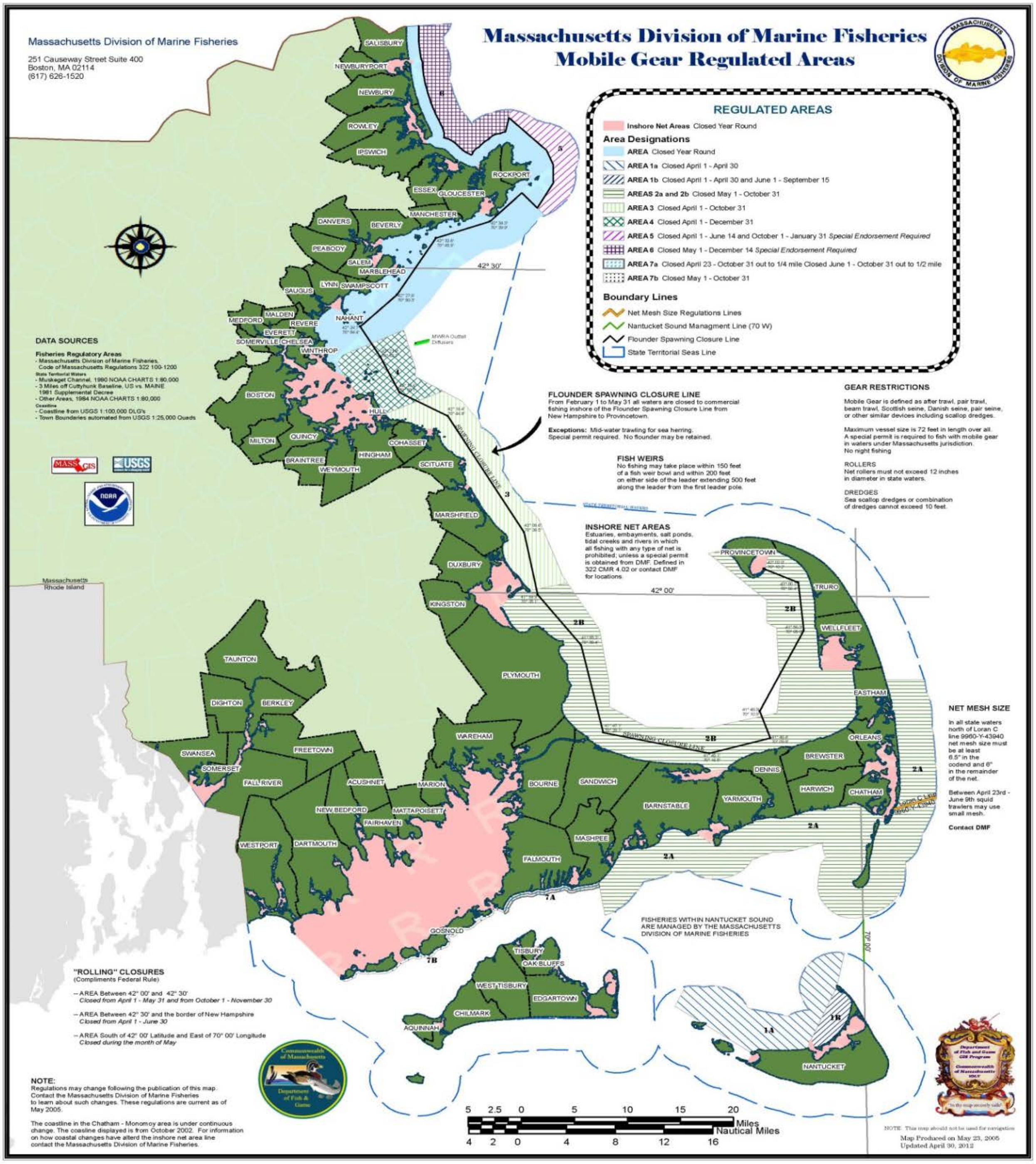
[12] indicators were developed for Grafton/Seaford, VA

4.3.3 Complementary state regulations

Four of the New England states have regulations pertaining to the use of mobile gear or gear capable of catching groundfish, either seasonally or year-round, within their state waters. The state of New Hampshire has a complete ban on mobile gear in state waters. In addition, gillnets in New Hampshire state waters are prohibited in April, May, and June, and they must comply with the Federal NE multispecies gillnet requirements (see the New Hampshire Marine Fishing Rules, Sections 602.06 and 602.07). The State of Maine has a seasonal, inshore closure from November until February in Sheepscot Bay (Maine Department of Marine Resources Regulations, Chapter 8). The State of Rhode Island limits rollers, rockhoppers, and discs to a maximum of 12 inches in diameter (R.I. Gen. Laws Title 20 Part X).

The Commonwealth of Massachusetts has several restrictions on mobile gear (Map 138). The waters north of Boston to the New Hampshire state line are closed to mobile gear year-round, with two exceptions. A portion of this closed area north of Rockport, MA is open to mobile gear from December 15 – March 31, and the “whiting area” off of Rockport is open in the months of February and March; however, no roller gear are allowed and there are restrictions on other aspects of the gear and vessels. The Outer Boston Harbor Area is closed to mobile gear from April through December. Moving south, there are several seasonal closures: (1) From Hull to Plymouth is closed April through October; (2) Plymouth to Provincetown and Eastham to Mashpee are closed May through October; (3) the north shore of Nantucket is closed in April; and (4) Great Point to Nantucket Harbor is closed June through mid-September. There are additional shoreline closures around Falmouth, from late April through October. In addition, there is a 12-inch maximum allowed for roller, disk, or rockhopper size, and a vessel size restriction (maximum of 90 ft) for all trawl fishing in state waters. There are further closures specific to spawning protection for flounders in the nearshore waters from Provincetown to the New Hampshire state line from February through May. There are two “Cod Conservation Zone” a winter closure (Map 139) that is closed from November 15 through January 31, and a spring closure (Map 140) that is closed from April 16 through July 21. Both of these areas are closed to any gear capable of catching cod, including gillnets, otter trawls, mid-water trawls, seines, and all hook and line gears (Mass. Gen. Laws. 322 CMR § 3.02 and § 8.01 through 8.15).

Map 138 Massachusetts Mobile Gear Regulated Areas



Massachusetts Division of Marine Fisheries
Mobile Gear Regulated Areas

Massachusetts Division of Marine Fisheries
251 Causeway Street Suite 400
Boston, MA 02114
(617) 626-1520

REGULATED AREAS

- 🟥 **Inshore Net Areas** Closed Year Round

Area Designations

- 🟦 **AREA** Closed Year Round
- ▨ **AREA 1a** Closed April 1 - April 30
- ▨ **AREA 1b** Closed April 1 - April 30 and June 1 - September 15
- ▤ **AREAS 2a and 2b** Closed May 1 - October 31
- ▥ **AREA 3** Closed April 1 - October 31
- ▩ **AREA 4** Closed April 1 - December 31
- ▨ **AREA 5** Closed April 1 - June 14 and October 1 - January 31 *Special Endorsement Required*
- ▦ **AREA 6** Closed May 1 - December 14 *Special Endorsement Required*
- ▦ **AREA 7a** Closed April 23 - October 31 out to 1/4 mile Closed June 1 - October 31 out to 1/2 mile
- ▦ **AREA 7b** Closed May 1 - October 31

Boundary Lines

- Net Mesh Size Regulations Lines
- Nantucket Sound Managment Line (70 W)
- Flounder Spawning Closure Line
- State Territorial Seas Line

DATA SOURCES

Fisheries Regulatory Areas
- Massachusetts Division of Marine Fisheries,
Code of Massachusetts Regulations 322 100-1200
State Territorial Waters
- Muskeget Channel, 1990 NOAA CHARTS 1:80,000
- 3 Miles off Cuttyhunk Baseline, US vs. MAINE
1981 Supplemental Decree
- Other Areas, 1984 NOAA CHARTS 1:80,000
Coastline
- Coastline from USGS 1:100,000 DLG's
- Town Boundaries automated from USGS 1:25,000 Quads

FLOUNDER SPAWNING CLOSURE LINE
From February 1 to May 31 all waters are closed to commercial fishing inshore of the Flounder Spawning Closure Line from New Hampshire to Provincetown.

Exceptions: Mid-water trawling for sea herring. Special permit required. No flounder may be retained.

FISH WEIRS
No fishing may take place within 150 feet of a fish weir bowl and within 200 feet on either side of the leader extending 500 feet along the leader from the first leader pole.

INSHORE NET AREAS
Estuaries, embayments, salt ponds, tidal creeks and rivers in which all fishing with any type of net is prohibited; unless a special permit is obtained from DMF. Defined in 322 CMR 4.02 or contact DMF for locations.

GEAR RESTRICTIONS

Mobile Gear is defined as after trawl, pair trawl, beam trawl, Scottish seine, Danish seine, pair seine, or other similar devices including scallop dredges.

Maximum vessel size is 72 feet in length over all. A special permit is required to fish with mobile gear in waters under Massachusetts jurisdiction. No night fishing

ROLLERS
Net rollers must not exceed 12 inches in diameter in state waters.

DREDGES
Sea scallop dredges or combination of dredges cannot exceed 10 feet.

NET MESH SIZE

In all state waters north of Loran C line 9960-Y-43940 net mesh size must be at least 6.5" in the codend and 6" in the remainder of the net.

Between April 23rd - June 9th squid trawlers may use small mesh.

Contact DMF

FISHERIES WITHIN NANTUCKET SOUND ARE MANAGED BY THE MASSACHUSETTS DIVISION OF MARINE FISHERIES

"ROLLING" CLOSURES
(Compliments Federal Rule)

– AREA Between 42° 00' and 42° 30'
Closed from April 1 - May 31 and from October 1 - November 30

– AREA Between 42° 30' and the border of New Hampshire
Closed from April 1 - June 30

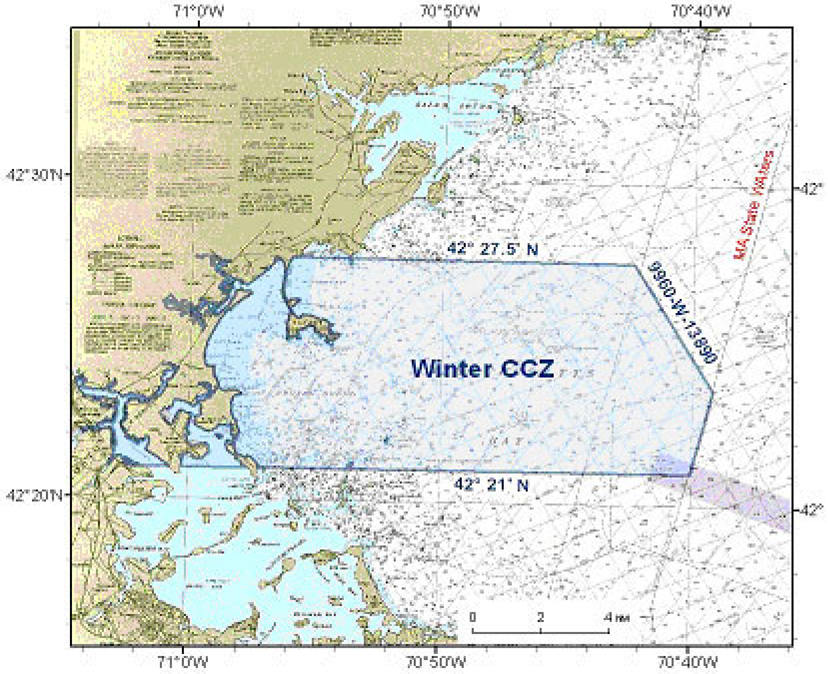
– AREA South of 42° 00' Latitude and East of 70° 00' Longitude
Closed during the month of May

NOTE:
Regulations may change following the publication of this map. Contact the Massachusetts Division of Marine Fisheries to learn about such changes. These regulations are current as of May 2005.

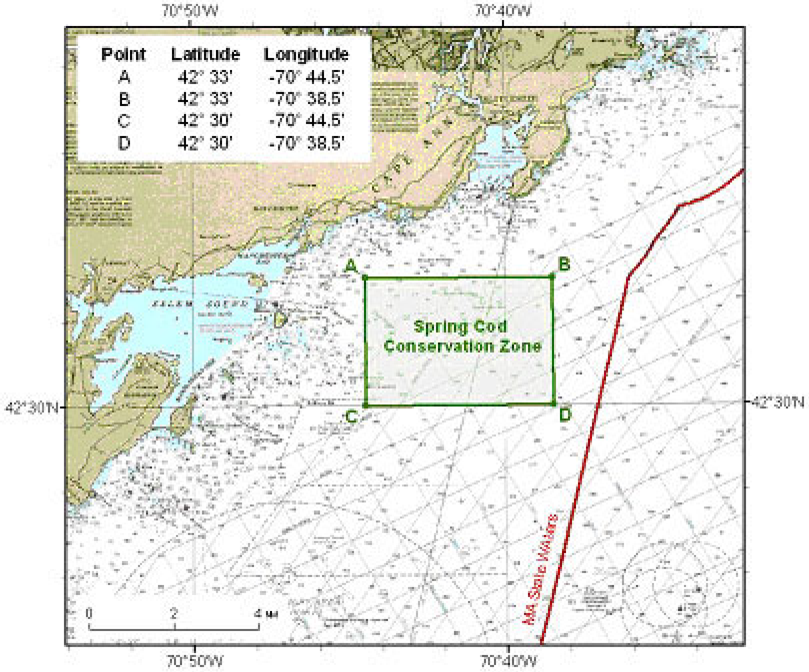
The coastline in the Chatham - Monomoy area is under continuous change. The coasline displayed is from October 2002. For information on how coastal changes have alterd the inshore net area line contact the Massachusetts Division of Marine Fisheries.

NOTE: This map should not be used for navigation
Map Produced on May 23, 2005
Updated April 30, 2012

Map 139 Massachusetts Winter Cod Conservation Zone



Map 140 Massachusetts Spring Cod Conservation Zone



Point	Latitude	Longitude
A	42° 33'	-70° 44.5'
B	42° 33'	-70° 38.5'
C	42° 30'	-70° 44.5'
D	42° 30'	-70° 38.5'

4.4 Protected resources

Numerous protected species inhabit the environment within the jurisdiction of the New England Fishery Management Council. Therefore, many protected species potentially occur in the operations area of the Council's fisheries. These species are under NMFS jurisdiction and are afforded protection under the Endangered Species Act of 1973 (ESA) and/or the Marine Mammal Protection Act of 1972 (MMPA). Non ESA-listed species protected by the MMPA that utilize this environment and have no documented interaction with NEFMC-managed fisheries will not be discussed in this section.

4.4.1 Species present in the area

Table 37 lists the species, protected either by the ESA, the MMPA, or both, that may be found in the environment utilized by the NEFMC fisheries. Table 37 also includes one candidate fish species, as identified under the ESA. Candidate species are those petitioned species that are actively being considered for listing as endangered or threatened under the ESA, as well as those species for which NMFS has initiated an ESA status review that it has announced in the Federal Register. Candidate species receive no substantive or procedural protection under the ESA; however, NMFS recommends that project proponents consider implementing conservation actions to limit the potential for adverse effects on candidate species from any proposed project. NMFS has initiated review of recent stock assessments, bycatch information, and other information for these candidate and proposed species. The results of those efforts are needed to accurately characterize recent interactions between fisheries and the candidate/proposed species in the context of stock sizes. Any conservation measures deemed appropriate for these species will follow the information reviews. Please note that once a species is proposed for listing the conference provisions of the ESA apply (see 50 CFR 402.10).

Table 37 – Species Present in the Area

Species	Status
Cetaceans	
North Atlantic right whale (*Eubalaena glacialis*)	Endangered
Humpback whale (*Megaptera novaeangliae*)	Endangered
Fin whale (*Balaenoptera physalus*)	Endangered
Sei whale (*Balaenoptera borealis*)	Endangered
Blue whale (*Balaenoptera musculus*)	Endangered
Sperm whale (*Physeter macrocephalus*	Endangered
Minke whale (*Balaenoptera acutorostrata*)	Protected
Long-finned pilot whale (*Globicephala melas*)	Protected
Short-finned pilot whale (*Globicephala macrorhynchus*)	Protected
Risso's dolphin (*Grampus griseus*)	Protected
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	Protected
Common dolphin (*Delphinus delphis*)	Protected
Spotted dolphin (*Stenella frontalis*)	Protected
Bottlenose dolphin (*Tursiops truncatus*)[b]	Protected
Harbor porpoise (*Phocoena phocoena*)	Protected

Species	Status
Sea Turtles	
Leatherback sea turtle (*Dermochelys coriacea*)	Endangered
Kemp's ridley sea turtle (*Lepidochelys kempii*)	Endangered
Green sea turtle (*Chelonia mydas*)	Endangered[c]
Loggerhead sea turtle (*Caretta caretta*), Northwest Atlantic DPS	Threatened
Hawksbill sea turtle (*Eretmochelys imbricate*)	Endangered
Fish	
Shortnose sturgeon (*Acipenser brevirostrum*)	Endangered
Atlantic salmon (*Salmo salar*)	Endangered
Atlantic sturgeon *(Acipenser oxyrinchus)*	
Gulf of Maine DPS	Threatened
New York Bight DPS, Chesapeake Bay DPS, Carolina DPS & South Atlantic DPS	Endangered
Cusk (*Brosme brosme*)	Candidate
Pinnipeds	
Harbor seal (*Phoca vitulina*)	Protected
Gray seal (*Halichoerus grypus*)	Protected
Harp seal (*Phoca groenlandicus*)	Protected
Hooded seal (*Cystophora cristata*)	Protected

[a] MMPA-listed species occurring on this list are only those species that have a history of interaction with similar gear types within the action area of the monkfish fishery, as defined in the 2012 List of Fisheries.
[b] Bottlenose dolphin (*Tursiops truncatus*), Western North Atlantic coastal stock is listed as depleted.
[c] Green turtles in U.S. waters are listed as threatened except for the Florida breeding population which is listed as endangered. Due to the inability to distinguish between these populations away from the nesting beach, green turtles are considered endangered wherever they occur in U.S. waters.

4.4.2 Species potentially affected

NEFMC-managed fisheries have the potential to affect the sea turtle, cetacean, pinniped, and fish species discussed below. A number of documents contain background information on the range-wide status of sea turtle and marine mammal species that occur in the area and are known or suspected of interacting with fishing gear (demersal gear including trawls, gillnets, and bottom longlines). These include:

- Sea turtle status reviews and biological reports (Conant et al. 2009; NMFS and USFWS 1995, 2007a, 2007b, 2007c, 2007d; Hirth 1997, Turtle Expert Working Group (TEWG) 1998, 2000, 2007, 2009);
- Recovery plans for Endangered Species Act-listed sea turtles and marine mammals (NMFS 1991; NMFS and USFWS 1991a, 1991b, 2008; NMFS et al. 2011; USFWS and NMFS 1992; NMFS 2005b);
- Marine mammal stock assessment reports (e.g., Waring et al. 2013); and
- Other publications (e.g., Clapham et al. 1999; Perry et al. 1999; Wynne and Schwartz 1999; Best et al. 2001; Perrin et al. 2002).

- Additional background information on the Gulf of Maine Distinct Population Segment of Atlantic salmon and the five distinct population segments of Atlantic sturgeon can be found in the respective status reviews (Fay et al. 2006; ASSRT 2007) and listing determinations for Atlantic salmon (74 FR 29344; June 19, 2009) and Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 3, 2012).

4.4.3 Sea turtles

Loggerhead, leatherback, Kemp's ridley, and green sea turtles occur seasonally in southern New England and Mid-Atlantic continental shelf waters north of Cape Hatteras, North Carolina. Turtles generally move up the coast from southern wintering areas as water temperatures warm in the spring (Braun-McNeill and Epperly 2004, Morreale and Standora 1998, Musick and Limpus 1997, Shoop and Kenney 1992, Keinath et al. 1987). A reversal of this trend occurs in the fall when water temperatures cool. Turtles pass Cape Hatteras by December and return to more southern waters for the winter (James et al. 2005, Morreale and Standora 2005, Braun-McNeill and Epperly 2004, Morreale and Standora 1998, Musick and Limpus 1997, Shoop and Kenney 1992, Keinath et al. 1987). Hard-shelled sea turtles are more commonly observed south of Cape Cod, but may occur in the Gulf of Maine. The more cold-tolerant leatherbacks range farther north than other sea turtles, feeding as far north as Canadian waters. Sightings per unit effort data can be used to visualize the seasonal distributions of loggerheads (Map 141), leatherbacks (Map 142), and green sea turtles (Map 143). (Shoop and Kenney 1992, STSSN database http://www.sefsc.noaa.gov/seaturtleSTSSN.jsp).

On March 16, 2010, NMFS and USFWS published a proposed rule (75 FR 12598) to divide the worldwide population of loggerhead sea turtles into nine DPSs, as described in the 2009 Status Review. Two of the DPSs were proposed to be listed as threatened and seven of the DPSs, including the Northwest Atlantic Ocean DPS, were proposed to be listed as endangered. NMFS and the USFWS accepted comments on the proposed rule through September 13, 2010 (June 2, 2010, 75 FR 30769). On March 22, 2011 (76 FR 15932), NMFS and USFWS extended the date by which a final determination on the listing action would be made to no later than September 16, 2011. This action was taken to address the interpretation of the existing data on status and trends and its relevance to the assessment of risk of extinction for the Northwest Atlantic Ocean DPS, as well as the magnitude and immediacy of the fisheries bycatch threat and measures to reduce this threat. New information or analyses to help clarify these issues were requested by April 11, 2011.

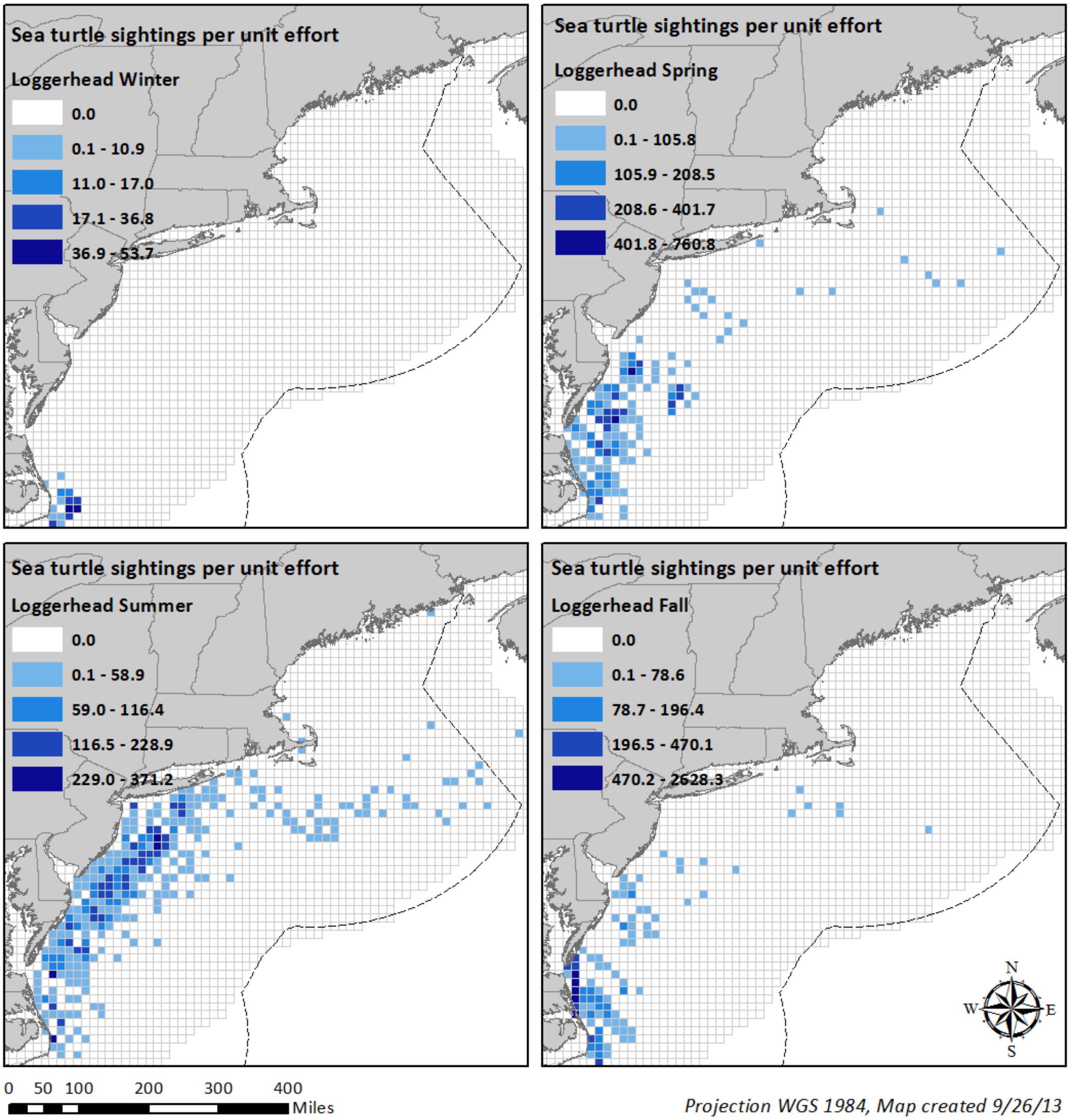
On September 22, 2011, NMFS and USFWS issued a final rule (76 FR 58868), determining that the loggerhead sea turtle is composed of nine DPSs (as defined in Conant et al., 2009) that constitute species that may be listed as threatened or endangered under the ESA. Five DPSs were listed as endangered (North Pacific Ocean, South Pacific Ocean, North Indian Ocean, Northeast Atlantic Ocean, and Mediterranean Sea), and four DPSs were listed as threatened (Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean). Note that the Northwest Atlantic Ocean (NWA) DPS and the Southeast Indo-Pacific Ocean DPS were original proposed as endangered. The NWA DPS was determined to be threatened based on review of nesting data available after the proposed rule was published, information provided in public comments on the proposed rule, and further discussions within the agencies. The two primary factors considered were population abundance and population trend. NMFS and USFWS found that an endangered status for the NWA DPS was not warranted given the large size of the nesting population, the overall nesting population remains widespread, the trend for the nesting population appears to be stabilizing, and substantial conservation efforts are underway to address threats.

The September 2011 final rule also noted that critical habitat for the two DPSs occurring within the U.S. (NWA DPS and North Pacific DPS) will be designated in a future rulemaking. Information from the public related to the identification of critical habitat, essential physical or biological features for this species, and other relevant impacts of a critical habitat designation was solicited.

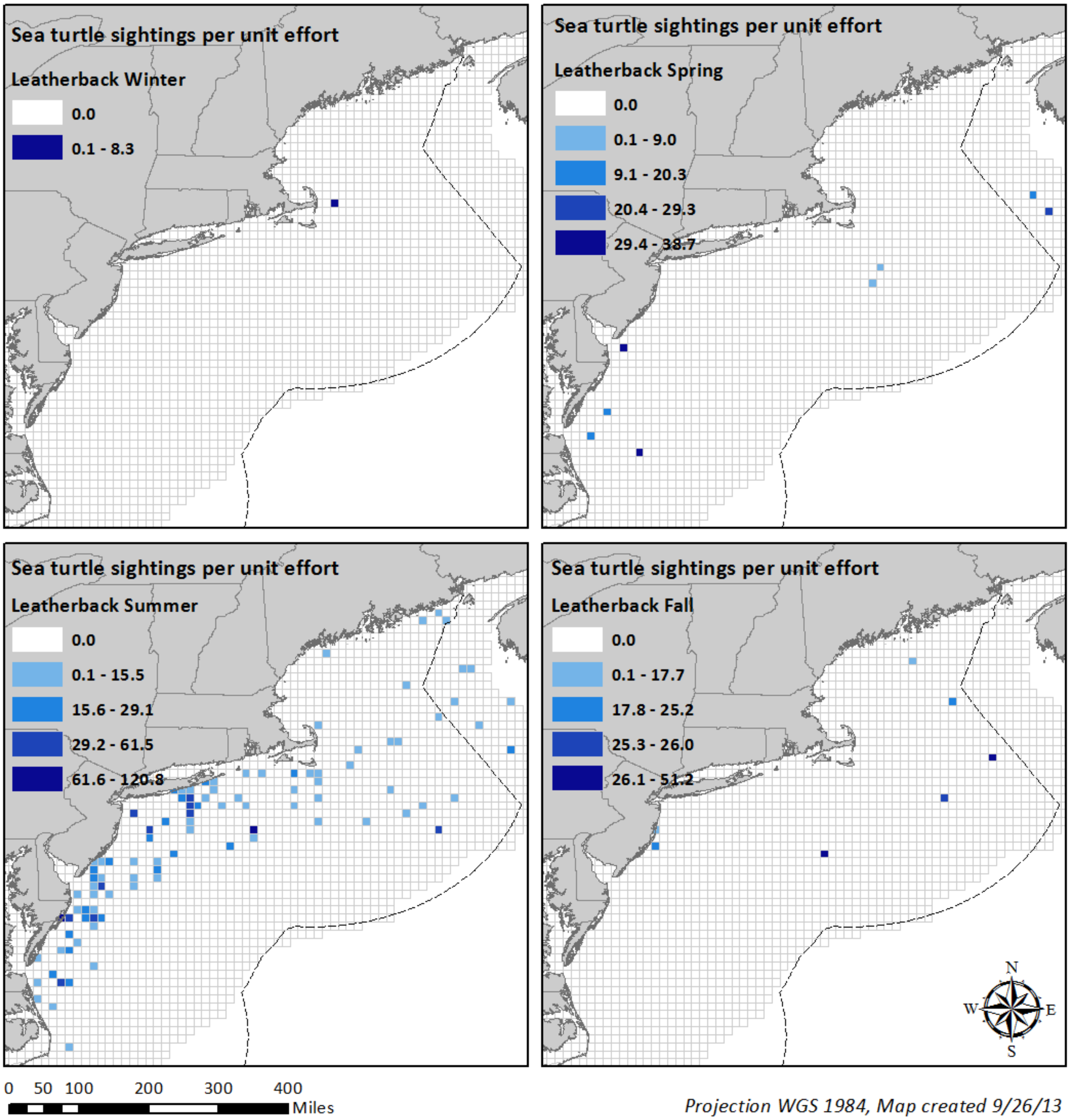
This Amendment would only occur in the Atlantic Ocean. As noted in Conant et al. (2009), the range of the four DPSs occurring in the Atlantic Ocean are as follows: NWA DPS – north of the equator, south of 60° N latitude, and west of 40° W longitude; Northeast Atlantic Ocean (NEA) DPS – north of the equator, south of 60° N latitude, east of 40° W longitude, and west of 5° 36’ W longitude; South Atlantic DPS – south of the equator, north of 60° S latitude, west of 20° E longitude, and east of 60° W longitude; Mediterranean DPS – the Mediterranean Sea east of 5° 36’ W longitude. These boundaries were determined based on oceanographic features, loggerhead sightings, thermal tolerance, fishery bycatch data, and information on loggerhead distribution from satellite telemetry and flipper tagging studies. Sea turtles from the NEA DPS are not expected to be present over the North American continental shelf in U.S. coastal waters, where the actions proposed in this amendment would occur (P. Dutton, NMFS, personal communication, 2011). Previous literature (Bowen et al. 2004) has suggested that there is the potential, albeit small, for some juveniles from the Mediterranean DPS to be present in U.S. Atlantic coastal foraging grounds. These data should be interpreted with caution however; as they may be representing a shared common haplotype and lack of representative sampling at Eastern Atlantic rookeries. Given that updated, more refined analyses are ongoing and the occurrence of Mediterranean DPS juveniles in U.S. coastal waters is rare and uncertain, if even occurring at all, for the purposes of this assessment we are making the determination that the Mediterranean DPS is not likely to be present in the action area. Sea turtles of the South Atlantic DPS do not inhabit the action area of this subject fishery (Conant et al. 2009). As such, the remainder of this assessment will only focus on the NWA DPS of loggerhead sea turtles, listed as threatened.

In general, sea turtles are a long-lived species and reach sexual maturity relatively late (NMFS SEFSC 2001; NMFS and USFWS 2007a, 2007b, 2007c, 2007d). Sea turtles are injured and killed by numerous human activities (NRC 1990; NMFS and USFWS 2007a, 2007b, 2007c, 2007d). Nest count data are a valuable source of information for each turtle species since the number of nests laid reflects the reproductive output of the nesting group each year. A decline in the annual nest counts has been measured or suggested for four of five western Atlantic loggerhead nesting groups through 2004 (NMFS and USFWS 2007a), however, data collected since 2004 suggests nest counts have stabilized or increased (TEWG 2009). Nest counts for Kemp’s ridley sea turtles as well as leatherback and green sea turtles in the Atlantic demonstrate increased nesting by these species (NMFS and USFWS 2007b, 2007c, 2007d).

Map 141 – Loggerhead sea turtle sightings per unit effort 1979-2007 (source – TNC NAMERA)

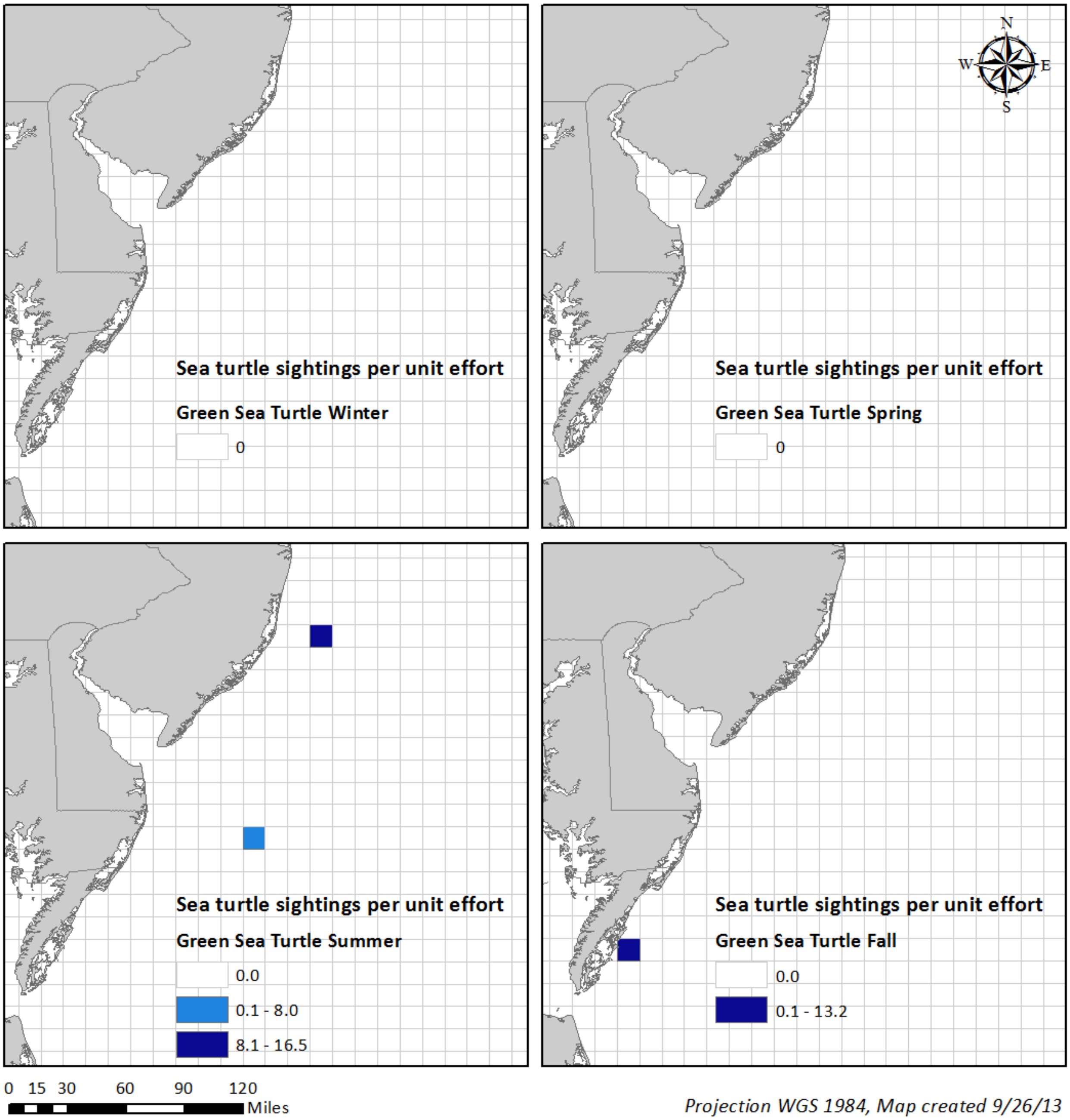


Map 142 – Leatherback sea turtle sightings per unit effort 1979-2007 (source – TNC NAMERA)



Projection WGS 1984, Map created 9/26/13

Map 143 - Green sea turtle sightings per unit effort 1979-2007 (source – TNC NAMERA)



Projection WGS 1984, Map created 9/26/13

4.4.4 Large cetaceans

The most recent Marine Mammal Stock Assessment Report (SAR) (Waring et al. 2013) reviewed the current population trend for each of these cetacean species within U.S. Economic Exclusion Zone (EEZ) waters. The SAR also estimated annual human-caused mortality and serious injury. Finally, it described the commercial fisheries that interact with each stock in the U.S. Atlantic. The following paragraphs summarize information from the SAR.

The western North Atlantic baleen whale species (North Atlantic right, humpback, fin, sei, and minke whales) follow a general annual pattern of migration. They migrate from high latitude summer foraging grounds, including the GOM and GB, to and latitude winter calving grounds (Perry et al. 1999, Kenney 2002). However, this is a simplification of species movements as the complete winter distribution of most species is unclear (Perry et al. 1999, Waring et al. 2013). Studies of some of the large baleen whales (right, humpback, and fin) have demonstrated the presence of each species in higher latitude waters even in the winter (Swingle et al. 1993, Wiley et al. 1995, Perry et al. 1999, Brown et al. 2002). Blue whales are most often sighted along the east coast of Canada, particularly in the Gulf of St. Lawrence. They occur only infrequently within the U.S. EEZ (Waring et al. 2013).

Available information suggests that the North Atlantic right whale population increased at a rate of 2.6 percent per year between 1990 and 2009. The total number of North Atlantic right whales is estimated to be at least 444 animals in 2009 (Waring et al. 2013). The minimum rate of annual human-caused mortality and serious injury to right whales in U.S. waters averaged 2.4 mortality or serious injury incidents per year during 2006 to 2010 (Waring et al. 2013). Of these, U.S. fishery interactions resulted in an average of 1.6 mortality or serious injury incidents per year.

The North Atlantic population of humpback whales is conservatively estimated to be 7,698 (Waring et al. 2013). The best estimate for the GOM stock of humpback whale population is 823 whales (Waring et al. 2013). Based on data available for selected areas and time periods, the minimum population estimates for other western North Atlantic whale stocks are 3,522 fin whales, 357 sei whales (Nova Scotia stock), 1,593 sperm whales, and 20,741 minke whales (Waring et al. 2013). Current data suggest that the GOM humpback whale stock is steadily increasing in size (Waring et al. 2013). Insufficient information exists to determine trends for these other large whale species.

The most recent revisions to the Atlantic Large Whale Take Reduction Plan (ALWTRP) (72 FR 57104, October 5, 2007) addressed entanglement risk of large whales (right, humpback, and fin whales, and acknowledge benefits to minke whales) in commercial fishing gear. The revisions seek to reduce the risk of death and serious injury from entanglements that occur in groundlines of commercial gillnet and trap/pot gear. On July 16, 2013 (78 FR 42654), NMFS published a proposed rule to revise the ALWTRP to address the entanglement risks to large whales posed by vertical lines on commercial trap/pot gear.

More details on fisheries interactions with these species, as well as management actions in place to reduce entanglement risk, can be found in Section 4.4.9, below.

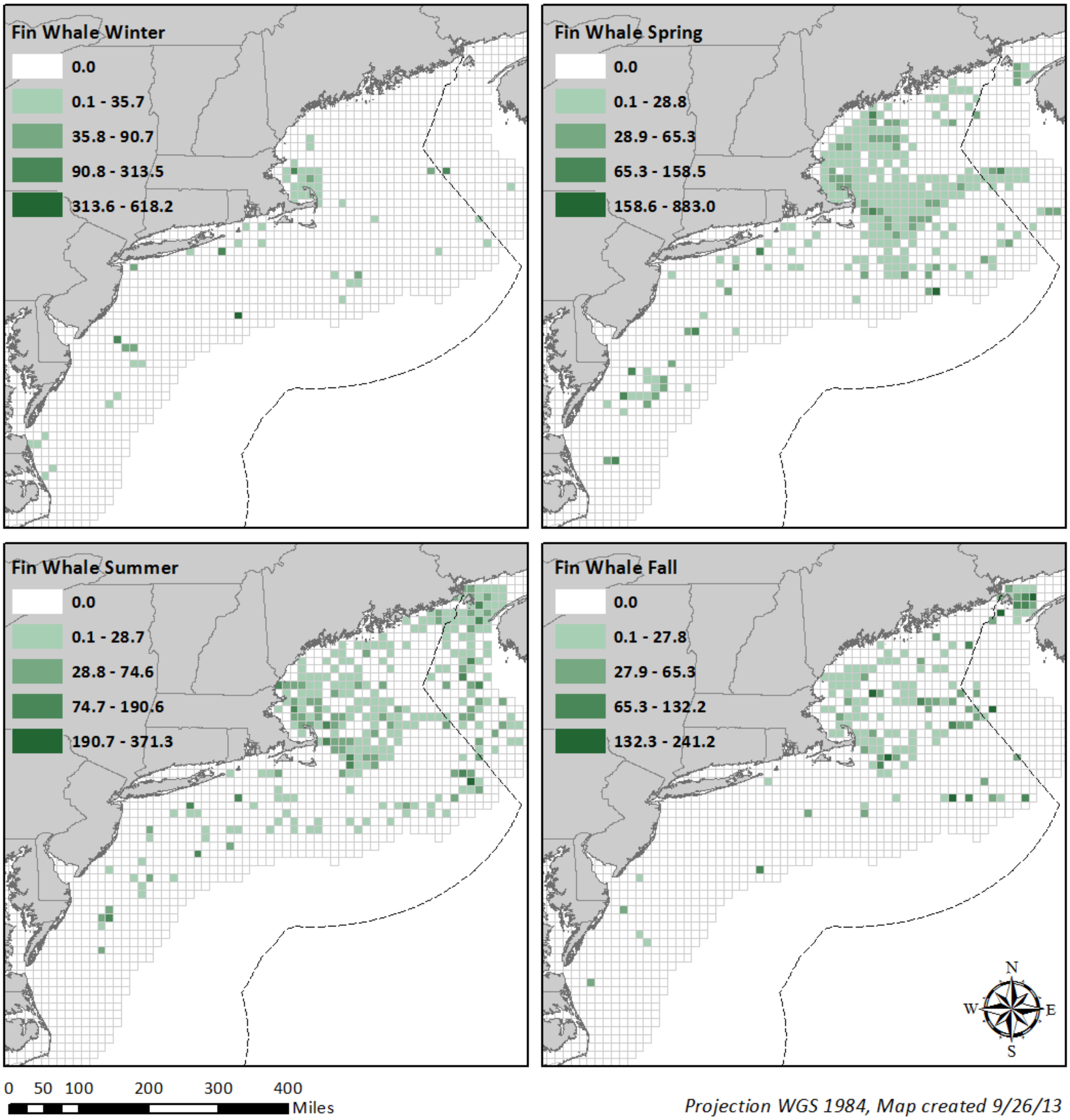
4.4.5 Small cetaceans

There is fishing related mortality of numerous small cetacean species (dolphins, pilot whales, and harbor porpoises) associated with New England-based fishing gear. Seasonal abundance and distribution of each species off the coast of the Northeast U.S. varies with respect to life history characteristics. Some species such as white-sided dolphins and harbor porpoises primarily occupy continental shelf waters. Other species such as the Risso's dolphin occur primarily in continental shelf edge and slope waters. Still other species like the common dolphin and the spotted dolphin occupy all three habitats. Waring et al. (2013) summarizes information on the distribution and geographic range of western North Atlantic stocks of each species.

The most commonly observed small cetaceans recorded as bycatch in multispecies (i.e., groundfish, monkfish, or skate) fishing gear (e.g., gillnets and trawls) are harbor porpoises, white-sided dolphins, common dolphins, and long- and short-finned pilot whales. These species are described in a bit more detail here. Harbor porpoises are found seasonally within New England and Mid-Atlantic waters. In the Mid-Atlantic, porpoises are present in the winter/spring (typically January through April) and in southern New England waters from December through May. In the Gulf of Maine, porpoises occur largely from the fall through the spring (September through May) and in the summer are found in northern Maine and through the Bay of Fundy and Nova Scotia area. White-sided dolphin distribution shifts seasonally, with a large presence from Georges Bank through the Gulf of Maine from June through September, with intermediate presence from Georges Bank through the lower Gulf of Maine from October through December. Low numbers are present from Georges Bank to Jeffrey's Ledge from January through May (Waring et al. 2013). Common dolphins are widely distributed over the continental shelf from Maine through Cape Hatteras, North Carolina. From mid-January to May they are dispersed from North Carolina through Georges Bank, and then move onto Georges Bank and the Scotia shelf from the summer to fall. They are occasionally found in the Gulf of Maine (Waring et al. 2013). Pilot whales are generally distributed along the continental shelf edge off the northeastern U.S. coast in the winter and early spring. In late spring, they move onto Georges Bank and into the Gulf of Maine and remain until late fall. They do occur along the Mid-Atlantic shelf break between Cape Hatteras, North Carolina and New Jersey (Waring et al. 2013). Since pilot whales are difficult to differentiate at sea, they are generally considered *Globicephala* sp. when they are recorded at sea (Waring et al. 2013).

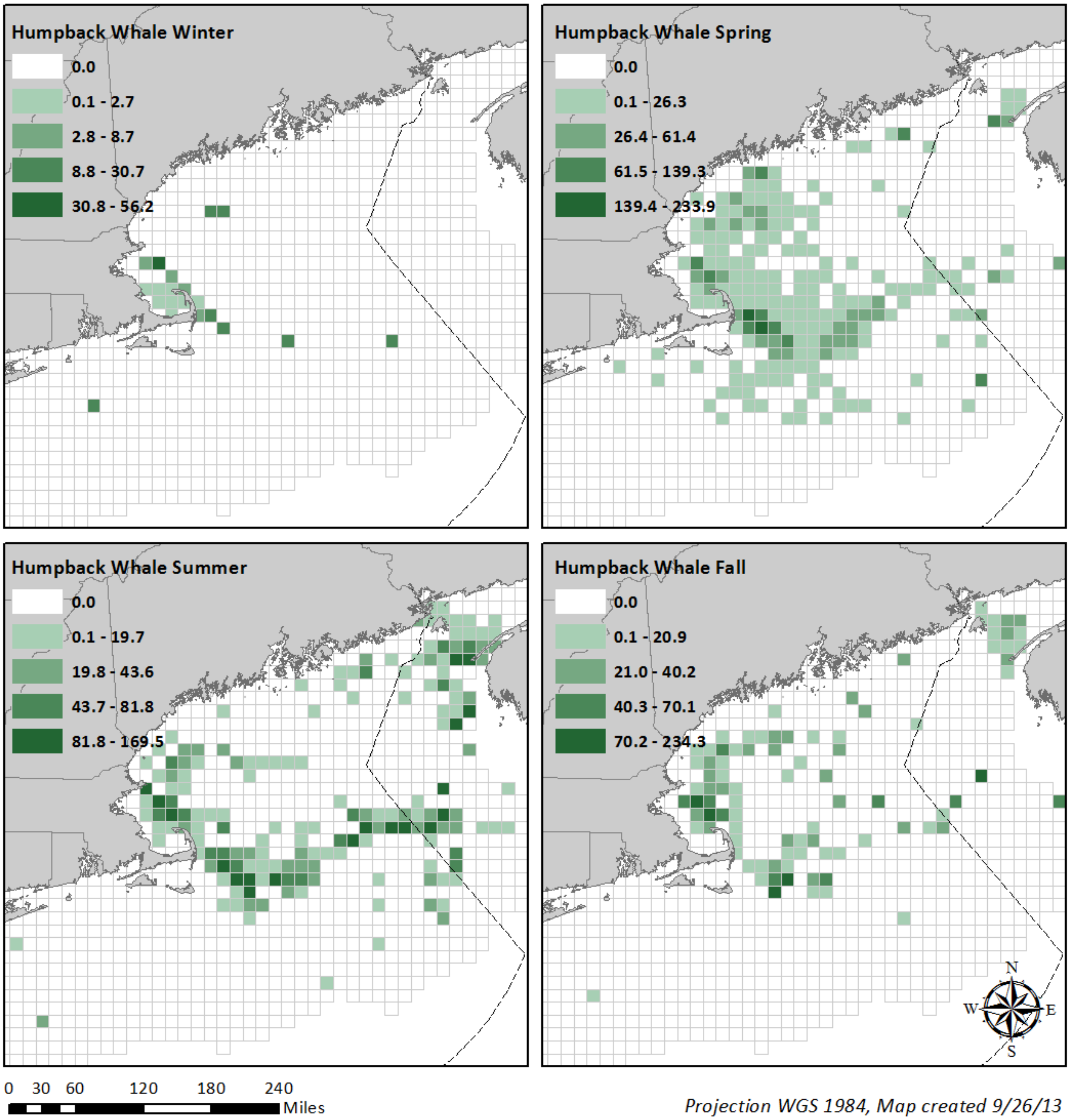
Sightings per unit effort data can be used to visualize the seasonal distributions of fin whales (Map 144), humpback whales (Map 145), sei whales (Map 146), minke whales (Map 147), right whales (Map 148), sperm whales (Map 149), and harbor porpoises (Map 150).

Map 144 – Fin whale sightings per unit effort 1979-2007 (source – TNC NAMERA)



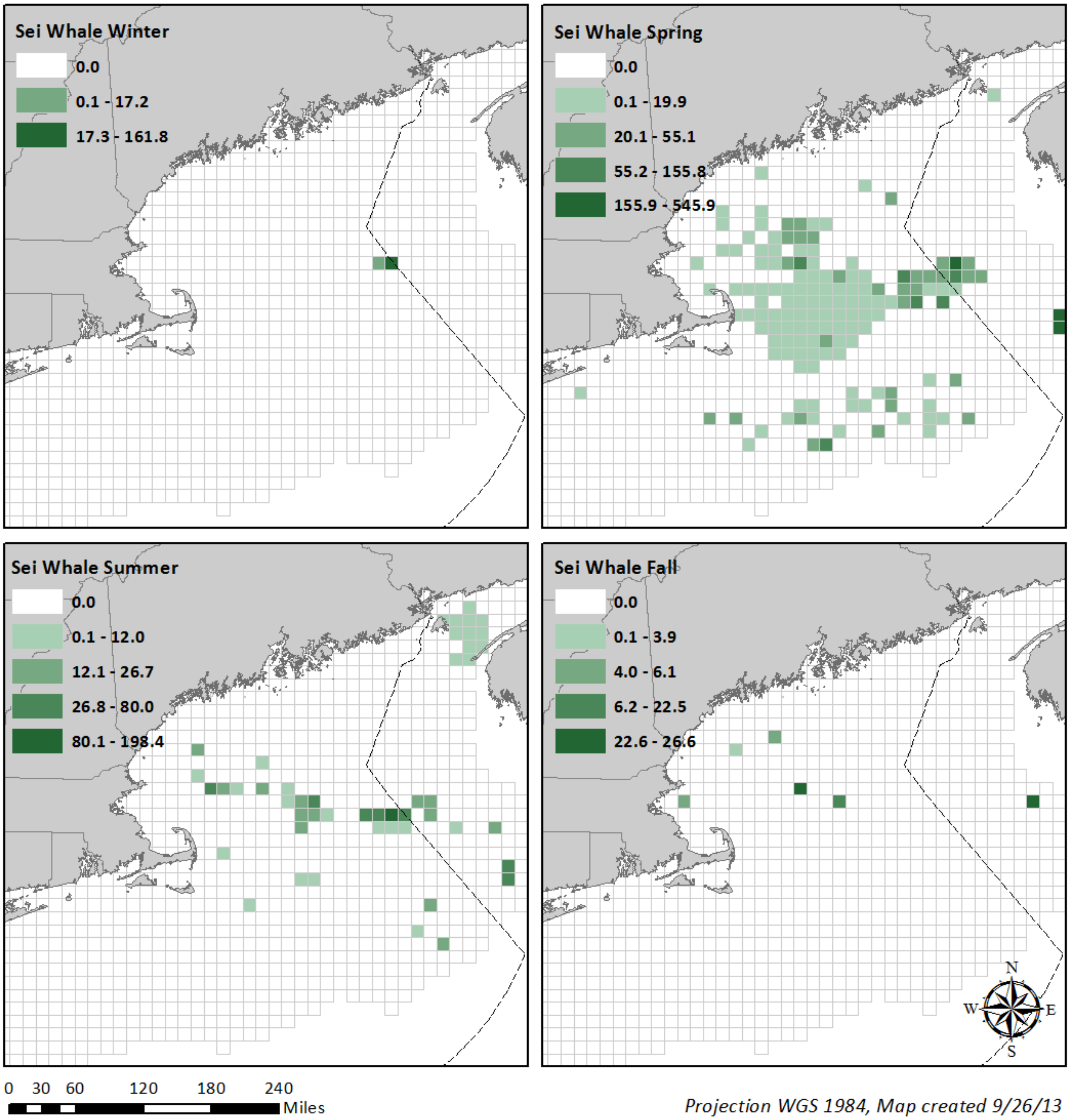
Projection WGS 1984, Map created 9/26/13

Map 145 – Humpback whale sightings per unit effort 1979-2007 (source – TNC NAMERA)



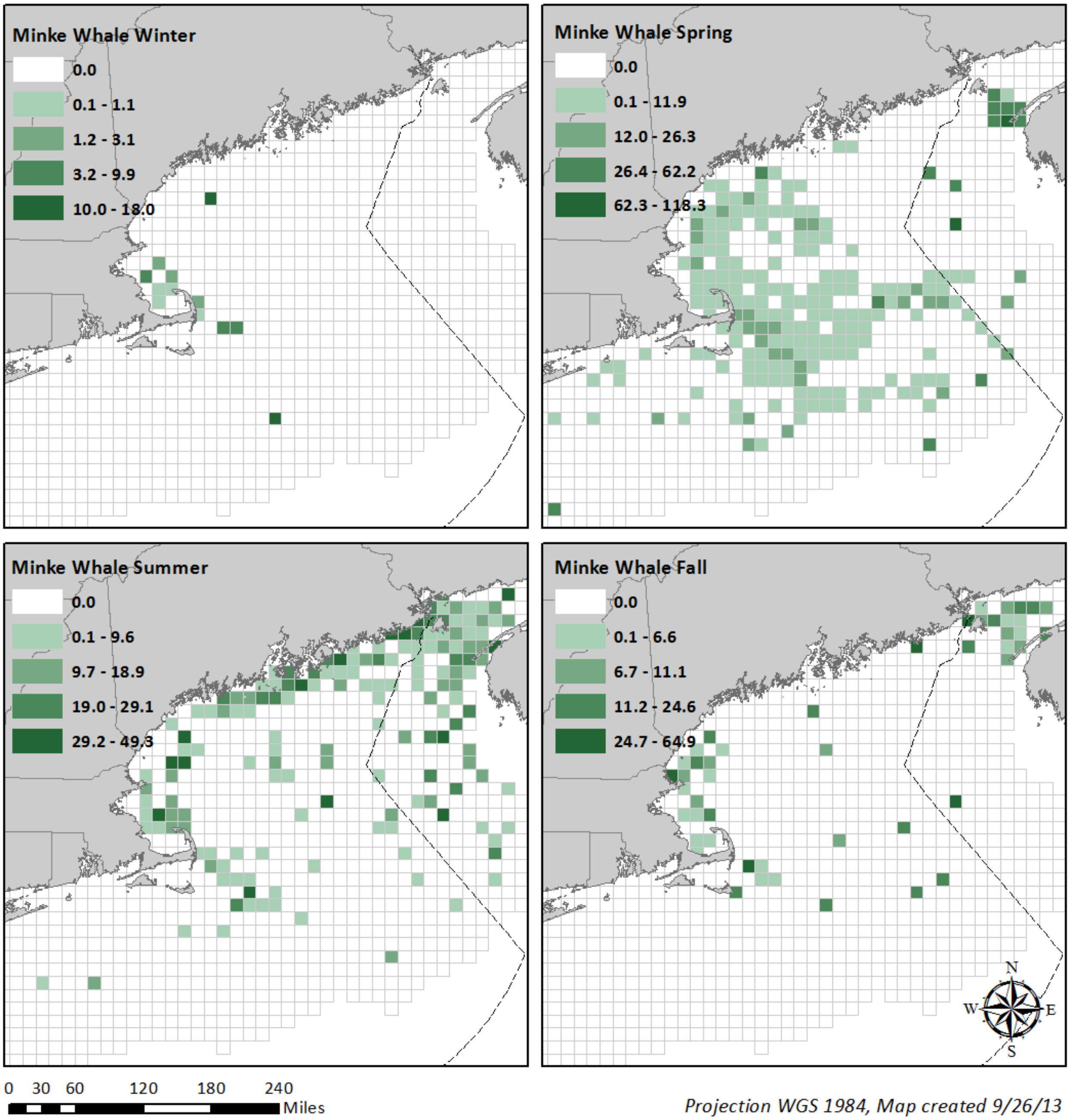
Projection WGS 1984, Map created 9/26/13

Map 146 – Sei whale sightings per unit effort 1979-2007 (source – TNC NAMERA)

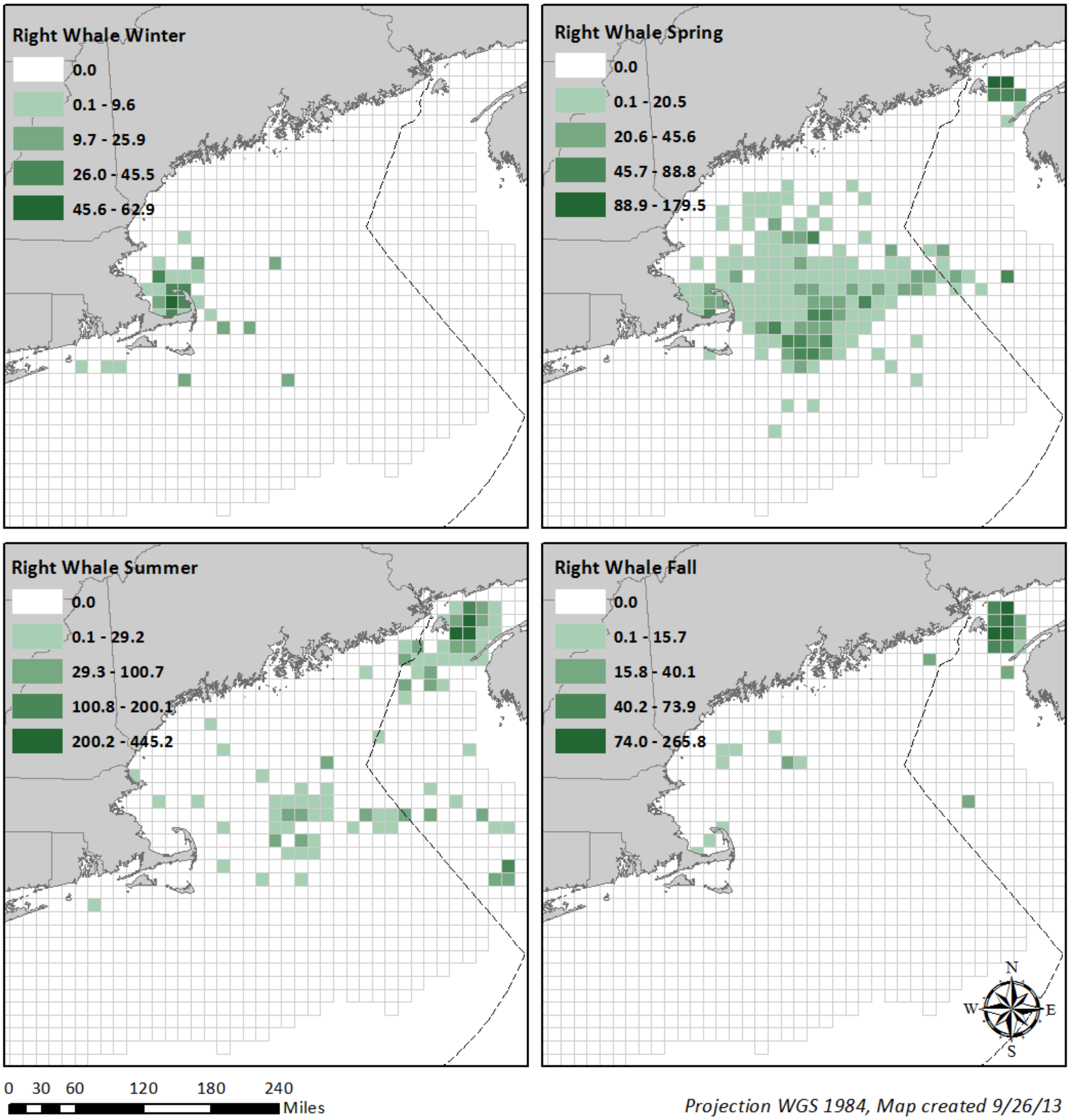


Projection WGS 1984, Map created 9/26/13

Map 147 – Minke whale sightings per unit effort 1979-2007 (source – TNC NAMERA)

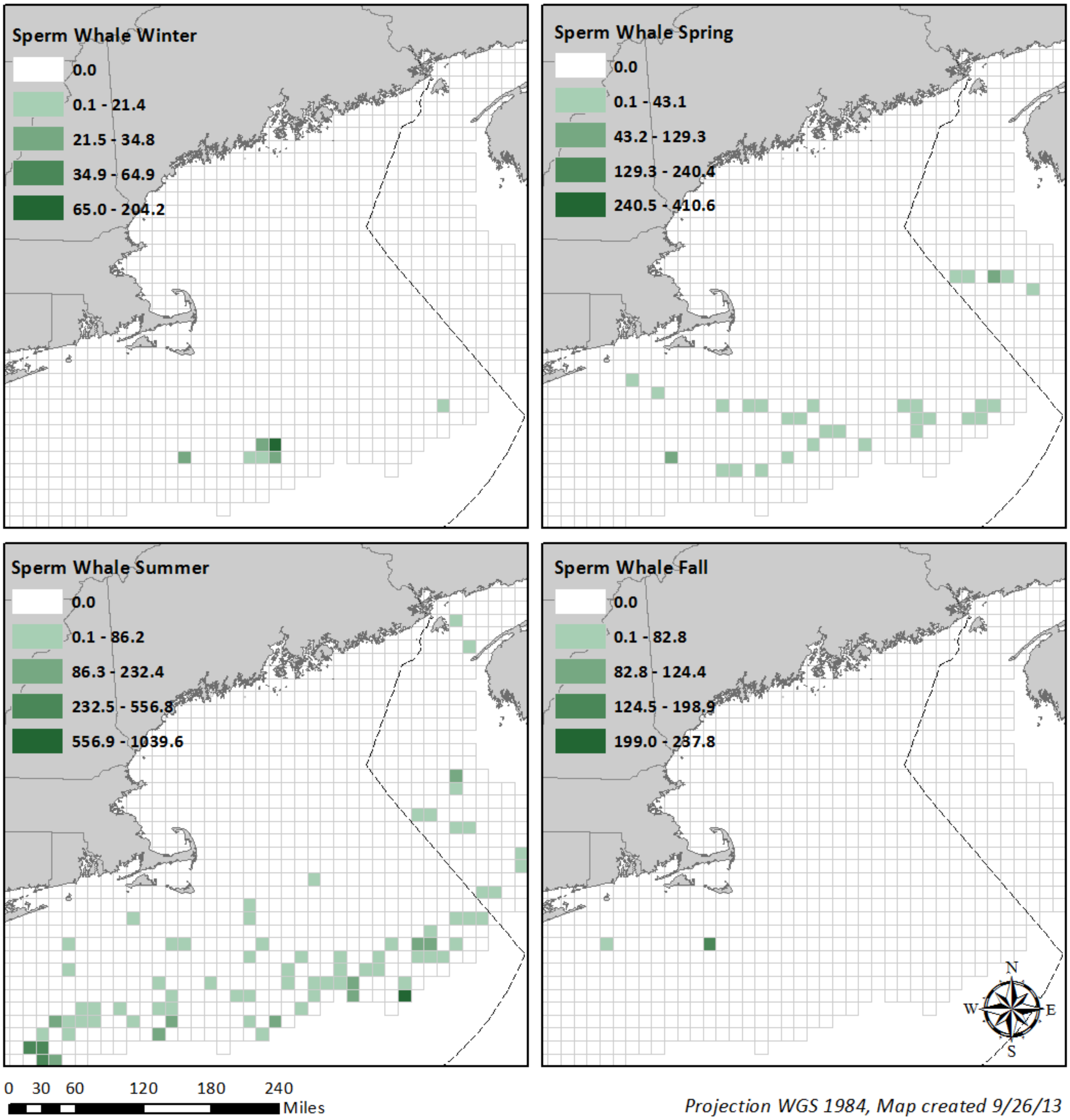


Map 148 – Right whale sightings per unit effort 1979-2007 (source – TNC NAMERA)



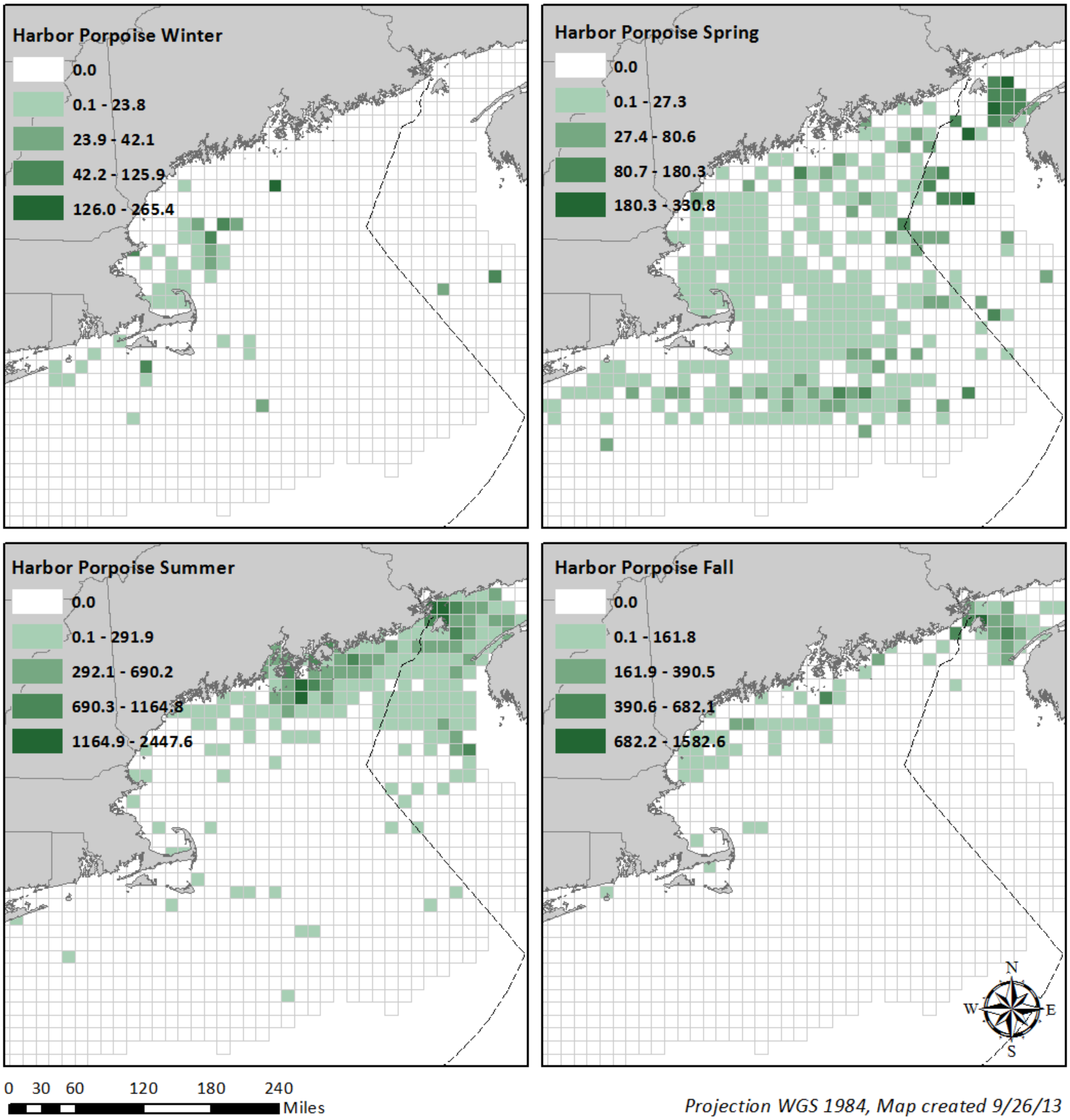
Projection WGS 1984, Map created 9/26/13

Map 149 – Sperm whale sightings per unit effort 1979-2007 (source – TNC NAMERA)



Projection WGS 1984, Map created 9/26/13

Map 150 - Harbor porpoise sightings per unit effort 1979-2007 (source – TNC NAMERA)



Projection WGS 1984, Map created 9/26/13

4.4.6 Pinnipeds

Harbor seals have the most extensive distribution of the four species of seal expected to occur in the area. Harbor seals sighting have occurred far south as 30° N (Katona et al. 1993, Waring et al. 2013). Their approximate year-round range extends from Nova Scotia, through the Bay of Fundy, and south through Maine to northern Massachusetts (Waring et al. 2013). Their more seasonal range (September through May) extends from northern Massachusetts south through southern New Jersey, and stranding records indicate occasional presence of harbor seals from southern New Jersey through northern North Carolina (Waring et al. 2013). Gray seals are the second most common seal species in U.S. EEZ waters. They occur from Nova Scotia through the Bay of Fundy and into waters off of New England (Katona et al. 1993; Waring et al. 2013) year-round from Maine through southern Massachusetts (Waring et al. 2013). A more seasonal distribution of gray seals occurs from southern Massachusetts through southern New Jersey from September through May. Similar to harbor seals, occasional presence from southern New Jersey through northern North Carolina indicate occasional presence of gray seals in this region (Waring et al. 2013). Pupping for both species occurs in both U.S. and Canadian waters of the western North Atlantic. The majority of harbor seal pupping is thought to occur in U.S. waters. While there are at least three gray seal pupping colonies in U.S., the majority of gray seal pupping likely occurs in Canadian waters. Observations of harp and hooded seals are less common in U.S. EEZ waters. Both species form aggregations for pupping and breeding off eastern Canada in the late winter/early spring. They then travel to more northern latitudes for molting and summer feeding (Waring et al. 2013). Both species have a seasonal presence in U.S. waters from Maine to New Jersey, based on sightings, stranding, and fishery bycatch information (Waring et al. 2013).

4.4.7 Atlantic sturgeon

Atlantic sturgeon is an anadromous species that spawns in relatively low salinity, river environments, but spends most of its life in the marine and estuarine environments from Labrador, Canada to the Saint Johns River, Florida (Holland and Yelverton 1973, Dovel and Berggen 1983, Waldman et al. 1996, Kynard and Horgan 2002, Dadswell 2006, ASSRT 2007). Tracking and tagging studies have shown that subadult and adult Atlantic sturgeon that originate from different rivers mix within the marine environment, utilizing ocean and estuarine waters for life functions such as foraging and overwintering (Stein et al. 2004a, Dadswell 2006, ASSRT 2007, Laney et al. 2007, Dunton et al. 2010). Fishery-dependent data as well as fishery-independent data demonstrate that Atlantic sturgeon use relatively shallow inshore areas of the continental shelf; primarily waters less than 50 m (Stein et al. 2004b, ASMFC 2007, Dunton et al. 2010). The data also suggest regional differences in Atlantic sturgeon depth distribution with sturgeon observed in waters primarily less than 20 m in the Mid-Atlantic Bight and in deeper waters in the Gulf of Maine (Stein et al. 2004b, ASMFC 2007, Dunton et al. 2010). Information on population sizes for each Atlantic sturgeon DPS is very limited. Based on the best available information, NMFS has concluded that bycatch, vessel strikes, water quality and water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon.

Since the ESA listing of Atlantic sturgeon, the NEFSC has completed new population estimates using data from the Northeast Area Monitoring and Assessment (NEAMAP) survey (Kocik et al. 2013). Atlantic sturgeon are frequently sampled during the NEAMAP survey. NEAMAP has been conducting trawl surveys from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths to 18.3 meters (60 feet) during the fall since 2007 and depths up to 36.6 meters (120 feet) during the spring since 2008 using a spatially stratified random design with a total of 35 strata and 150 stations per survey. The information from this survey can be directly used to calculate minimum swept area population estimates during the fall, which range from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57 and during the spring, which range from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65. These are considered minimum estimates because the calculation makes the unlikely assumption that the gear will capture 100% of the sturgeon in the water column along the tow path. Efficiencies less than 100% will result in estimates greater than the minimum. The true efficiency depends on many things including the availability of the species to the survey and the behavior of the species with respect to the gear. True efficiencies much less than 100% are common for most species. The NEFSC's analysis also calculated estimates based on an assumption of 50% efficiency, which reasonably accounts for the robust, yet not complete sampling of the Atlantic sturgeon, oceanic temporal and spatial ranges, and the documented high rates of encounter with NEAMAP survey gear and Atlantic sturgeon. For this analysis, the best available scientific information for the status of Atlantic sturgeon at this time are the population estimates derived from NEAMAP swept area biomass (Kocik et al. 2013) because the estimates are derived directly from empirical data with few assumptions. In addition, this analysis uses the median value of the 50% efficiency as the best estimate of the Atlantic sturgeon ocean population is most appropriate at this time. This results in a total population size estimate of 67,776 fish, which is considerably higher than the estimates that were available at the time of listing. This estimate is the best available estimate of Atlantic sturgeon abundance at the time of this analysis. The ASMFC has begun work on a benchmark assessment for Atlantic sturgeon to be completed in 2014, which would be expected to provide an updated population estimate and stock status. The ASMFC is currently collecting public submissions of data for use in the assessment: http://www.asmfc.org/press_releases/2013/pr20AtlSturgeonStockAssmtPrep.pdf.

4.4.8 Species not likely to be affected

The actions being considered in this EIS are not likely to adversely affect shortnose sturgeon, the GOM DPS of Atlantic salmon, hawksbill sea turtles, blue whales, or sperm whales, all of which are listed as endangered species under the ESA. The following discussion provides the rationale for these determinations.

Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They occupy rivers along the western Atlantic coast from St. Johns River in Florida, to the Saint John River in New Brunswick, Canada. Although, the species is possibly extirpated from the Saint Johns River system. The species is anadromous in the southern portion of its range (i.e., south of Chesapeake Bay), while some northern populations are amphidromous (NMFS 1998). Since sectors would not operate in or near the rivers where concentrations of shortnose sturgeon are most likely found, it is highly unlikely that sectors would affect shortnose sturgeon.

The wild populations of Atlantic salmon are listed as endangered under the ESA. Their freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River. Juvenile salmon in New England rivers typically migrate to sea in spring after a one- to three-year period of development in freshwater streams. They remain at sea for two winters before returning to their U.S. natal rivers to spawn (Kocik and Sheehan 2006). Results from a 2001-2003 post-smolt trawl survey in the nearshore waters of the Gulf of Maine indicate that Atlantic salmon post-smolts are prevalent in the upper water column throughout this area in mid to late May (Lacroix, Knox, and Stokesbury 2005). Therefore, commercial fisheries deploying small-mesh active gear (pelagic trawls and purse seines within 10 m of the surface) in nearshore waters of the Gulf of Maine may have the potential to incidentally take smolts. However, it is highly unlikely that the action being considered will affect the GOM DPS of Atlantic salmon given that operation of the multispecies fishery does not occur in or near the rivers where concentrations of Atlantic salmon are likely to be found. Additionally, multispecies (groundfish, monkfish, and skate) and herring gear operate in the ocean at or near the bottom, rather than near the surface where Atlantic salmon are likely to occur. Thus, this species will not be considered further in this EIS.

The hawksbill turtle is uncommon in the waters of the continental U.S. Hawksbills prefer coral reefs, such as those found in the Caribbean and Central America. Hawksbills feed primarily on a wide variety of sponges, but also consume bryozoans, coelenterates, and mollusks. The Culebra Archipelago of Puerto Rico contains especially important foraging habitat for hawksbills. Nesting areas in the western North Atlantic include Puerto Rico and the Virgin Islands. There are accounts of hawksbills in south Florida and individuals have been sighted along the east coast as far north as Massachusetts; however, east coast sightings north of Florida are rare (NMFS 2009a). Operations of the NEFMC-managed fisheries would not occur in waters that are typically used by hawksbill sea turtles. Therefore, it is highly unlikely that fishery operations would affect this turtle species.

Blue whales do not regularly occur in waters of the U.S. EEZ (Waring et al. 2013). In the North Atlantic region, blue whales are most frequently sighted from April to January (Sears 2002). No blue whales were observed during the Cetacean and Turtle Assessment Program surveys of the mid- and North Atlantic areas of the outer continental shelf (Cetacean and Turtle Assessment Program 1982). Calving for the species occurs in low latitude waters outside of the area where the sectors would operate. Blue whales feed on euphausiids (krill) that are too small to be captured in fishing gear. There were no observed fishery-related mortalities or serious injuries to blue whales between 1996 and 2000 (Waring et al. 2013). The species is unlikely to occur in areas where the NEFMC-managed species typically operate, and fishery operations would not affect the availability of blue whale prey or areas where calving and nursing of young occurs. Therefore, the proposed action would not be likely to adversely affect blue whales.

Unlike blue whales, sperm whales do regularly occur in waters of the U.S. EEZ. However, the distribution of the sperm whales in the U.S. EEZ occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions (Waring et al. 2013). Sperm whale distribution is typically concentrated east-northeast of Cape Hatteras in winter and shifts northward in spring when whales are found throughout the MA Bight (Waring et al. 2013). Distribution extends further northward to areas north of GB and the Northeast Channel region in summer and then south of New England in fall, back to the MA Bight (Waring et al. 2013). In contrast, the subject fisheries in this action operate primarily in continental shelf waters. The average depth over which sperm whale sightings occurred during the Cetacean and Turtle Assessment Program surveys was 5,879 ft (1,792 m) (Cetacean and Turtle Assessment Program 1982). Female sperm whales and young males almost always inhabit open ocean, deep water habitat with bottom depths greater than 3,280 ft (1,000 m) and at latitudes less than 40° N (Whitehead 2002). Sperm whales feed on large squid and fish that inhabit the deeper ocean regions (Perrin et al. 2002). There were no observed fishery-related mortalities or serious injuries to sperm whales between 2001 and 2005 (Waring et al. 2013). Sperm whales are unlikely to occur in water depths where NEFMC-managed fisheries, including the deep-sea red crab fishery, typically operate, and fishery operations would not affect the availability of sperm whale prey or areas where calving and nursing of young occurs. Therefore, this amendment would not be likely to adversely affect sperm whales.

Although marine turtles and large whales could be potentially affected through interactions with fishing gear, NMFS has determined that the continued authorization of the monkfish, multispecies (large and small mesh), skate, herring, scallop, and red crab fisheries, and, therefore, the preferred alternative, would not have any adverse effects on the availability of prey for these species. Sea turtles feed on a variety of plants and animals, depending on the species. However, none of the turtle species are known to feed upon monkfish or groundfish. Right whales and sei whales feed on copepods (Horwood 2002, Kenney 2002). The NEFMC-managed fisheries will not affect the availability of copepods for foraging right and sei whales because copepods are very small organisms that will pass through fishing gear, even small-mesh, rather than being captured in it. Humpback whales and fin whales also feed on krill as well as small schooling fish such as sand lance, herring and mackerel (Aguilar 2002, Clapham 2002). The majority of the fishing gear in the Council’s jurisdiction operates on or very near the bottom. Fish species caught in fishing gear are species that live in benthic habitat (on or very near the bottom) such as flounders, groundfish, and skates. As a result, this gear does not typically catch schooling fish such as herring and mackerel that occur within the water column. Humpback whales and fin whales feed on krill as well as small schooling fish (e.g., sand lance, herring, mackerel) (Aguilar 2002, Clapham 2002). The TRAC Status Report of 2006 suggests that although predator consumption estimates have increased since the mid-1980s, the productive potential of the herring stock complex has improved in recent years. The management measures that govern the herring fishery may provide a benefit to the protected resources by providing a greater quantity of food available. Therefore, the continued authorization of the multispecies (large and small mesh), skate, herring, scallop, and red crab fisheries or the approval of the preferred alternative will not affect the availability of prey for foraging humpback or fin whales.

4.4.9 Interactions between gear and protected resources

4.4.9.1 Marine mammals

NMFS categorizes commercial fisheries based on a two-tiered, stock-specific fishery classification system that addresses both the total impact of all fisheries on each marine mammal stock as well as the impact of individual fisheries on each marine mammal stock. NMFS bases the system on the numbers of animals per year that incur incidental mortality or serious injury due to commercial fishing operations relative to a marine mammal stock's PBR level. Tier 1 takes into account the cumulative mortality and serious injury to marine mammals caused by commercial fisheries. Tier 2 considers marine mammal mortality and serious injury caused by the individual fisheries. This EIS uses Tier 2 classifications to indicate how each type of gear typically used by New England fisheries may affect marine mammals (NMFS 2009b). Table 38 identifies the classifications used in the final List of Fisheries for FY 2013 (78 FR 53336; August 29, 2013; NMFS 2013), which are broken down into Tier 2 Categories I, II, and III.

Table 38 – Descriptions of the Tier 2 Fishery Classification Categories (50 CFR 229.2)

Category	Category Description

Category	**Category Description**
Category I	A commercial fishery that has frequent incidental mortality and serious injury of marine mammals. This classification indicates that a commercial fishery is, by itself, responsible for the annual removal of 50 percent or more of any stock's PBR level.
Category II	A commercial fishery that has occasional incidental mortality and serious injury of marine mammals. This classification indicates that a commercial fishery is one that, collectively with other fisheries, is responsible for the annual removal of more than 10 percent of any marine mammal stock's PBR level and that is by itself responsible for the annual removal of between 1 percent and 50 percent, exclusive of any stock's PBR.
Category III	A commercial fishery that has a remote likelihood of, or no known incidental mortality and serious injury of marine mammals. This classification indicates that a commercial fishery is one that collectively with other fisheries is responsible for the annual removal of: a. Less than 50 percent of any marine mammal stock's PBR level, or b. More than 1 percent of any marine mammal stock's PBR level, yet that fishery by itself is responsible for the annual removal of 1 percent or less of that stock's PBR level. In the absence of reliable information indicating the frequency of incidental mortality and serious injury of marine mammals by a commercial fishery, the Assistant Administrator would determine whether the incidental serious injury or mortality is "remote" by evaluating other factors such as fishing techniques, gear used, methods used to deter marine mammals, target species, seasons and areas fished, qualitative data from logbooks or fisher reports, stranding data, and the species and distribution of marine mammals in the area or at the discretion of the Assistant Administrator.

Interactions between gear and a given species occur when fishing gear overlaps both spatially and trophically with the species' niche. Spatial interactions are more "passive" and involve inadvertent interactions with fishing gear when the fishermen deploy gear in areas used by protected resources. Trophic interactions are more "active" and occur when protected species attempt to consume prey caught in fishing gear and become entangled in the process. Spatial and trophic interactions can occur with various types of fishing gear used by the multispecies fishery through the year. Many large and small cetaceans and sea turtles are more prevalent within the operations area during the spring and summer. However they are also relatively abundant during the fall and would have a higher potential for interaction with sector activities that occur during these seasons. Although harbor seals may be more likely to occur in the operations area between fall and spring, harbor and gray seals are year-round residents. Therefore, interactions could occur year-round. The uncommon occurrences of hooded and harp seals in the operations area are more likely to occur during the winter and spring, allowing for an increased potential for interactions during these seasons.

This discussion assumes the potential for entanglements to occur is higher in areas where more gear is set and in areas with higher concentrations of protected species.

Table 39 lists the marine mammals known to have had interactions with gear used by New England fisheries. The gear used in the Northeast multispecies, monkfish, and skate fisheries gear includes sink gillnets, traps/pots, bottom trawls, and bottom longlines within the Northeast Multispecies region, as excerpted from the List of Fisheries for FY 2013 (NMFS 2013), also see Waring et al. 2013). Sink gillnets have the greatest potential for interaction with protected resources, followed by bottom trawls. There are no observed reports of interactions between bottom longline gear used in the Multispecies fishery and marine mammals in FY 2009 through FY 2011. However, interactions between the pelagic longline fishery and both pilot whales and Risso's dolphins led to the development of the Pelagic Longline Take Reduction Plan. Although interactions between protected species and gear deployed by the Northeast Multispecies fishery would vary, interactions generally include:

- becoming caught on hooks (bottom longlines)
- entanglement in mesh (gillnets and trawls)
- entanglement in the float line (gillnets and trawls)
- entanglement in the groundline (traps/pots, gillnets, trawls, and bottom longlines)
- entanglement in anchor lines (gillnets and bottom longlines), or
- entanglement in the vertical lines that connect gear to the surface and surface systems (gillnets, traps/pots, and bottom longlines).

The herring fishery is prosecuted by midwater trawl gear (single), paired midwater trawls, purse seines, stop seines and weirs. A full description of the gear used in the fishery is provided in the Amendment 1 FEIS. Only the first three are considered to be primary gears in the Atlantic herring fishery. Weirs and stop seines are responsible for a only a small fraction of herring landings (see Amendment 1 FEIS), operate exclusively within State waters and are not regulated by the Federal FMP, and therefore will not be discussed further in this document relative to protected species. It should be noted, however, that both gear types have accounted for interactions with protected species, notably minke whales and harbor porpoise, as well as harbor and gray seals. Animals, particularly pinnipeds, may be released alive.

ALWTRP is a program to reduce the risk of serious injury to or mortality of large whales due to incidental entanglement in U.S. commercial fishing gear. The plan is required by the MMPA and has been developed by NMFS. The ALWTRP focuses on the critically endangered North Atlantic right whale, but is also intended to reduce entanglements of endangered humpback and fin whales and to benefit non-endangered minke whales. For the purposes of ALWTRP, the red crab fishery is considered part of the Atlantic Mixed Species Trap/Pot fishery, and takes place primarily in the Offshore Trap/Pot Area. Regulations pertaining to this area, in addition to the universal requirements, include gear marking and weak links, which are designed to reduce injury should an interaction occur. The red crab fishery is considered a Category II fishery under the MMPA, which means occasional incidental interactions and serious injury may occur, however, given the small scale of the fleet and the management measures that restrict the number of traps a vessel may use, interaction with protected species is rare.

According to the 2013 List of Fisheries, there have been no documented marine mammal species interactions with either the sea scallop dredge fishery or the Atlantic shellfish bottom trawl fishery; therefore, the scallop fishery is considered a Category III fishery under the MMPA (i.e., a remote likelihood or no known incidental mortality and serious injuries of marine mammals).

Table 39 – Marine Mammal Species and Stocks Incidentally Killed or Injured Based on New England Fishing Areas and Gear Types (based on 2013 List of Fisheries)

Fishery		Estimated Number of Vessels/Persons	Marine Mammal Species and Stocks Incidentally Killed or Injured
Category	Type		
Category I	Mid-Atlantic gillnet	5,509	Bottlenose dolphin, Northern Migratory coastal [a]
			Bottlenose dolphin, Southern Migratory coastal [a]
			Bottlenose dolphin, Northern NC estuarine system [a]
			Bottlenose dolphin, Southern NC estuarine system [a]
			Bottlenose dolphin, WNA offshore
			Common dolphin, WNA
			Gray seal, WNA
			Harbor porpoise, GOM/Bay of Fundy
			Harbor seal, WNA
			Harp seal, WNA
			Humpback whale, Gulf of Maine
			Long-finned pilot whale, WNA
			Minke whale, Canadian east coast
			Risso's dolphin, WNA
			Short-finned pilot whale, WNA
			White-sided dolphin, WNA
	Northeast sink gillnet	4,375	Bottlenose dolphin, WNA, offshore
			Common dolphin, WNA
			Fin whale, WNA
			Gray seal, WNA
			Harbor porpoise, GOM/Bay of Fundy
			Harbor seal, WNA
			Harp seal, WNA
			Hooded seal, WNA
			Humpback whale, GOM
			Long-finned Pilot whale, WNA
			Minke whale, Canadian east coast
			North Atlantic right whale, WNA
			Risso’s dolphin, WNA
			Short-finned Pilot whale, WNA
			White-sided dolphin, WNA
Category II	Mid-Atlantic bottom trawl	631	Bottlenose dolphin, WNA offshore
			Common dolphin, WNA [a]
			Gray seal, WNA

Fishery		**Estimated Number of Vessels/Persons**	**Marine Mammal Species and Stocks Incidentally Killed or Injured**
Category	**Type**		
			Harbor seal, WNA
			Long-finned pilot whale, WNA a
			Risso’s dolphin, WNA
			Short-finned pilot whale, WNA [a]
			White-sided dolphin, WNA
	Northeast bottom trawl	2,987	Bottlenose dolphin, WNA offshore
			Common dolphin, WNA
			Gray seal, WNA
			Harbor porpoise, GOM/ Bay of Fundy
			Harbor seal, WNA
			Harp seal, WNA
			Long-finned pilot whale, WNA
			Minke whale, Canadian East Coast
			Short-finned pilot whale, WNA
			White-sided dolphin, WNA [a]
	Atlantic mixed species trap/pot [c]	3,467	Fin whale, WNA
			Humpback whale, GOM
	Mid-Atlantic midwater trawl (including pair trawl)	669	Bottlenose dolphin, WNA offshore
			Common dolphin, WNA
			Long-finned pilot whale, WNA
			Risso's dolphin, WNA
			Short-finned pilot whale, WNA
			White-sided dolphin, WNA
	Northeast midwater trawl (including pair trawl)	887	Harbor seal, WNA
			Long-finned pilot whale, WNA
			Short-finned pilot whale, WNA
			White-sided dolphin, WNA
	Gulf of Maine Atlantic herring purse seine	>6	Harbor seal, WNA
			Gray Seal, WNA
	Gulf of Maine herring and Atlantic mackerel stop seine/weir	Unknown	Gray seal, Northwest North Atlantic
			Harbor porpoise, GME/BF
			Harbor seal, WNA
			Minke whale, Canadian East Coast
			White-sided dolphin, WNA
Category III	Northeast/Mid-Atlantic bottom longline/hook-and-line	1,207	None documented in recent years
	Gulf of Maine, U.S.	>403	None documented in recent years

Fishery		Estimated Number of Vessels/Persons	Marine Mammal Species and Stocks Incidentally Killed or Injured
Category	Type		
	Mid-Atlantic sea scallop dredge		

Marine mammals are taken in gillnets, trawls, and trap/pot gear used in the New England fisheries area. Documented marine mammal interactions in Northeast sink gillnet and Mid-Atlantic gillnet fisheries include harbor porpoise, white-sided dolphin, harbor seal, gray seal, harp seal, hooded seal, pilot whale, bottlenose dolphin (various stocks), Risso's dolphin, and common dolphin.

Table **40** and Table 41 summarize the estimated mean annual mortality of small cetaceans and seals that are taken in the Northeast sink gillnet and Mid-Atlantic gillnet fisheries according to the most recent SAR for each particular species.

Documented marine mammal interactions with Northeast and Mid-Atlantic bottom trawl fisheries include minke whale, harbor porpoise, white-sided dolphin, harbor seal, gray seal, harp seal, pilot whale, and common dolphin.

Table 42 and Table 43 provide the estimated mean annual mortality of small cetaceans and seals that are taken in the Northeast and Mid-Atlantic bottom trawl fisheries, based on the most recent SAR for each particular species. The data in these tables are based on takes observed by fishery observers as part of the Northeast Fisheries Observer Program (NEFOP).Given the target species of the herring fishery and because herring is a primary prey species for seals, porpoises and some whales, levels of protected species interactions with the fishery are likely for the midwater and pair trawl. The NOAA Fisheries Northeast Fisheries Science Center incidental take reports are published on the Northeast Fisheries Science Center website - http://www.nefsc.noaa.gov/femad/fishsamp/fsb/. A number of takes have occurred in the past four years by the midwater trawl fishery, as indicated in Table 44.

Table 40 – Estimated Marine Mammal Mortalities in the Northeast Sink Gillnet Fishery

Species	Years Observed	Mean Annual Mortality (CV)	Total PBR
Harbor porpoise	06-10	511 (0.17)	706
Atlantic white-sided dolphin	06-10	38 (0.46)	304
Common dolphin (short-beaked)	06-10	30 (0.42)	529
Western North Atlantic Offshore bottlenose dolphin	06-10	Unknown[+]	566
Harbor seal	06-10	280 (0.17)	Undetermined
Gray seal	06-10	794 (0.13)	Undetermined
Harp seal	06-10	218 (0.20)	Undetermined
Hooded seal	06-10	25 (0.82)	Undetermined

Source: Waring et al. (2013)

[+] While there have been documented interactions between the Western North Atlantic Offshore bottlenose dolphin stock and the Northeast sink gillnet fishery during the five year time period, estimates of bycatch mortality in the fishery have not been generated.

Table 41 – Estimated Marine Mammal Mortalities in the Mid-Atlantic Gillnet Fishery

Species	Years Observed	Mean Annual Mortality (CV)	Total PBR
Harbor porpoise	06-10	275 (0.29)	706
Common dolphin (short-beaked)	06-10	8.4 (0.55)	529
Risso's dolphin	06-10	6.6 (0.73)	95
Bottlenose dolphin - Western North Atlantic Northern Migratory Coastal stock	06-10	5.27 (0.19) min; 6.02 (0.19) max	71
Bottlenose dolphin - Western North Atlantic Southern Migratory Coastal stock	06-10	5.71 (0/31 min; 41.91 (0.14) max	96
Bottlenose dolphin - Northern North Carolina Estuarine System stock	06-10	2.39 (0.25) min; 18.99 (0.11) max	Undetermined
Bottlenose dolphin - Southern North Carolina Estuarine System stock	06-10	0.61 (0.30) min; 0.92	16
Bottlenose dolphin - Western North Atlantic Offshore stock	06-10	(0.21) max Unknown[+]	566
Harbor seal	06-10	63 (0.46)	Undetermined
Harp seal	06-10	57 (0.5)	Undetermined

Source: Waring et al. (2013)

[+] While there have been documented interactions between the Western North Atlantic Offshore bottlenose dolphin stock and the Mid-Atlantic gillnet fishery during the five year time period, estimates of bycatch mortality in the fishery have not been generated.

Table 42 – Estimated Marine Mammal Mortalities in the Northeast Bottom Trawl Fishery

Species	Years Observed	Mean Annual Mortality (CV)	Total PBR
Minke whale	06-10	3.5 (0.34)	69
Harbor porpoise	06-10	4.5 (0.30)	706
Atlantic white-sided dolphin	06-10	142 (0.15)	304
Common dolphin (short-beaked)	06-10	20 (0.13)	529
Pilot whales*	06-10	12 (0.14)	93 (long-finned); 172 (short-finned)
Harbor seal	06-10	0.8 (n/a)	Undetermined
Gray seal	06-10	6 (n/a)	Undetermined
Harp seal	06-10	0.2 (n/a)	Undetermined

Source: Waring et al. (2013). *Total fishery-related serious injuries and mortalities to pilot whales (*Globicephala* sp.) cannot be differentiated to species due to uncertainty in species identification by fishery observers (Waring et al. 2013). However, separate PBRs have been calculated for long-finned and short-finned pilot whales.

Table 43 – Estimated Marine Mammal Mortalities in the Mid-Atlantic Bottom Trawl Fishery

Species	Years Observed	Mean Annual Mortality (CV)	Total PBR
Atlantic white-sided dolphin	06-10	20 (0.09)	304
Common dolphin (short-beaked)	06-10	103 (0.13)	529
Risso's dolphin	06-10	3 (n/a)	95
Harbor seal	06-10	0.2 (n/a)	Undetermined
Pilot whales*	06-10	30 (0.16)	93 (long-finned); 172 (short-finned)

Source: Waring et al. (2013). *Total fishery-related serious injuries and mortalities to pilot whales (*Globicephala* sp.) cannot be differentiated to species due to uncertainty in species identification by fishery observers (Waring et al. 2013). However, separate PBRs have been calculated for long-finned and short-finned pilot whales.

Table 44 – Number of Mid-Water Trawl Incidental Takes Recorded by Fisheries Observers Protected Species Encountered

	2011 (To August)	2010	2009	Total
Gray Seal	10	5	1	6
Harbor Seal	3	4	1	5
Common Dolphin		1		1
Unknown dolphin		1		1
Unknown mammal		1		1
Unknown seal	8	1		1

Takes of large whales are typically not documented within observer records as large whales are typically entangled in fixed fishing gear and the chances of observing an interaction are small. Although large whales can become anchored in gear, they more often swim off with portions of the fishing gear; therefore, documentation of their incidental take is based primarily on the observation of gear or markings on whale carcasses, or on whales entangled and observed at-sea. Even if a whale is anchored in fishing gear, it is extremely difficult to make any inferences about the nature of the entanglement event and initial interaction between the whale and the gear. Frequently, it is difficult to attribute a specific gear type to an entangled animal based on observed scars or portions of gear remaining attached to whales or their carcasses; however, gillnet gear has been identified on entangled North Atlantic right whales, humpback whales, fin whales, and minke whales. Minke whales have been observed to be taken in the Northeast bottom trawl fishery by fishery observers. At this time, there is no evidence suggesting that other large whale species interact with trawl gear fisheries.

One interaction between a large whale and scallop fishing gear is known to have occurred. In 1983, a humpback whale became entangled in the cables of scallop dredge gear off of Chatham, Massachusetts. This was a unique and very rare event that is extremely unlikely to reoccur given that large whales have the speed and maneuverability to get out of the way of oncoming scallop fishing gear. Also, observer coverage of many fishing trips using dredge gear has shown that this gear types do not pose a reasonable risk of entanglement or capture for large whales. Therefore, we believe that large whales are not likely to interact with gear used in the scallop fishery.

A number of marine mammal management plans are in place along the U.S. east coast to reduce serious injuries and deaths of marine mammals due to interactions with commercial fishing gear. All fishing vessels are required to adhere to measures in the ALWTRP, which manages from Maine through Florida, to minimize potential impacts to certain cetaceans. The ALWTRP was developed to address entanglement risk to right, humpback, and fin whales, and to acknowledge benefits to minke whales in specific Category I or II commercial fishing efforts that utilize traps/pots and gillnets. The ALWTRP calls for the use of gear markings, area restrictions, weak links, and sinking groundline. Fishing vessels are required to comply with the ALWTRP in all areas where applicable.

Fishing vessels are also required to comply, where applicable, with the requirements of the Bottlenose Dolphin Take Reduction Plan (BDTRP), which manages coastal waters from New Jersey through Florida, and Harbor Porpoise Take Reduction Plan (HPTRP), which manages coastal and offshore waters from Maine through North Carolina. The BDTRP spatially and temporally restricts night time use of gillnets and requires net tending in the Mid-Atlantic gillnet region. The HPTRP aims to reduce interactions between harbor porpoises and gillnets in the Gulf of Maine, southern New England, and Mid-Atlantic regions. In New England waters, the HPTRP implements seasonal area closures and the seasonal use of pingers (acoustic devices that emit a sound) to deter harbor porpoises from approaching the nets (Map 151). In Mid-Atlantic waters, the HPTRP implements seasonal area closures and the seasonal use of gear modifications for large mesh (7-18 in) and small mesh (<5 to >7 in) gillnets to reduce harbor porpoise bycatch (Map 152).

Map 151 – HPTRP management areas in New England

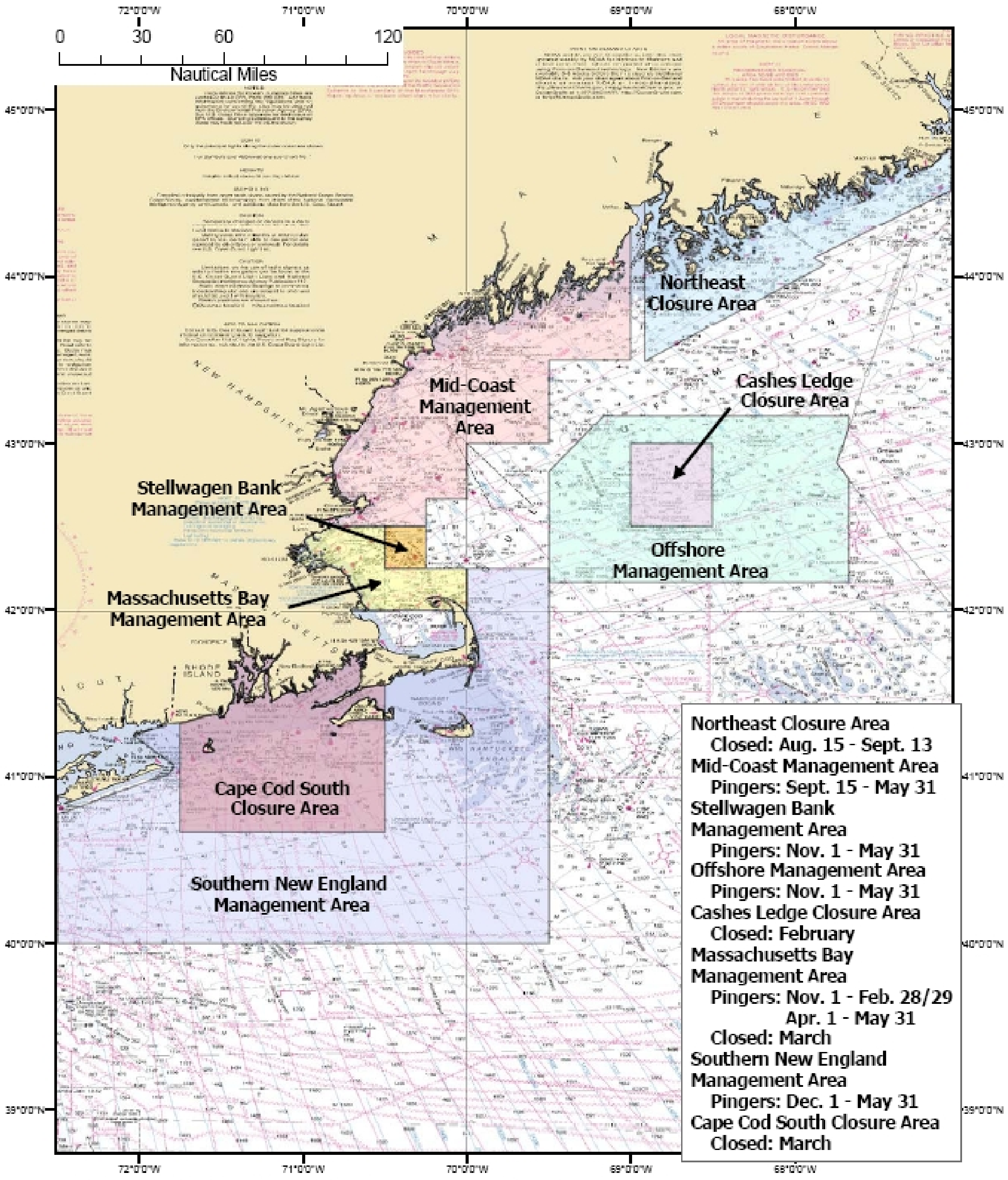


Chart Name: Cape Sable to Cape Hatteras
Chart #: 13003_1
- Not for navigational purposes

- Depth units = fathoms
- For a complete description of the HPTRP, see 50 CFR 229.33 or visit the HPTRP web site at www.nero.noaa.gov/hptrp

Map 152 – HPTRP management areas in the mid-Atlantic

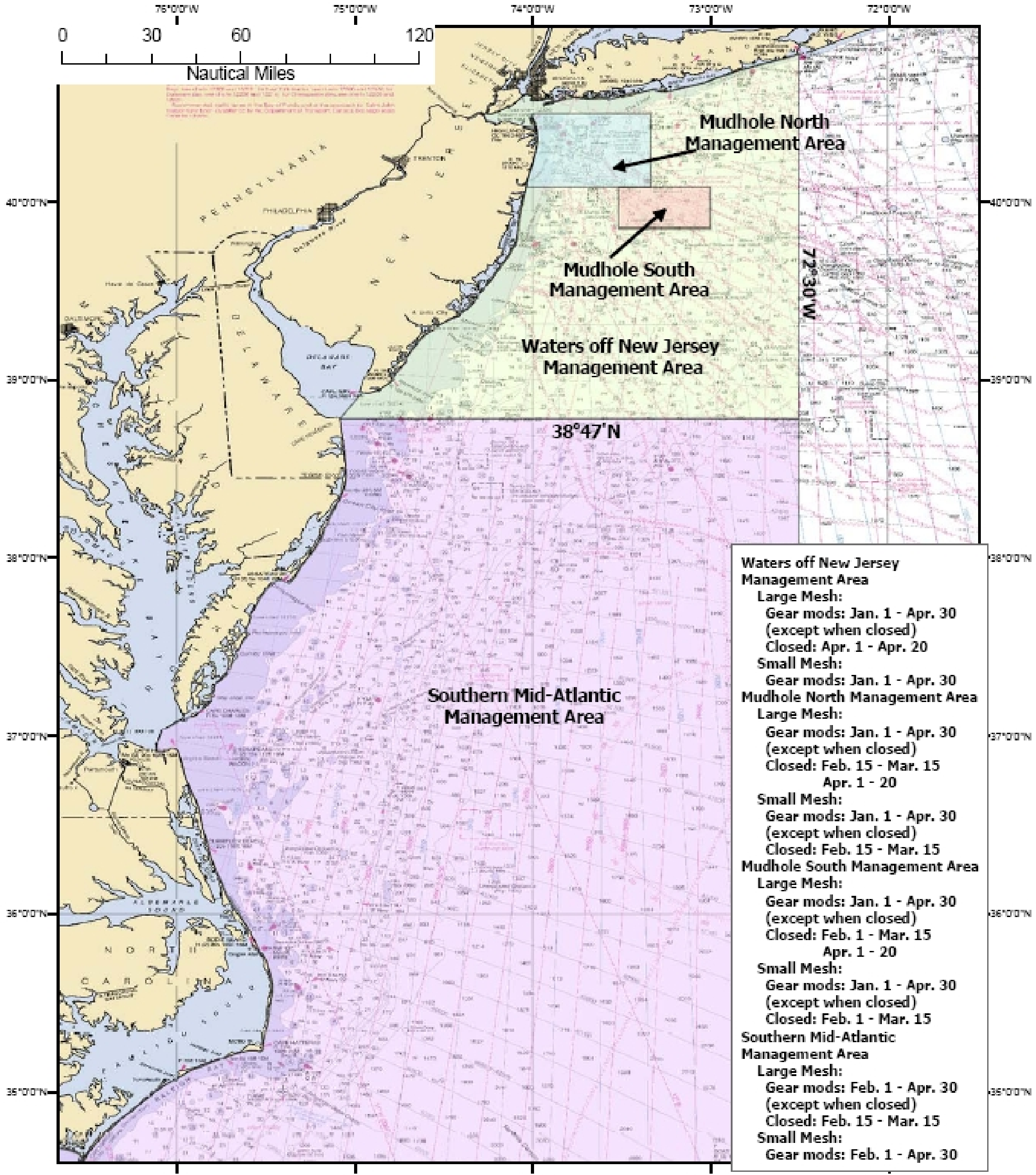


Chart Name: Cape Sable to Cape Hatteras
Chart #: 13003_1
- Not for navigational purposes
- Depth units = fathoms

- For a complete description of the HPTRP, see 50 CFR 229.34 or visit www.nero.noaa.gov/hptrp
- Note that the southern boundary of the Southern Mid-Atlantic Management Area is the NC/SC border (33°51.1'N)

An Atlantic Trawl Gear Take Reduction Team was formed in 2006 to address the bycatch of white-sided and common dolphins and pilot whales in Northeast and Mid-Atlantic trawl gear fisheries. While a take reduction plan with regulatory measures was not implemented (bycatch levels were not exceeding allowable thresholds under the MMPA), a take reduction strategy was developed that recommends voluntary measures to be used to reduce the chances for interactions between trawl gear and these marine mammal species. The two voluntary measures that were recommended are: 1) reducing the number of turns made by the fishing vessel and tow times while fishing at night; and 2) increasing radio communications between vessels about the presence and/or incidental capture of a marine mammal to alert other fishermen of the potential for additional interactions in the area.

4.4.9.2 Sea Turtles

Sea turtles have been caught and injured or killed in multiple types of fishing gear, including dredges, gillnets, trawls, and hook and line gear. However, impact due to inadvertent interaction with trawl gear is almost twice as likely to occur when compared with the other gear types (NMFS 2009d). Interaction with trawl gear is more detrimental to sea turtles than other groundfishing gear as they can be caught within the trawl itself and will drown after extended periods underwater. A study conducted in the Mid-Atlantic region showed that bottom trawling accounts for an average annual take of 616 loggerhead sea turtles, although Kemp’s ridleys and leatherbacks were also caught during the study period (Murray 2006). Impacts to sea turtles may still occur under this action, even though sea turtles generally occur in more temperate waters than those in the NEFMC area.

The 2012 consultation (Endangered Species Act Section 7 Consultation on the Atlantic Sea Scallop Fishery Management Plan, July 12, 2012) on the scallop fishery, both scallop dredge and trawl fishing, concludes that the continued operation of the scallop fishery may adversely affect, but is not likely to jeopardize the continued existence of loggerhead, leatherback, Kemp’s ridley, or green sea turtles, or any other ESA-listed species under NMFS jurisdiction. NMFS anticipates the incidental take of ESA-listed species as follows:

- for the NWA DPS of loggerhead sea turtles, we anticipate (a) the annual average take of up to 161 individuals in dredge gear, of which up to 129 per year may be lethal in 20l2 and up to 46 per year may be lethal in2013 and beyond,[5] and (b) the annual average take of up to 140 individuals in trawl gear, of which up to 66 per year may be lethal;
- for leatherback sea turtles, we anticipate the annual lethal take of up to two individuals in dredge and trawl gear combined;
- for Kemp's ridley sea turtles, we anticipate the annual take of up to three individuals in dredge and trawl gear combined (for 2012, up to three takes are anticipated to be lethal, while for 2013 and beyond, up to two takes are anticipated to be lethal);
- for green sea turtles, we anticipate the annual lethal take of up to two individuals in dredge and trawl gear combined;
- for Atlantic sturgeon, we anticipate the annual take of up to one individual from either the GOM, NYB, CB, Carolina, or SA DPS in trawl gear; once every 20 years this take is expected to result in mortality.

---

[5] The estimated mortality numbers presented in the Biological Opinion for scallop dredges with chain mats in 2012 are conservative in that they are overestimates of actual mortalities. Mortality rates used for 2012 are based on those estimated for observed turtle takes (e.g., turtles captured in the dredge and brought on deck), yet a percentage of the estimated takes are not observed (e.g., interactions where turtles were excluded by the chain mat) and these takes are considered to have a lower mortality rate.

NMFS is still required to minimize these takes so several Reasonable and Prudent (RPMs) have been identified. Terms and conditions are included to specify how the RPMs should be implemented. Both RPMs and terms and conditions are non-discretionary and must be implemented by NMFS.

Reasonable and Prudent Measures

1. NMFS must annually monitor and assess the distribution of fishing effort in the Mid-Atlantic scallop dredge fishery during the period of known sea turtle overlap (May through November) to ensure that there are no increases in the likelihood of interactions with sea turtles that may result from increased effort.
2. NMFS must continue to investigate and implement, within a reasonable time frame following sound research, modifications to gears used in these fisheries to reduce incidental takes of sea turtles and Atlantic sturgeon and the severity of the interactions that occur.
3. NMFS must continue to review available data to determine whether there are areas or conditions within the action area where sea turtle and Atlantic sturgeon interactions with fishing gear used in the scallop fishery are more likely to occur.
4. NMFS must continue to quantify the extent to which chain mats and TDDs reduce the number of serious injuries/deaths of sea turtles that interact with scallop dredge gear.
5. NMFS must continue to research the extent to which sea turtle interactions with scallop dredge gear occur on the bottom versus within the water column.
6. NMFS must ensure that any sea turtles incidentally taken in scallop dredge or trawl gear and any Atlantic sturgeon incidentally taken in scallop trawl gear are handled in a way as to minimize stress to the animal and increase its survival rate.
7. NMFS must seek to ensure that monitoring and reporting of any sea turtles and Atlantic sturgeon encountered in scallop fishing gear: (1) detects any adverse effects such as injury or mortality; (2) detects whether the anticipated level of take has occurred or been exceeded; and (3) collects data from individual encounters.
8. NMFS must continue to engage in outreach efforts with commercial fishermen regarding the proper installation and use of chain mats on their scallop dredges.

Terms and Conditions

1. To comply with RPM #1 above, NMFS must continue to monitor dredge hours in the Mid-Atlantic scallop dredge fishery during the months of May through November when sea turtle interactions are most likely to occur. NMFS must collect and review effort data as stipulated under the monitoring plan below (i.e.,two-year running averages) to determine if dredge effort in the Mid-Atlantic is on the rise, and, if needed, re-evaluate the monitoring plan methodology annually in the event more refined methods become available through discussions within the agency or with the NEFMC or scallop industry. The calculation and comparison of two-year running averages should also be performed on an annual basis, wtth 2007-2008 serving as the baseline efforl levels post-chain mats.
2. To comply with RPM #2 above, NMFS must continue to investigate modifications to scallop dredge and trawl gear to further minimize adverse effects on sea turtles due to collisions with and/or entrainment in the gear. Through continued experimental gear trials

from or by any source (e.g., through the Scallop RSA program), NMFS and its partners must review all data collected from those trials, determine the next appropriate course of action (e.g., expanded gear testing, further gear modification, rulemaking to require the gear modification), and initiate management action based on the determination. These trials may include further refinements of and improvements to the TDD as well as continued testing and evaluation of modified trawls (e.g. trawls with TEDs, topless trawls).

3. To comply with RPM #3 above, NMFS must continue to review all available data on the incidental take of sea turtles in the scallop fishery (observable plus unobservable, quantifiable) and other suitable information (e.g., data on observed sea turtle interactions with other trawl fisheries, sea turtle distribution information, or fishery surveys in the area where the scallop fishery operates) to assess whether correlations with environmental conditions (e.g., depth, SST, salinity) or other drivers of incidental take (e.g., gear configuration) can be made for some or all portions of the action area. If additional analysis is deemed appropriate, within a reasonable amount of time after completing the review, NMFS must take action, if appropriate, to reduce sea turtle interactions and/or their impacts.
4. To comply with RPM #4 above, NMFS must continue to use available and appropriate technologies to quantify the extent to which chain mats and TDDs reduce the number of serious injuries/deaths of sea turtles that interact with scallop dredge gear. This information is necessary to better determine the extent to which these two gear modifications reduce injuries leading to death for sea turtles and may result in further modifications of the fishery to ensure sea turtle interactions, including those causing serious injuries and mortalities are minimized.
5. To comply with RPM#5 above, NMFS must continue to use available and appropriate technologies to better determine where (on the bottom or in the water column) and how sea turtle interactions with scallop dredge gear are occurring. Such information is necessary to assess whether further gear modifications in the scallop dredge fishery will actually provide a benefit to sea turtles by either reducing the number of interactions or the number of interactions causing serious injury and mortality.
6. To comply with RPM #6 above, NMFS must ensure that all Federal permit holders in the scallop fishery possess handling and resuscitation guidelines for sea turtles and Atlantic sturgeon. For sea turtles, all Federally-permitted fishing vessels should have the handling and resuscitation requirements listed in 50 CFR 223.206(d)(1) and reproduced in Appendix C. For Atlantic sturgeon, NMFS must instruct fishermen and observers to resuscitate any individuals that may appear to be dead by providing a running source of water over the gills.
7. To also comply with RPM #6 above, NMFS must continue to develop and distribute training materials for commercial fishermen regarding the use of recommended sea turtle and Atlantic sturgeon release equipment and protocols. Such training materials would be able to be brought onboard fishing vessels and accessed upon incidental capture (e.g., CD that could be used in on-board computer, placard, etc.).
8. To comply with RPM #7 above, NMFS must continue to place observers onboard scallop dredge and trawl vessels to document and estimate incidental bycatch of sea turtles and Atlantic sturgeon, Monthly summaries and an annual report of observed sea turtle takes

in gears primarily landing scallops must be provided to the NERO Protected Resources Division. A similar data reporting plan must be developed for Atlantic sturgeon.

9. To also comply with RPM #7 above, NMFS must continue to instruct observers to tag and take tissue samples from incidentally captured sea turtles as stipulated under their ESA section 10 permit. The current NEFOP protocols are to tag any sea turtles caught that are larger than 26 centimeters in notch-to-tip carapace length and to collect tissue samples for genetic analysis from any sea turtles caught that are larger than centimeters in notch-to-tip carapace length. NMFS must continue to instruct observers to send any genetic samples of sea turtles taken to the NEFSC. NMFS must further instruct observers to take fin clips from all incidentally captured Atlantic sturgeon and send them to NMFS for genetic analysis. Fin clips must be taken according to the procedures outlined in appendix D and prior to preservation of other fish parts or whole bodies.
10. To also comply with RPM #7 above, NMFS must continue to reconvene the Sea Turtle Injury Working Group in order to better assess and evaluate injuries sustained by sea turtles in scallop dredge and trawl gear, and their potential impact on sea turtle populations. New data should be reviewed on an annual basis.
11. To comply with RPM #8 above, NMFS must distribute information to scallop permit holders specifying the chain mat and TDD regulations and be prepared to provide them assistance to resolve issues that may cause chain mats or any components of the TDD to be rigged improperly or malfunction.

4.4.9.3 Atlantic Sturgeon

Atlantic sturgeon are known to be captured in sink gillnet, drift gillnet, and otter trawl gear (Stein et al. 2004a, ASMFC TC 2007). Of these gear types, sink gillnet gear poses the greatest known risk of mortality for bycaught sturgeon (ASMFC TC 2007). Sturgeon deaths were rarely reported in the otter trawl observer dataset (ASMFC TC 2007). However, the level of mortality after release from the gear is unknown (Stein et al. 2004a). In a review of the Northeast Fishery Observer Program (NEFOP) database for the years 2001-2006, observed bycatch of Atlantic sturgeon was used to calculate bycatch rates that were then applied to commercial fishing effort to estimate overall bycatch of Atlantic sturgeon in commercial fisheries. This review indicated sturgeon bycatch occurred in statistical areas abutting the coast from Massachusetts (statistical area 514) to North Carolina (statistical area 635) (ASMFC TC 2007). Based on the available data, participants in an ASMFC bycatch workshop concluded that sturgeon encounters tended to occur in waters less than 50 m throughout the year, although seasonal patterns exist (ASMFC TC 2007). The ASMFC analysis determined that an average of 650 Atlantic sturgeon mortalities occurred per year (during the 2001 to 2006 timeframe) in sink gillnet fisheries. Stein et al. (2004a), based on a review of the NMFS Observer Database from 1989-2000, found clinal variation in the bycatch rate of sturgeon in sink gillnet gear with lowest rates occurring off of Maine and highest rates off of North Carolina for all months of the year.

The NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs. The analysis estimates that from 2006 through 2010, there were averages of 1,239 and 1,342 encounters per year in observed gillnet and trawl fisheries, respectively, with an average of 2,581 encounters combined annually. Mortality rates in gillnet gear were approximately 20%. Mortality rates in otter trawl gear observed are generally lower, at approximately 5%. The highest incidence of sturgeon bycatch in sink gillnets is associated with depths of <40 meters, larger mesh sizes, and the months April-May. Sturgeon bycatch in ocean fisheries is actually documented in all four seasons with higher numbers of interactions in November and December in addition to April and May. Mortality is also correlated to higher water temperatures, the use of tie-downs, and increased soak times (>24 hours). Most observed sturgeon deaths occur in sink gillnet fisheries. For otter trawl fisheries, Atlantic sturgeon bycatch incidence is highest in depths <30 meters and in the month of June.

However, scallop dredge gear is much more rigid, has a lower profile while on being fished on the ocean bottom, and is hauled up more vertically than trawl gear. As a result, dredge gear does not pose a threat of bycatch to Atlantic sturgeon on the bottom or in the water column as trawl gear. In addition, there is no documented bycatch of Atlantic sturgeon in midwater trawls and herring purse-seine gear, which makes up the majority of the herring fishing effort. There is also no documented bycatch of Atlantic sturgeon in red crab pot/trap gear from 2001-2010. In addition, red crab traps are set much deeper (400-800 m) than sturgeon's preferred water depth (50 m) (ASMFC TC 2007).