NEW YORK STATE
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New York Department of State
Offshore Atlantic Ocean Study

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Acknowledgements

The New York State Department of State (DOS) recognizes and appreciates the federal, state, and public partnerships that made this offshore study possible.

Thanks to the many stakeholders that participated in the data workshops and provided their passion and expertise. Cornell Cooperative Extension of Suffolk County provided invaluable assistance working with commercial fishers and boat-for-hire captains, who generously shared their time and local knowledge.

New York State agencies provided support through their participation in the Offshore Renewable Energy Work Group and the Offshore Habitat Work Group. Both work groups are chaired by DOS and include representatives from: New York State Department of Environmental Conservation; New York State Energy Research and Development Authority; New York State Office of General Services; and New York State Office of Parks, Recreation, and Historic Preservation.

- The Offshore Renewable Energy Work Group also includes representatives from: New York State Department of Public Service/Public Service Commission; Empire State Development; and the Port Authority of New York and New Jersey.
- The Offshore Habitat Work Group also includes issue-area experts from: the State University of New York at Stony Brook; The National Oceanic and Atmospheric Administration (NOAA) National Centers for Coastal and Ocean Science's (NCCOS); and the Riverhead Foundation.

Federal staff were responsive to DOS's requests and needs and helpful in translating information they developed for the offshore planning area:

- NCCOS's Biogeography Branch provided geostatistical analysis and ecological modeling that was invaluable to the Habitat Work Group's efforts. They provided high quality broad-scale predictive models for seabirds and benthic habitats, and compiled and mapped known locations of deep sea corals and sponges.
- NOAA's Coastal Services Center (CSC) provided data and information support in developing, planning and carrying out Offshore Use participatory geographic information system (pGIS) workshops which helped DOS fill a critical information gap.
- With funding and technical support provided by the U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM), CSC developed the Multi-purpose Marine Cadastre (MMC), an online information repository of federal data that allowed DOS to view and download a range of data, including offshore jurisdictional information.

- The U.S. Coast Guard and CSC staff deciphered Automated Information System (AIS) ship tracking data which are comprised of millions of point locations of vessels transiting the Northwest Atlantic. Their analysis allowed DOS to better understand vessel traffic in the offshore planning area.
- NOAA National Marine Fisheries Service's Northeast Fisheries Science Center (NEFSC) provided two different types of fisheries data to DOS: industry-independent bottom trawl surveys of groundfish, and commercial fisheries Vessel Trip Report data. NEFSC staff also provided valuable support and feedback in understanding and displaying the data.
- The BOEM – New York Outer Continental Shelf Renewable Energy Task Force provided an important public forum for presenting data in the study area to federal, state, local, and tribal government representatives.
- NOAA's Coral Program maintains a database of known deep-sea coral locations and provided this information to NCCOS.

DOS gratefully acknowledges additional data in this study provided by:

- The New England Aquarium (NEA), who provided geostatistical models of marine mammal and sea turtle distributions in the study area.
- The North Atlantic Right Whale Consortium (NARWC), who provided survey data to NEA.
- Stone Environmental, Inc., who pre-processed NEFSC groundfish trawl data in preparation for DOS's modeling efforts.

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New York Offshore Atlantic Ocean Study

I. Introduction

A. Background

New York State's Department of State (DOS) has completed a two-year study to generate and assemble the most comprehensive dataset of physical, biological, geographic, and socioeconomic information available for the Atlantic Ocean waters offshore New York State.

New Yorkers rely on the ocean for a wide range of economic activities. Over two-thirds of all New Yorkers live in counties that are located within the State's ocean and estuarine regions, accounting for over 275,000 ocean and coastal-related jobs and nearly $7.5 billion in wages in 2009.[1] The Port of New York and New Jersey is North America's largest container port and the third biggest port in the United States, handling over $175 billion in cargo.[2] The overall economic contributions of the sport fishing, commercial fishing, and seafood industries to New York State total $11.5 billion annually.[3] Long Island's tourism industry accounts for over $4 billion annually and includes a robust community of recreational divers, boaters, fishers, and others who enjoy using the water. In fact, New York has the largest concentration of registered recreational boats in the Northeast, with Suffolk and Nassau Counties accounting for almost two-thirds of the 15,502 total vessels in New York.

In addition to these important economic activities, New York's coastal communities are deeply connected to the ocean by physical and ecological ties. In the past, severe coastal storms have caused significant damage to New York's coastal communities because of this connectivity. Most recently, in October of 2012, Hurricane Sandy's high winds and related storm surge devastated portions of New York City and Long Island, causing fatalities, injuries, property damage and extended power outages, and disrupting life for millions of New Yorkers. Taking a longer view, the ocean-related impacts of climate change will pose additional strains on coastal communities. Warming ocean temperatures and rising sea levels will affect coastal infrastructure,[4] and the distributions of fish stocks and other wildlife may shift farther north.[5,6] While the focus of this study is on offshore areas, understanding the relationship between New Yorkers and the ocean will provide insight into opportunities to strengthen and improve connections to the ocean, leading to more economically-vibrant communities that are also more resilient.

In acknowledgement of the breadth of connections between New York's coastal area and the offshore environment, DOS studied an expansive area. In its entirety, the offshore planning area constitutes approximately 12,650 square nautical miles (16,740 square miles[7]) off the south shore of New York City and Long Island. These waters are under the jurisdiction of either the state (0-3 nautical miles from shore) or federal (3-200 nautical miles) governments, and are managed by numerous government agencies. Through the New York State Coastal Management Program, authorized by the federal Coastal Zone Management Act (CZMA) and administered by DOS, New York has an important role in federal decisions made in waters beyond the State's territorial boundary through its Federal Consistency authority.[8]

This study provides information for state and federal decision-making, supplementing available use and resource data. When future decisions are to be made regarding offshore activities, state and federal agencies will rely upon all data and information available at the time of the decision-making. This study illustrates the abundance and diversity of the uses and resources that can be found off New York's offshore Atlantic environment. The information that follows supplements existing datasets and highlights a broader body of ongoing work. It is not intended to be an exhaustive accounting of New York's ocean interests.

This study contains physical, biological, geographic, and socioeconomic information including:

- the locations and characteristics of existing uses, such as commercial vessel traffic, recreational boating, commercial fishing, recreational fishing, diving, surfing, nature viewing, and research and exploration;
- predicted locations of existing natural resources, such as fish, whales, seabirds, and sea turtles, and observed locations of corals and sponges;
- a range of modeled physiographic information, such as ocean floor features, sediment characterization, depth, current, temperature, wind speeds, and bathymetry (bottom contours); and
- the locations of infrastructure and regulated areas, such as dump sites, unexploded ordnance, navigation lanes, turning basins, fiber-optic cables, electric transmission cables, pipelines, and aviation-restricted areas.

B. Purpose

The purpose of this study is to improve the understanding of habitats that New York's existing ocean-based industries depend upon based on the actual or predicted locations of existing uses and resources. This study is the first of many steps to guide and inform the future siting of offshore activities. The methodologies and data represented here can be found in their entirety in a series of separate scientific reports developed for DOS by federal partner agencies and oceanographic organizations. These reports contain more detail on the methodologies used and include additional data and analyses. The reports can be accessed online at http://www.dos.ny.gov/communitieswaterfronts/offshoreResources/index.html. Readers that may be interested in learning more about any of the natural resources presented here, such as marine mammals or sea turtles, can refer to the supporting documents.

The continued growth and vitality of New York's Atlantic coastal communities are closely linked to a healthy and productive ocean ecosystem that remains accessible to New Yorkers for their commercial and recreational activities. As the understanding of ocean resources increases and as ocean-based technologies mature, new opportunities are becoming available for commercial development. These opportunities include an increased technical ability to harness offshore wind energy resources, and new research and exploration into biological resources that have the potential for biomedical and other technical applications.[9]

In particular, one of the main drivers for this study is to aid the siting and associated state and federal regulatory review of future offshore wind energy projects in the study area. The wind resources offshore of New York State in the Atlantic Ocean are relatively strong,[10] close to load centers, and commercially-available technology currently exists to generate and transmit electricity from offshore wind resources to New York's electric grid. The taking advantage of this renewable resource could help New York State reduce its dependency on fossil fuels while meeting a growing energy demand. In addition, offshore wind could bring new economic development opportunities to New York industries involved in the siting, permitting, manufacturing, construction, operations, or decommissioning activities necessary to build, maintain and retire an offshore wind energy facility. As with any new form of energy development, decision-making requires a robust analysis of the potential costs, including impacts on electric rates, as well as the benefits of future projects.

The public interest in offshore wind is complicated by a current relative lack of data on the locations of important offshore habitats and uses. The offshore environment is relatively vast and unknown, particularly when compared to information available for coastal and nearshore areas. The geographic focus of this study therefore emphasizes the offshore aspects of ocean uses and resources to help address this knowledge gap. The data and information contained in this document show, for the first time,[11] the State's perspective on the complexity of the natural and human environment offshore New York.

In developing the scope and methodologies for this study, DOS relied on modeling approaches rather than invest substantial resources to collect and process new natural resource observational data. These models utilized datasets that provided the best available information for the offshore environment and are a cost-effective means to inform and guide future research, fulfill regulatory requirements, and aid in project review analyses.

While some nearshore and coastal information is included, this study is not designed to highlight or draw attention to nearshore and coastal areas. Instead, the study complements existing data and information that show the value of nearshore areas (e.g., bycatch data that show important coastal foraging areas used by sea turtles and also acoustic survey data showing patterns of nearshore foraging activity by Atlantic sturgeon) and is intended to be used in conjunction with these other datasets for decision-making. While the State's interest in coastal uses and resources is relatively well-understood, the information in this study confirms that the geographic breadth of State interests extends well beyond the State's territorial boundary, requiring collaboration and partnership across multiple levels of government.

Both nearshore and offshore data will be important to aid future decision-making in the siting of offshore wind projects. As examples, existing and future data on important nearshore recreational areas in Moriches and Shinnecock Bays or the coastal foraging habitats of sea turtles may be important for analyzing potential transmission cable sites and landfall locations. Likewise, the whale information in this study and other reports on marine mammal presence may be important for analyzing potential sites for project elements that are farther offshore, such as wind turbine foundations and offshore electrical collection and transmission infrastructure.

The immediate impacts of this study will include:

- Informing future analyses that will guide offshore wind project development and permitting efforts toward the areas that demonstrate potential for compatibility with existing uses and resources.

- Informing future protection measures for the habitats and places that sustain New York's ocean-based industries, particularly commercial fishing and marine navigation.

- Increasing the availability of information for use in decision-making in federal waters, using widely-accepted scientific analyses and information collected directly from New Yorkers who depend on the ocean for their livelihoods and enjoyment.

Future offshore planning efforts will build from this Study and will include additional data collection and analysis of uses and resources important to New York. DOS is continuing to work with partners to model natural resources (e.g., benthic habitats, commercially and recreationally-valuable fish stocks) and obtain use data (e.g., surfclamming activity) and anticipates making data from these future analyses available in the same data portal used for this study.

This study and subsequent efforts are intended as a planning exercise and do not bind or pre-determine future decision-making. As a result, the pre-screening of sites is based upon a scientific analysis of available data and information and does not constitute a pre-clearance, a pre-approval or an exemption from current and future compliance with all state and federal statutory and regulatory requirements pertaining to the siting of offshore energy facilities.

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C. Offshore Planning Area and Setting

(Figure 1)

The offshore planning area covers much of the New York Bight and includes New York's Atlantic territorial sea and those federal waters where located actions are most likely to have an effect on New York's coastal uses and resources.[12] The offshore planning area extends from 1,500 feet off the southern shore of Long Island and New York City to the edge of the continental shelf and encompasses approximately 16,740 square miles. The eastern boundary extends from the shared state territorial sea boundary with Rhode Island, off Montauk Point, out to the western foot of Block Canyon. The western boundary begins at the shared state territorial sea boundary with New Jersey, extends southeast to the Ambrose navigation buoy, then south along the western side of the Ambrose to Barnegat shipping lane to a point approximately 7.7 nautical miles from the Ambrose navigation buoy, and from that point to the western foot of Spencer Canyon (Figure 1).

The offshore planning area ranges from approximately 90 to 125 miles wide, from 1500 feet from the shore to the edge of the Outer Continental Shelf (OCS). At its outer edge, the shelf meets the continental slope, an area 25 - 35 miles wide with very steep slopes that extend to water depths greater than 1.5 miles from the ocean surface. The most prominent topographic feature in the offshore planning area is the Hudson Canyon, a large submarine canyon at the continental shelf edge. At the continental shelf break, waters above the shelf and above the slope meet, creating a highly dynamic zone where water moves due to wind forcing, gravitational flow, and large scale weather patterns.[13] Changes in the relative position of these dynamic waters can affect physical parameters such as water temperature and influence species distributions.

The hydrography, or water currents, within the study area varies significantly by season, driven by considerable freshwater input from rivers, storm-dominated sediment transport and interactions among large distinct water masses. These characteristics, along with those of the seafloor, affect the presence and location of resources (e.g., fish, sand) and ecosystem services (e.g., coastal protection, tourism and transportation).

Figure 1: Offshore Planning Area

The Offshore Planning Area includes the continental shelf, slope and a variety of seafloor features such as canyons.

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II. Methods and Findings

A. Summary

(Figure 2)

DOS staff partnered with multiple federal and state agencies, non-government organizations, universities, and other stakeholders. These partners provided critical support in developing, vetting, organizing, analyzing and depicting the information provided in this report. In particular, the National Oceanic and Atmospheric Administration (NOAA) National Centers for Coastal Ocean Science Biogeography Branch (NCCOS) provided significant technical assistance and direct modeling efforts in support of DOS.

Most of the data used in this planning effort are from federal agencies or from universities with oceanographic research and exploration programs. DOS engaged key federal entities responsible for offshore environmental and industry regulation, and other activities related to ocean energy planning within federal waters. Many of these federal entities maintain datasets relevant to DOS's offshore planning area and have helped to analyze the information included in this study.

DOS also created an "Offshore Renewable Energy Work Group" and an "Offshore Habitat Work Group". The work groups were created as issue-specific forums for discussing site information needs for renewable energy projects offshore New York, and evaluating the best available data to identify and describe unique offshore habitats, respectively.

DOS evaluated and organized information into four general data topics: infrastructure, bio-geography, renewable energy requirements and offshore use. This review led to the identification of initial data gaps, particularly offshore use information. DOS then worked with a wide range of interests and stakeholder groups to identify, locate and characterize offshore uses. This new dataset includes commercial and recreational fishing, boating, surfing, diving, and wildlife viewing activities. DOS supplemented this work with existing information on commercial fishing and commercial vessel traffic generated by the federal government.

The Offshore Atlantic Ocean Study is the most comprehensive collection of information available for the offshore planning area. The study is built from 750 datasets, involved dozens of federal agencies, state agencies and non-government organizations, and includes input from over one hundred individual ocean users and user groups. DOS's emphasis on collaboration and direct engagement with ocean users and data repositories provided real-time peer review and greater confidence in study results. The figures and information presented here are a representative subset of the hundreds of datasets collected and accessed by DOS (Figure 2). DOS will make the information in this study, and additional data, available on the DOS website. The website will be updated periodically to incorporate additions and modifications.

Figure 2: Selected Datasets.

Dataset	Sample size within Offshore Planning Area	Time Period
Groundfish trawl survey	4,000 trawl stations	1975 – 2009
Seabird surveys	4,500 observations	1980 – 1988
Marine mammal and sea turtle database	2,500 observations	1978 – 2006
Deep-sea coral and sponge database	587 records	1880 – 2005
Commercial fisheries regulatory data	200 grid cells*	2001 – 2010
Commercial fisher interviews	104 records	2012
Recreational user interviews	130 records	2010 – 2012

**trip reports are aggregated by grid cell to protect confidentiality*

B. Study Base Map

(Figure 3)

DOS developed a base map to provide the viewer with context when displaying use or resource data layers (Figure 3). The size of the offshore planning area and relatively low resolution of some data required the underlying base map to be standardized at a scale of 1 inch = 20 nautical miles. This scale provides an appropriate focus on resource and use presence in offshore areas (i.e., beyond 1500 feet from shore) consistent with the purpose of this study. However, many datasets have higher resolution that also allows for zoomed-in views and maps focused on smaller subsets of the offshore planning area that will be the focus of future planning work.

The GIS data layers used in the base map are:

- **States/coastline** – Details state boundaries, giving regional context to the location of the offshore planning area within New England and the Mid-Atlantic.
- **New York Counties** – Details county boundaries, providing state-level context to New York stakeholders. This data layer was obtained from the New York State GIS Clearinghouse and is maintained by the New York State Office of Cyber Security.
- **Bathymetry** – Details seafloor bathymetry (also called seafloor topography) that influences the planning of human activities (e.g., construction, shipping) and many physical, chemical and ecological processes, including habitat characteristics. DOS used bathymetric data layers provided by federal agencies.
- **Navigation (shipping) traffic lanes** – Details established navigation routes familiar to the ocean use community that provide a visual reference for individual use and resource data layers. Offshore wind project development is completely restricted within traffic lanes. For this reason, data layers relevant to offshore wind project siting are often displayed underneath the traffic lane layer (see II.F.1 for more discussion of siting constraints). Three major navigation traffic corridors[14] leading to/from New York Harbor are at least partially within the offshore planning area: a west – east corridor off the southern coast of Long Island that includes the Ambrose to Nantucket / Nantucket to Ambrose navigation lanes; a north – south corridor that includes the Ambrose to Barnegat / Barnegat to Ambrose navigation lanes; and a northwest – southeast corridor that generally follows the Hudson Shelf Valley out to the Hudson Canyon and includes the Ambrose to Hudson Canyon / Hudson Canyon to Ambrose navigation lanes. The navigation traffic lane data layer was acquired from NOAA's online Electronic Navigation Chart (ENC) site.[15]
- **Federal/state territorial seas** – Details the boundaries for state and federal territorial seas, which are jurisdictional layers that represent defined management areas. DOS acquired this layer from the federal Multi-purpose Marine Cadastre.[16]

- **Federal Outer Continental Shelf Lands Act lease grid** – Details the grid used to identify areas available for leasing for offshore wind project development. The U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) uses 3 nautical mile x 3 nautical mile "lease blocks" as the basic units for identifying offshore wind lease areas.[17] The offshore data and information in this study can be used to identify locations that may be appropriate for offshore wind energy development. The lease block grid therefore is included as a base layer. DOS acquired this layer from BOEM.

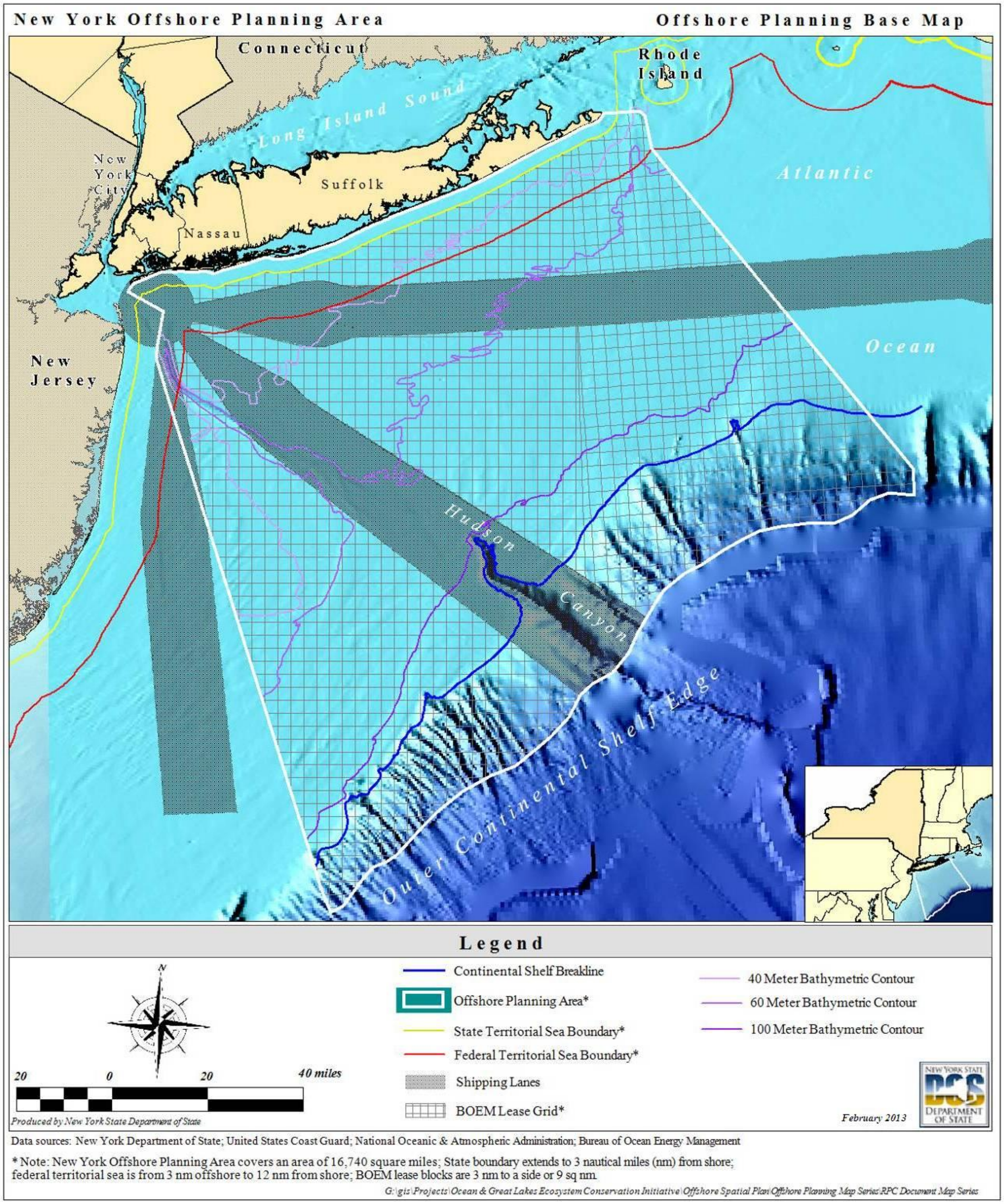

Figure 3: Offshore Planning Area – Base Map

Navigation lanes and state and federal territorial sea boundaries transect the offshore planning area. Each BOEM lease block grid is 9 square nautical miles. Bathymetric contour lines illustrate the seafloor terrain in the offshore planning area.

C. Infrastructure

(Figure 4)

The seabed offshore New York contains numerous active and relic infrastructure sites. These sites include utility line crossings, ocean observation platforms, and material disposal sites. DOS incorporated the following NOAA data layers representing known, existing infrastructure from the Office of Coast Survey[18] (Figure 4):

- **Buoys** – Details the location and physical characteristics of the navigational buoys, lights, and day beacons that mark where channels and potential obstructions are located, including observational buoys used for monitoring weather conditions and other parameters of the sea state at that location.
- **Dump (Disposal) sites** – Details the location and general nature of undesirable and/or dangerous materials that have been disposed of in a number of areas offshore New York.[19] Dump sites containing materials such as chemical and industrial waste, unexploded ordnance, and even municipal sewage sludge have been identified and mapped.
- **Submarine cables** – Details the location of submerged cables, including intercontinental telecommunications cables and interstate electrical transmission cables.
- **Submarine pipelines** – Details the location of the planned Transco pipeline, the only known natural gas pipeline in the offshore planning area.
- **Sand Borrow Sites –** Details the location of areas that have either been identified as sand borrow sites or are potential sand borrow sites that require additional analysis. Analysis of potential sites includes consideration of spatial extent of the sand resource, sediment composition and size, depth, biological assessments and other factors. Once identified, sand in these sites may be appropriately used for various needs, such as beach nourishment, etc. The offshore planning area includes 44 current and potential borrow sites totaling 9,414 acres, of which 62.25 acres are in federal waters. Further analysis is needed to determine the full extent of available sand resources across these sites.

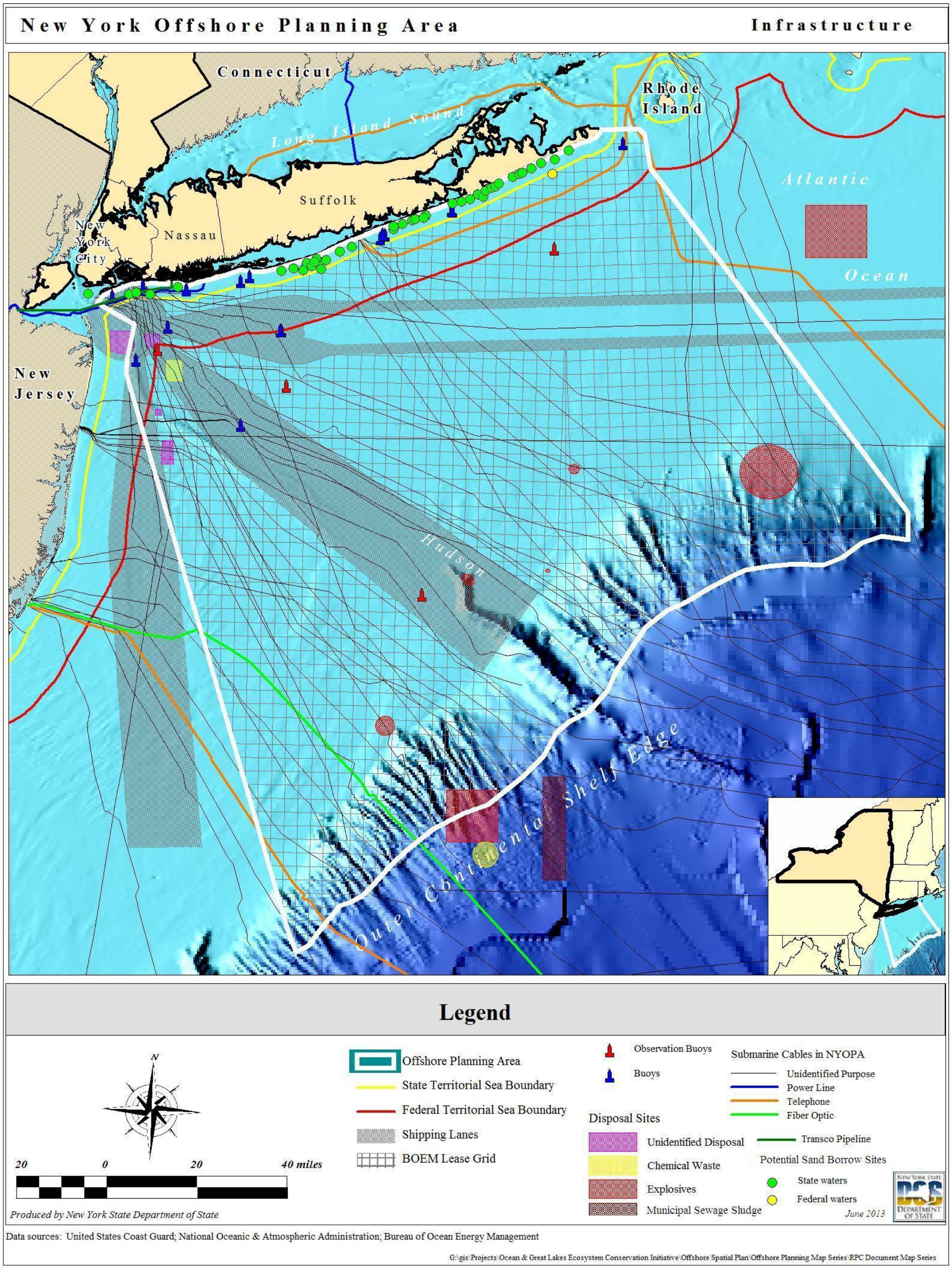

Figure 4: Infrastructure

Multiple layers of marine infrastructure can be seen in this map. These include stationary navigation and research buoys, and submarine cables, many trans-Atlantic, which cross the offshore planning area. A number of locations offshore have been used for disposal of undesirable materials.

D. Biogeophysical

Biogeophysical information covers a wide range of natural processes and resources of potential significance to New York. The biogeophysical data available to DOS include information on:

- physical "landscape" characteristics of the ocean floor, including water depth (D.1.Bathymetry) and seafloor composition (D.2. Substrate);
- annual and seasonal atmospheric and oceanic conditions (D.3.Meteorological-Oceanographic); and
- many of the biological resources that are present in the offshore planning area during at least some part of the year or at some phase of their life-cycle (D.4.Deep Sea Coral and Sponges, D.5.Marine Mammals and Sea Turtles, D.6.Seabirds, and D.7.Groundfish).

The biogeophysical data - particularly the data on biological resources - came from a variety of sources, and consist of a range of sample sizes, spatial resolutions and time frames. Many of the data sets are large and long-standing. For example, the North Atlantic Right Whale Consortium (NARWC) database, housed at the University of Rhode Island, is made up of thousands of observations spanning 31 years from 1978 to 2009.[20] The Manomet Cetacean and Seabird Assessment Program database includes 9,099 survey locations with observations spanning from 1980 through 1988.

DOS formed a significant partnership with NCCOS to interpret seabird data sets in applying them to the offshore planning area.[21] NCCOS developed models using environmental variables as well as sightings data to predict seabird abundance and distribution. DOS also worked with the New England Aquarium and Stone Environmental, Inc. to interpret additional data for taxa of interest (marine mammals, sea turtles and groundfish). New England Aquarium developed relative abundance maps for marine mammals and sea turtles based on survey sightings data. These efforts were captured in several reports generated specifically to support this study.[22]

The predicted distribution and abundance maps in this study represent model outputs based on work described in these supporting documents. A fundamental characteristic of modeled information is that the biases in a model's output reflect the data that were input to develop it. For this reason, a survey methodology that focuses on offshore observations rather than nearshore (e.g., the NARWC database) will lead to maps that are more appropriate for predicting abundance or distribution offshore rather than nearshore.

The predicted distribution and abundance estimates are a relative index and should not be confused with absolute population estimates. Interpolation smoothed out the relative density contours and filled-in predicted values in some unsampled areas. For the seasonal maps, the entire dataset (i.e., all observation points, including those outside the study area) was ranged. A unique range of values was then created for each annual map to highlight "hotspots" within the study area.

As a final note, units of abundance are relative to each species. Units needed to be statistically standardized across all species before creating grouped maps (e.g., All Cetaceans).

1. **Bathymetry**

The technologies used to measure water depth are expensive, time-consuming, and cover relatively narrow swaths as an area is surveyed. Because of the infeasibility of completely surveying the offshore planning area, DOS relied on modeling to fill in the gaps between measured water depths.

NCCOS developed a new bathymetric model for the offshore planning area, based on data from the standard NOAA Coastal Relief Model (CRM). NCCOS used a geostatistical approach to predict a continuous surface from scattered sounding locations. They retrieved all available NOAA National Ocean Service Hydrographic Survey Data within the study area, including information on how and when each sounding was collected. While certain soundings were corrected or eliminated due to accuracy concerns, the vast majority were retained. Soundings were then divided into four depth strata, and interpolated using separate models appropriate for each stratum. Model performance was assessed using cross-validation and comparison to an independent high-resolution dataset. [23]

The NCCOS model builds on previous predictive bathymetric modeling completed in the region,[24] providing a continuous bathymetric surface for the offshore planning area. While the spatial resolution of the new model is identical to the standard NOAA CRM, the new model provides estimates of prediction certainty, which can be used to prioritize areas where new bathymetric surveys are needed and to better understand the reliability of existing depth predictions and derived spatial layers (e.g., benthic habitats, positions of depth contours).[25] Certainty was generally higher at shallower depths and lower at deeper depths. Error also increased with distance from soundings. Cross-validation results indicated that the model performed extremely well in the 0-30 m and 30-100 m depth strata (mean absolute errors of 0.60 m and 0.55 m, respectively) and reasonably well in the 100 - 200 m depth stratum (mean absolute error of 2.1 m). Accuracy at depths deeper than 200 m was considerably degraded. [26] This model represents the best currently available broad-scale data for the offshore planning area. Collection of new high-resolution bathymetric data will be incorporated by DOS in future updates to the study data layers available online.[27]

The bathymetric model provided an important base environmental layer for spatial planning since bathymetry influences the viability of human activities (e.g., bottom features that may limit offshore project construction, water depths necessary for deep-draft shipping) and many physical, chemical and ecological processes. For instance, reliable bathymetric information can simultaneously improve habitat conservation and energy development by supporting the identification of:

- unique or vulnerable benthic habitats;
- distributions of rare or endangered species;
- efficient corridors for transmission lines; and
- suitable sites for wind turbine platforms.

2. Substrate
(Figure 5-Figure 6)

Mapping seafloor features, including sediment characteristics and distribution, provides crucial information for a number of offshore activities. Like bathymetric data, other seafloor data can be used to help select appropriate offshore wind development sites, and plan sand/gravel mining operations. Bottom sediments play critical roles as habitats for benthic organisms such as groundfish (e.g., cod, flounder), clams and corals, and in the storage and processing of organic matter.[28]

NCCOS developed predictive models of mean sediment grain size and the probability of hard bottom occurrence for DOS's offshore planning area (Section IV).[29] Predictions were made on a 30 arc-second (0.5 nautical mile) geographic grid.

NCCOS obtained mean grain size data from Dr. John Goff,[30] who obtained data from the publicly available usSEABED Atlantic Coast Offshore Surficial Sediment Data Release and applied bias corrections and quality control procedures. Using the same general geostatistical modeling approach they applied to the bathymetric data, NCCOS created a continuous surface for surficial sediment mean grain size from scattered sediment survey point data. NCCOS also compiled an integrated point dataset of known hard bottom locations from the usSEABED database, the NOAA and U.S. Coast and Geodetic Survey Bottom Type Descriptions from Hydrographic Surveys database, and National Marine Fisheries Service (NMFS) surveys.[31]

The new NCCOS models build upon existing data compilations and analytical frameworks. The mean (sediment) grain size model provides a continuous predictive map and corresponding certainty estimates. The hard bottom occurrence model also provides a continuous predictive map representing the likelihood of hard bottom occurrence. For display purposes, these models are combined in one map to show areas with the greatest likelihood of hard bottom occurrence, as well as those likely to have grain sizes equal to or greater than those of coarse sand (Figure 5). Nonetheless, any model based on presence-only data should be approached with caution.

Mean grain size model certainty was poorer in areas offshore of the continental shelf break vs. nearshore areas, reflecting the paucity of surveys past the offshore shelf break. Note that mean grain size predictions are likely biased toward finer particles due to issues with sediment sample processing.

Hard bottom likelihood was high in nearshore areas and in the vicinity of canyon features. It is important to note that the model provides a relative likelihood of at least one hard bottom point occuring at a given location, and that these points may be in areas predominated by non-hard bottom (e.g., sandy) substrate.

Although model predictions are static, the offshore planning area is characterized by spatially variable seafloor features that have formed as a result of dynamic marine geological processes, particularly the dramatic (>100 m) rise in sea level following the last glaciations.[32,33] The present distribution of surficial sediments in the region reflects deposition, erosion, and other sedimentary processes during this period of sea level rise.[34]

The continental shelf within the study area has relatively simple topography and slopes gradually from the shore to the shelf edge. The seafloor on the continental shelf is generally composed of sand which grades to finer sediments such as silt and clay as water depth increases.[35] The relatively homogeneous seafloor has sporadic relic sand and gravel ridges from past glacial periods, exposed sandstone and bedrock, dumping sites and other infrastructure as detailed above, scuttled vessels, artificial reefs (including subway cars submerged through a New Jersey reuse program), shipwrecks, and lost cargo. The most pronounced topographic features in the offshore planning area are the Hudson Shelf Valley, which crosses the entire shelf at the southern end of the offshore planning area,[36] and the Hudson Canyon, which connects to the Hudson Shelf Valley and is the largest submarine canyon on the U.S. Atlantic continental margin.[37] The shelf edge also features numerous submarine canyons spanning the offshore planning area (Figure 6).

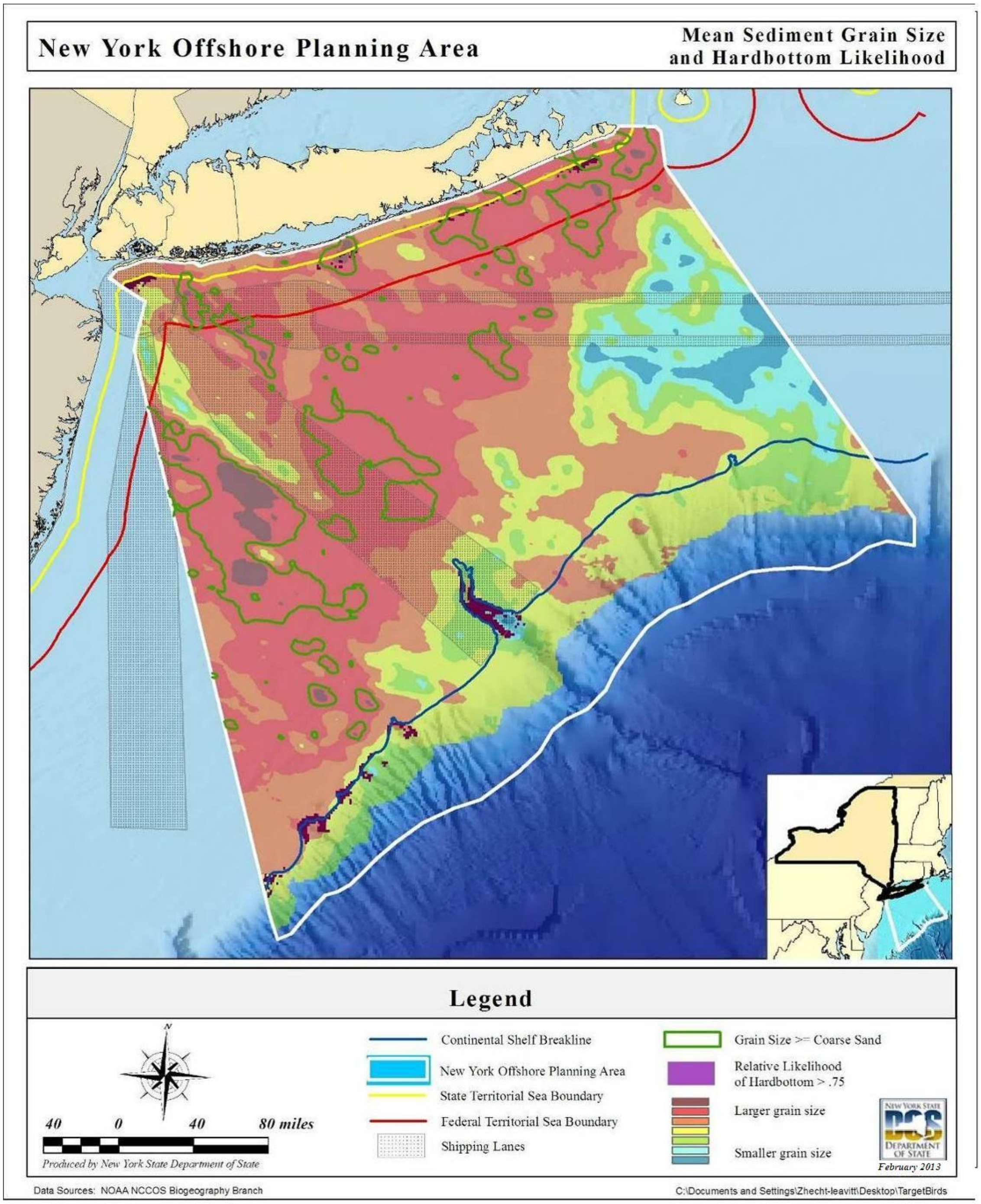

Figure 5: Substrate

This map shows areas with a high likelihood of hard bottom presence as modeled by NCCOS using a point dataset of known hard bottom locations. Areas highly likely to have hard bottom (greater than .75 relative likelihood) are shown in purple, and areas with a predicted grain size equal to or greater than coarse sand (0.5 mm – 1mm) are outlined in green. Remaining areas are color-ramped from smaller grain size (fine silt; approx. 0.016 mm) to larger grain size (pebbles; approx. 4 mm).

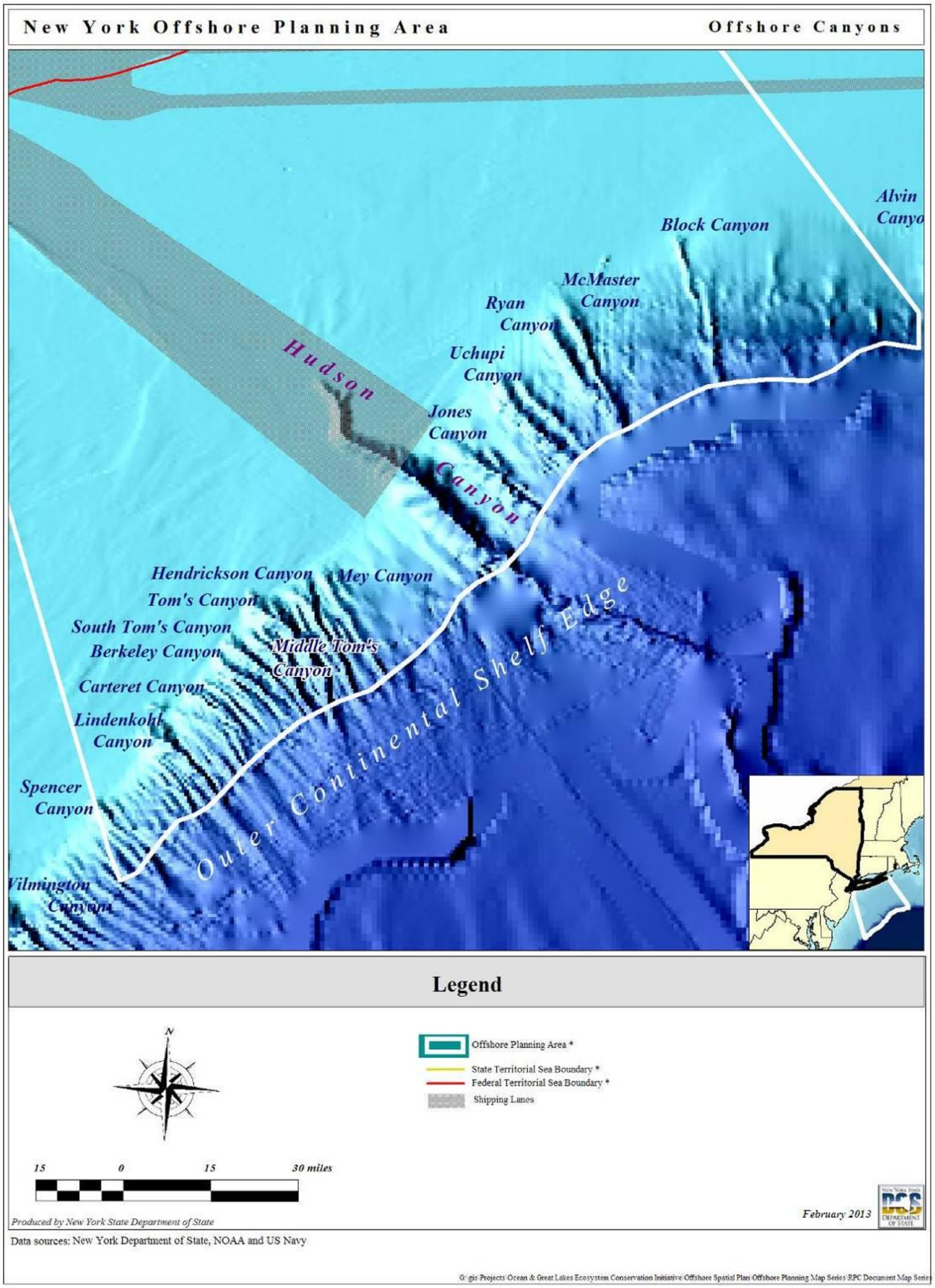

Figure 6: Submarine Canyons

The Continental Shelf Edge within the offshore planning area is cut by many canyons from Spencer Canyon in the southwest to Block Canyon in the Northeast, with the most significant being the Hudson Canyon centered in this map. Due to water transfer, upwellings, varied slopes, and sea floor make-up, submarine canyons are relatively dynamic features of the offshore planning area.

3. Meteorological-Oceanographic
(Figure 7-Figure 13)

Basic physical processes that occur in the offshore planning area can have a significant influence on the presence of certain species and the viability of a range of commercial and recreational ocean uses. In particular, oceanographic conditions are of fundamental importance to understanding the context and root causes of many biological processes.

Meteorological conditions of particular relevance for offshore wind-related planning include average wind speeds (annualized) and extreme weather events.[38] The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) is the United States' primary laboratory for renewable energy and energy efficiency research and development. NREL's meteorologists, engineers, and GIS staff have led the production of wind resource characterization maps and reports, working with leading private industry experts.[39] DOS used NREL-validated offshore wind resource maps to approximate predicted wind resources in the offshore planning area. Data on hurricanes and extratropical/subtropical storms and depressions were obtained from NOAA's National Hurricane Center.[40] Extratropical storms most frequently take the form of nor'easters, which usually occur during winter months.

Wind speeds in the offshore planning area are consistently above 8.5 m/s (Figure 7). Extreme weather events include Atlantic hurricanes that have historically occured in and around the offshore planning area (Figure 8). Because of the large size and high energy of these storms, significant impacts may be felt in areas far from the storm's center.

Several key dynamic oceanographic variables are important to understand spatial and seasonal patterns in the offshore planning area. NCCOS compiled data on: relative ocean temperature at the surface (sea surface temperature, or SST) and within the water column (stratification); the relative presence of particulates in the water (surface turbidity); and the relative biological productivity, both primary/photosynthetic (suface chlorophyll *a*, a type of chlorophyll) and secondary (near-surface zooplankton biomass), a measure of the amount of particulates in the water. Data were gridded and long-term averages were mapped by season.[41]

SST estimates were obtained by averaging monthly satellite data from the NASA Advanced Very High Resolution Radiometer SST archive for the Northwest Atlantic region, 1985-2001. NCCOS calculated stratification values by subtracting seawater density at 50 meters depth from seawater density at the surface.[42] Three-dimensional seawater density estimates were interpolated by NCCOS from conductivity-temperature-depth casts. By this definition, stratification is usually negative, corresponding to less dense, warmer water occurring on top of denser, colder water. Higher negative values indicate greater stratification.

Surface chlorophyll *a* and turbidity data for the period 1998-2006 were extracted from SeaWiFS satellite imagery. Point estimates of zooplankton biomass were obtained from the NMFS

Copepod database from 1966-2001[43]. The NMFS Copepod database does not include larval fish in its zooplankton dataset. Points were interpolated for each season.

SST is dynamic and varies seasonally (Figure 9). Stratification and chlorophyll *a* concentrations are greatest in the spring and summer and lowest in the winter, following seasonal patterns of ocean warming (Figure 10 and Figure 12, respectively). The shelf's water column stratifies in the spring and summer from solar warming and freshwater inputs. Stratification isolates warm, well-mixed surface water from cold, deeper water and deprives the upper water column of nutrients. During stratification, primary productivity -particularly algal growth- is highest nearshore where periodic coastal upwelling and runoff from upland areas can provide nutrients.[44] Offshore productivity is limited to discrete pockets where algae can get nutrients from the currents and weather-generated movement of water. In late summer, stratification breaks down due to storms and surface cooling. By winter the entire water column over the shelf is well-mixed and a sharp frontal zone separates cold, fresh nearshore water from warmer, more saline slope water. In all months, chlorophyll *a* concentrations are highest nearshore and low over most of the shelf and offshore of the continental shelf break. Turbidity showed a similar spatial pattern (Figure 11). Zooplankton biomass is greatest in the fall, with patches of relatively high biomass south of Long Island (Figure 13).

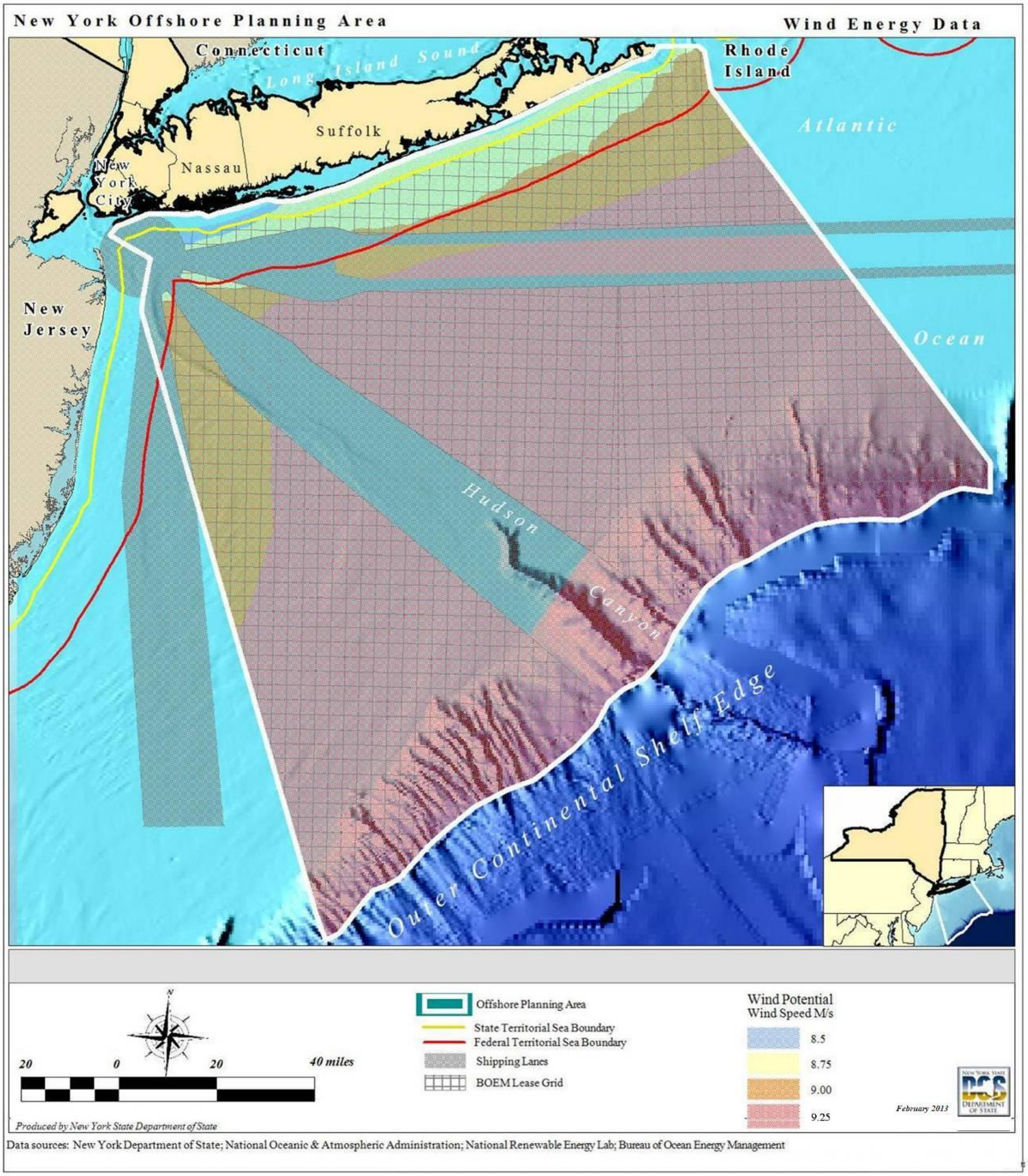

Figure 7: Wind Energy Data

This map shows predicted offshore wind speeds as modeled for NREL.

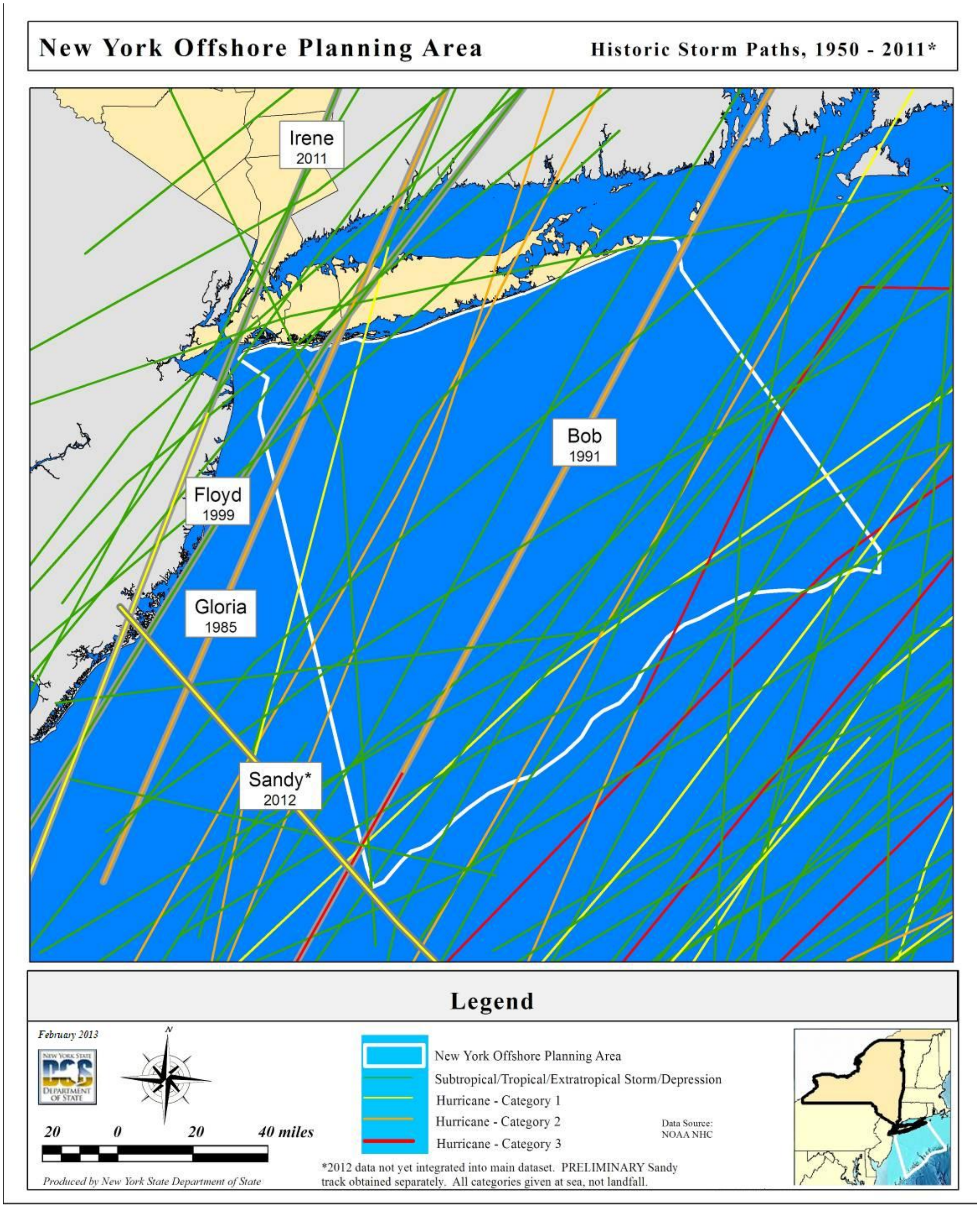

Figure 8: Hurricane and Tropical Storm Paths, 1950–2012
This map shows the path of previous hurricanes, tropical storms or depressions, and nor'easters during the period 1950–2012. A different color-coded path is shown for the period during which the event was classified as a storm, depression or hurricane. Notable recent severe weather events that made landfall on New York's shoreline or had a significant impact on New York are identified on the map by the names assigned by the National Hurricane Center.

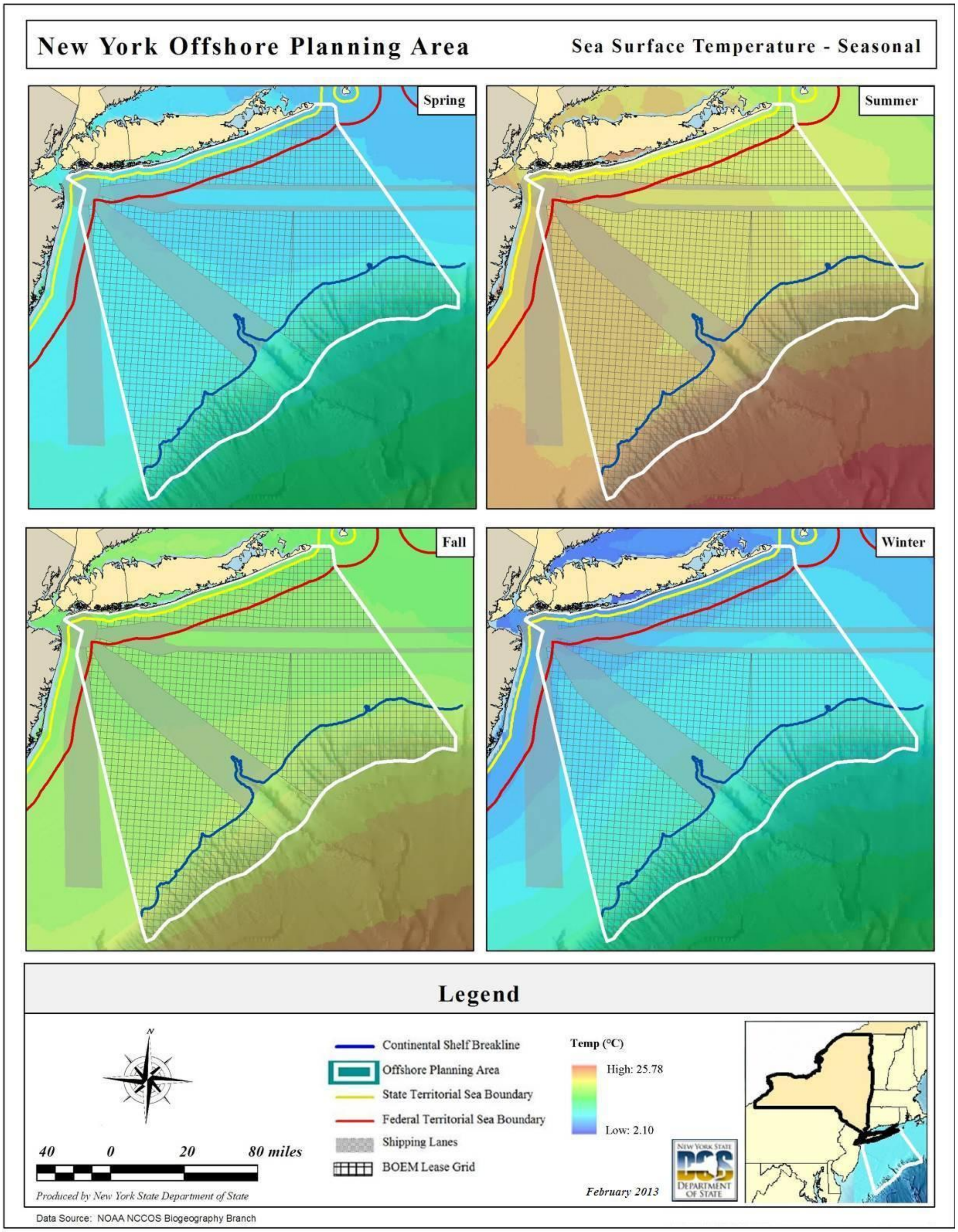

Figure 9: Sea Surface Temperature – Seasonal

This map series shows seasonal variation in sea surface temperature. Higher temperatures southeast of the offshore planning area reflect the influence of warmer Gulf Stream waters.

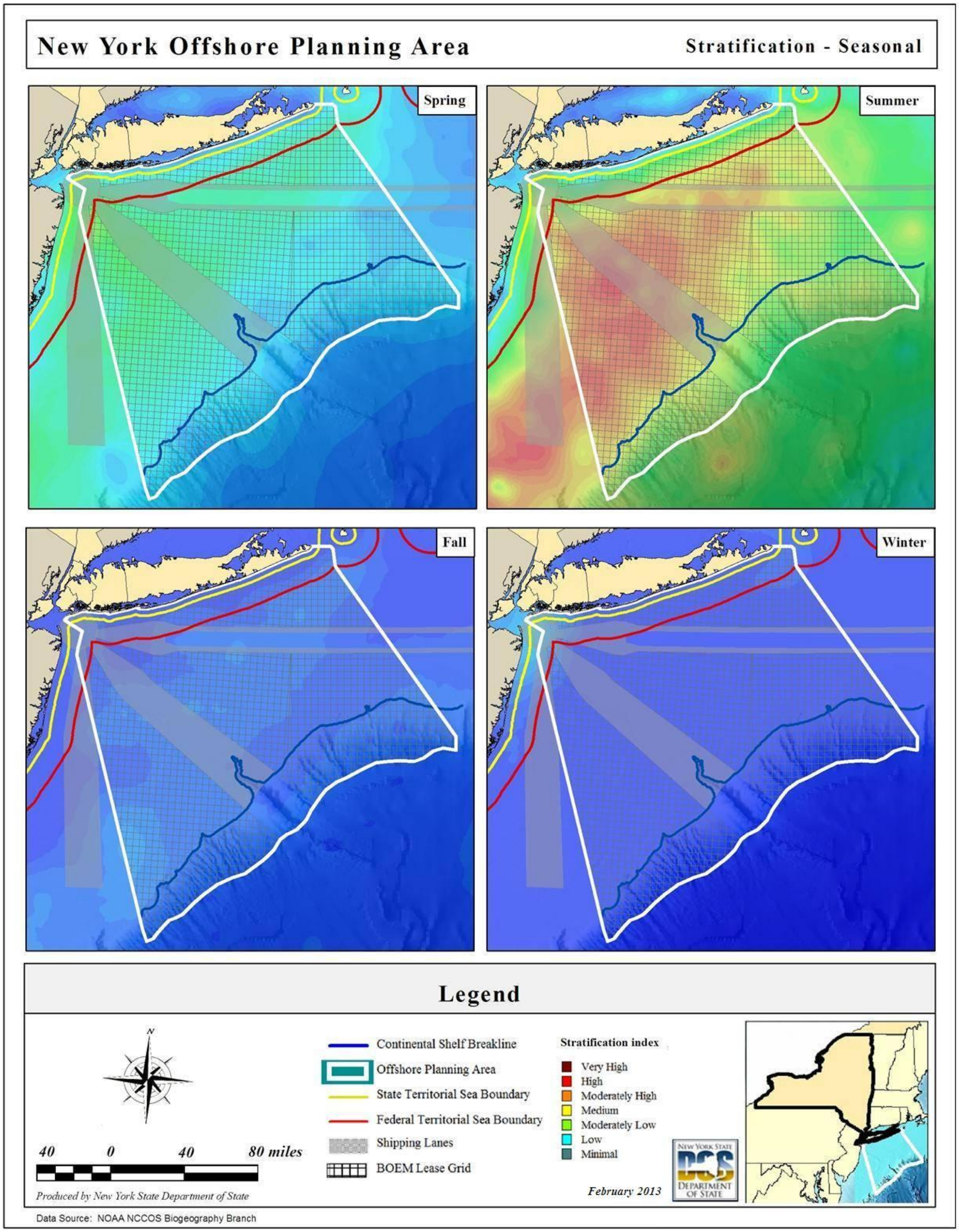

Figure 10: Stratification – Seasonal

This map series shows greatest stratification during summer months, with stratification starting sometime during the spring months and dispersing during the fall. Low stratification values in winter represent a homogenous, well-mixed water column.

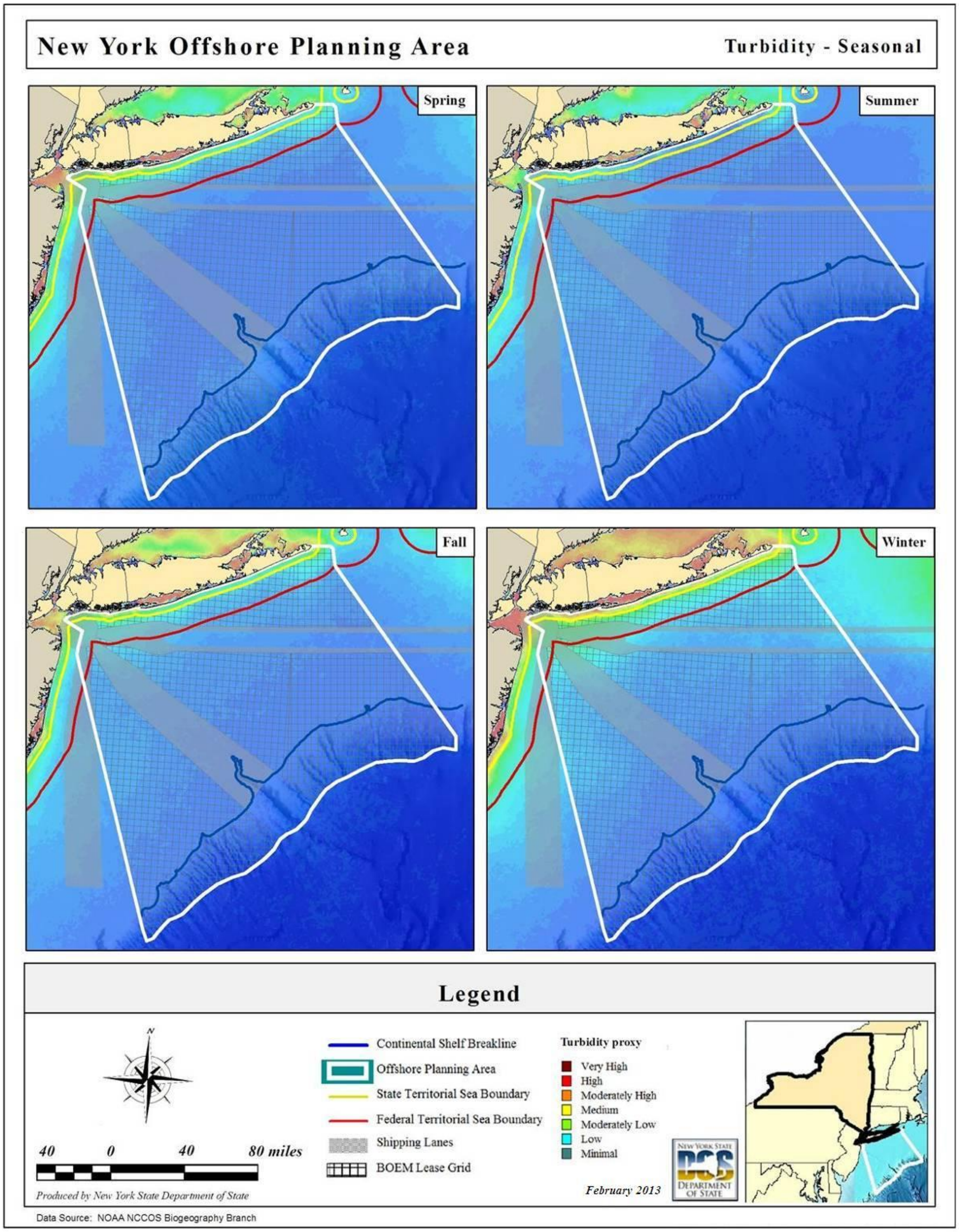

Figure 11: Turbidity – Seasonal

This map series shows that turbidity, or particulates suspended in the water column, is largely a nearshore phenomenon. This map also shows a slight increase in the extent of high-turbidity areas away from the coast during winter months, which follows the trend of low-stratification, high-mixing in winter, as seen in Figure 10.

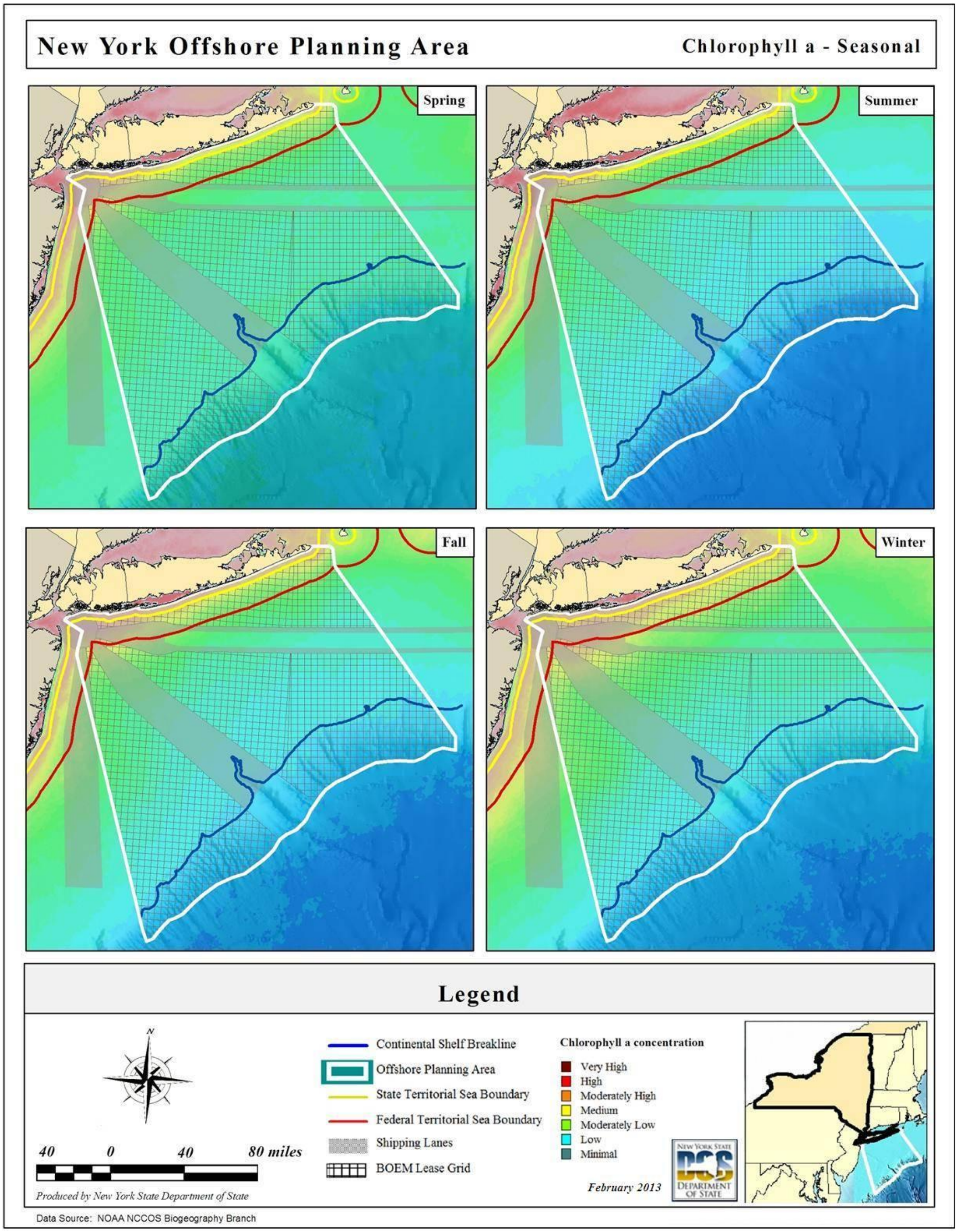

Figure 12: Chlorophyll *a* – Seasonal

This map series shows concentrations of chlorophyll *a* were highest nearshore in all seasons and low over most of the shelf and offshore of the continental shelf break.

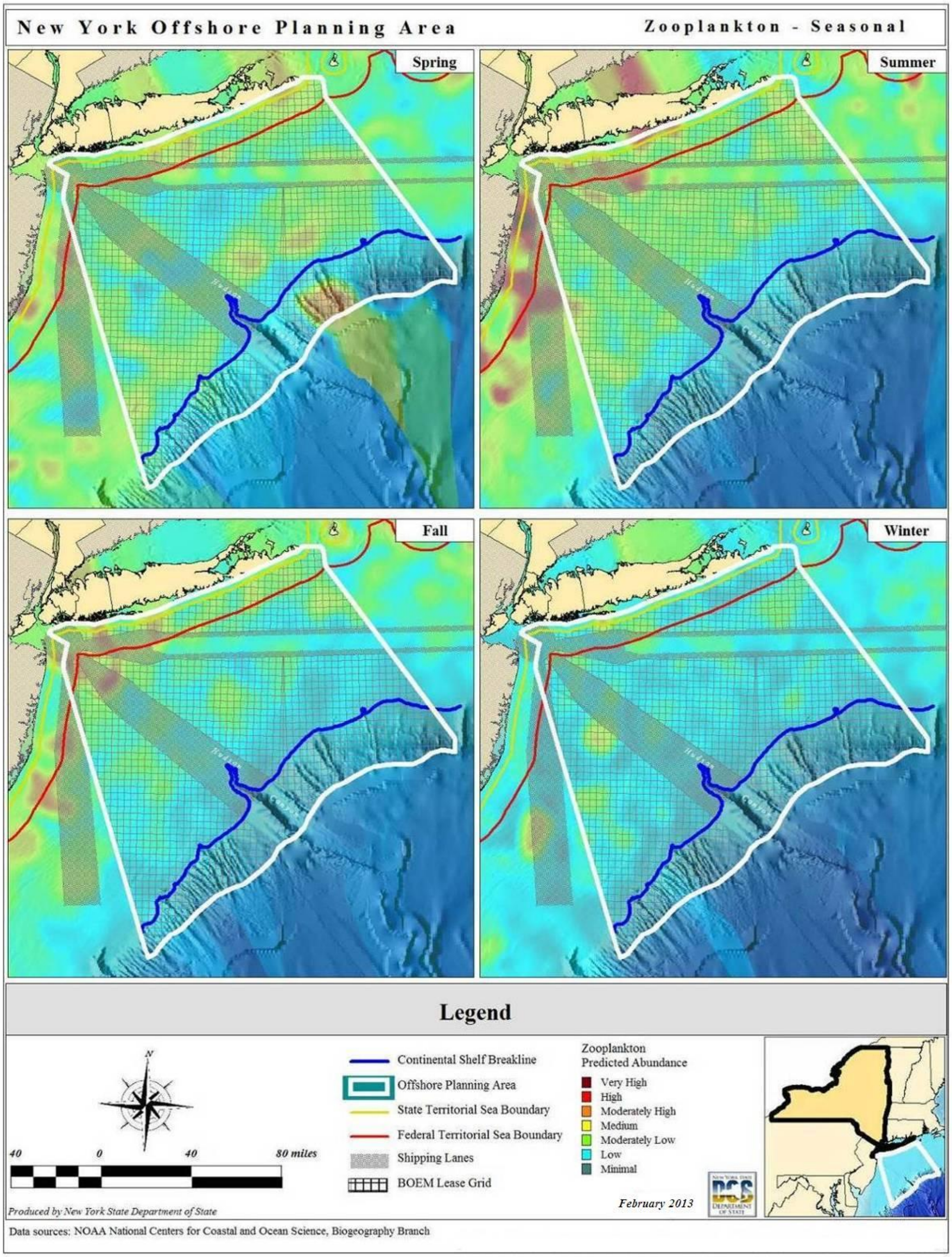

Figure 13: Zooplankton – Seasonal

This map series shows highest predicted abundances of zooplankton during the spring and summer and lower predicted abundances during the fall and winter.

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4. Deep Sea Coral and Sponges
(Figure 14)

NCCOS compiled information on known locations and taxonomy of deep-sea, coldwater corals and sponges in the offshore planning area. The primary data source was the U.S. Geological Survey Cold-Water Coral Geographic Database, which includes over 1,700 entries.[45] Information in this database was collected from over 20 research vessels, including the deep submersibles *Alvin* and *Diaphus,* and includes data collected from 1880 through 2008. This database was supplemented with additional records from at least eight other sources (mostly museum collections). Together this combined database, known as NOAA's Deep-sea Coral Research and Technology Program, represents 5,619 records of known deep sea coral and sponge locations.

Information on deep sea coral and sponge presence and life history are extremely limited for the Northeast. Marine sponges have shown great potential for biomedical applications and may be the subject of future research focus.[46] Therefore, the best available data have been included, regardless of temporal or spatial distributions, to show historically-present species.

These data show presence only; they only describe where deep sea coral and sponges were observed or collected, rather than where species were sought but not observed. This lack of data on absences made application of NCCOS's modeling technique infeasible. Since all areas have not been surveyed and since some specimens were not identified, the full extents of the distributions of these species remain unknown. However, these combined databases represent the best currently available data on the locations of deep sea coral and sponges in the northeast region. Known deep sea coral and sponge locations can be seen concentrated along the continental shelf edge and in the Hudson Canyon (Figure 14).

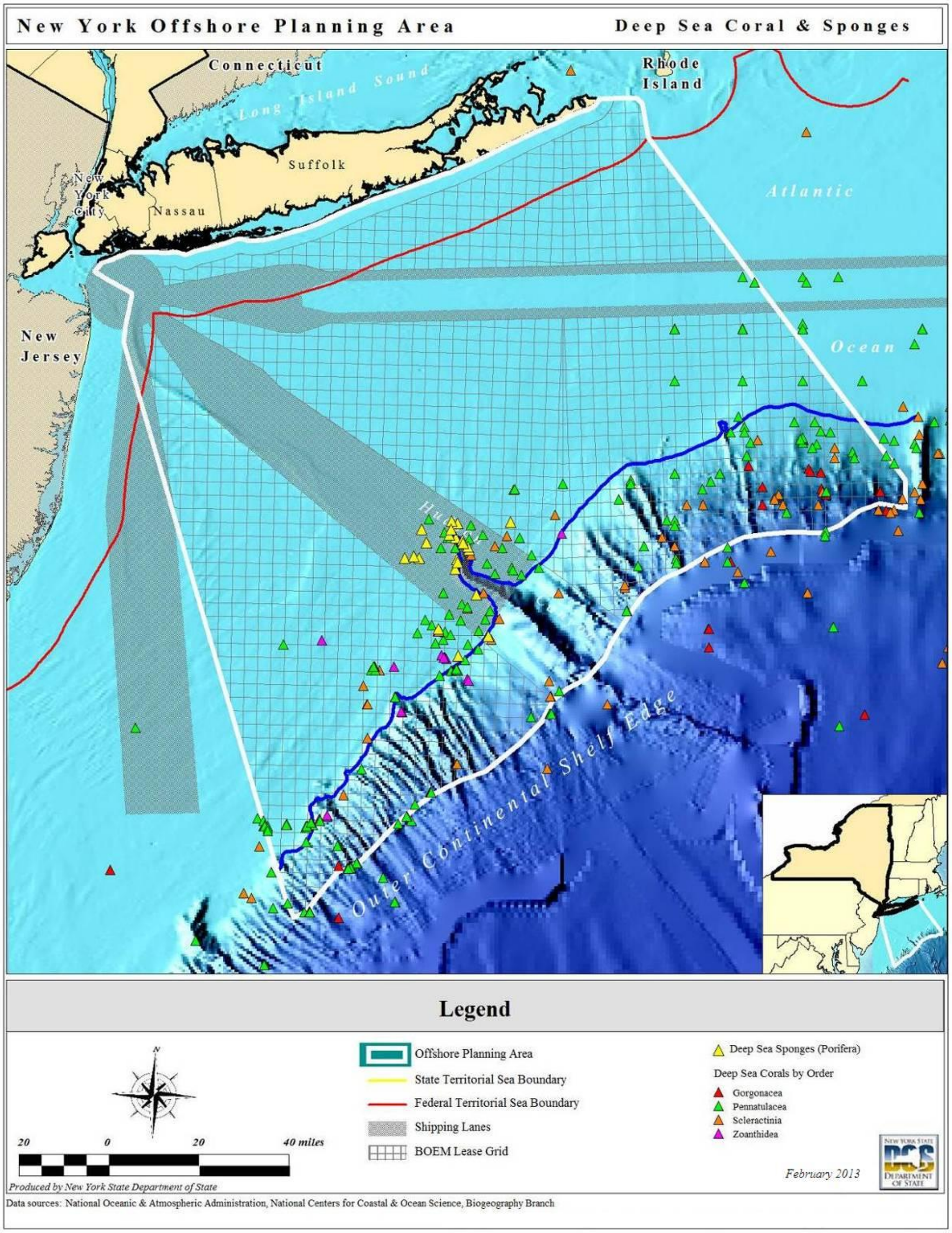

Figure 14: Deep Sea Coral and Sponges

The map above illustrates locations known to support deep sea corals and sponges. This information only shows where positive results were found; it does not show where corals and sponges were not found. Much of the study area remains to be surveyed.

5. Marine Mammals and Sea Turtles

(Figure 15-Figure 32)

The NARWC database, managed by Dr. Robert Kenney at the University of Rhode Island and funded by NMFS, contains thousands of aerial and shipboard survey observations from 1978-2011 for marine mammals and sea turtles in southern New England waters. Data extend into the New York study area and represent the majority of existing survey records for the region.[47] The New England Aquarium (NEA) refined this database for DOS, selecting usable records that conformed to certain standards[48], and assigning them to a regular grid of cells that were approximately 25 square nautical miles each. The number of animals sighted in each cell was divided by the survey flight or cruise length in each cell (in kilometers) and multiplied by 1,000 to avoid decimals, resulting in a relative index of abundance called sightings per unit effort (SPUE), represented here as sightings per 1,000 kilometers. For the majority of species, or in some cases groups of species (e.g., dolphins, endangered baleen whales), observational data points were interpolated by NEA staff using modeling techniques which resulted in relative abundance maps, where relative abundance is an index of the average number of animal sightings normalized by survey effort.[49] Pinnipeds are not included in this study due to relatively few sightings in the offshore planning area.

Species groupings maps were achieved by combining the number of sightings for all species in that group within each 5 nm x 5 nm cell and then calculating the resultant SPUE (survey effort was constant across species in each grouping, because the same set of survey data were used for every species). Since SPUEs for grouped species were based on the combined number of sightings across species, the relative abundances were influenced more by species with higher numbers of sightings than those with fewer numbers. For example, the All Turtles maps were based on sightings data for loggerheads, leatherbacks, hawksbill, green, Kemp's ridley and a category of unidentified turtles, and the total number of sightings for loggerheads (N=1236) was an order of magnitude greater than for leatherbacks (N=169) and even greater when compared to number of sightings of other species.

DOS undertook a separate assessment of the modeling technique used by NEA to better understand the spatial nature of the model's certainty (Section IV).

The maps that follow are representative of the over 20 individual marine mammal and sea turtle species modeled by NEA. Each annual map or set of four seasonal maps for each species or grouping utilizes a unique range tailored to the SPUE information. Many cetacean and certain sea turtle species migrate through the Atlantic Ocean waters offshore New York (Figure 15 through Figure 32). Based on the sightings data input, models show that all whale species spend at least part of the year on and around the contintental shelf edge (Figure 16, Figure 18, Figure

20, and Figure 26), while harbor porpoise distribution does not extend as far as the continental shelf edge (Figure 23 through Figure 24).

The All Cetaceans maps provide a general picture of the overall distribution of cetaceans in the study area. The most utilized cetacean habitat in the study area occurs along the shelf break where large numbers of dolphins and other small toothed whales congregate.[50]

Sea turtle relative distribution occurs almost exclusively on the continental shelf, and is centered on a slight rise in the seafloor in the western edge of the offshore planning area (Figure 29 through Figure 32).

Recent whale monitoring efforts support the predicted presence of baleen whales in many areas offshore New York (Figure 21). An acoustic monitoring study by the Cornell Bioacoustics Research Program revealed that the endangered and rare North Atlantic right whale, as well as blue, fin, and humpback whales, occur regularly in the offshore planning area.[51]

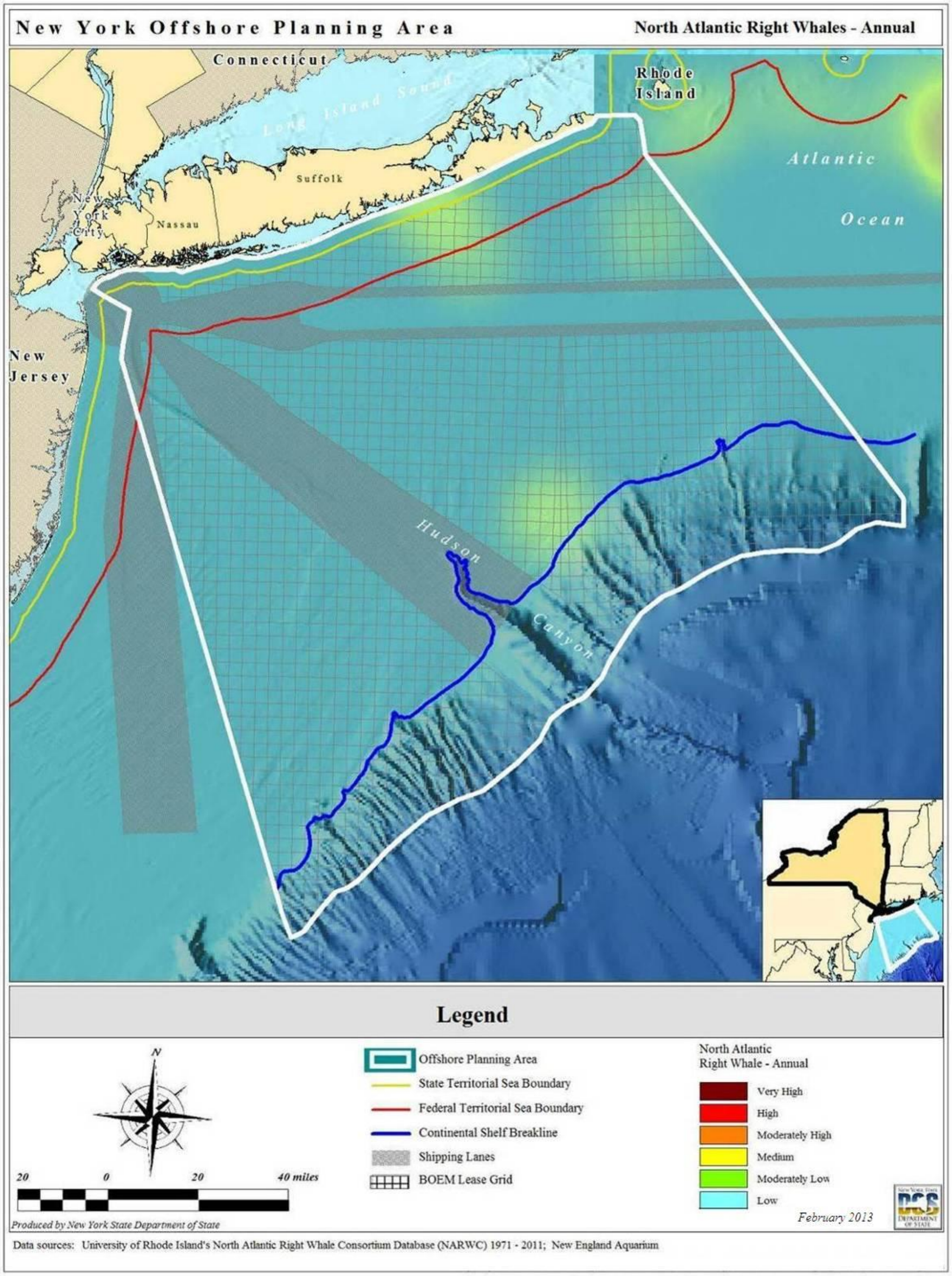

Figure 15: North Atlantic Right Whales – Annual Relative Abundance

This map shows estimated annual distribution of North Atlantic right whales as modeled by the New England Aquarium using the NARWC Database.

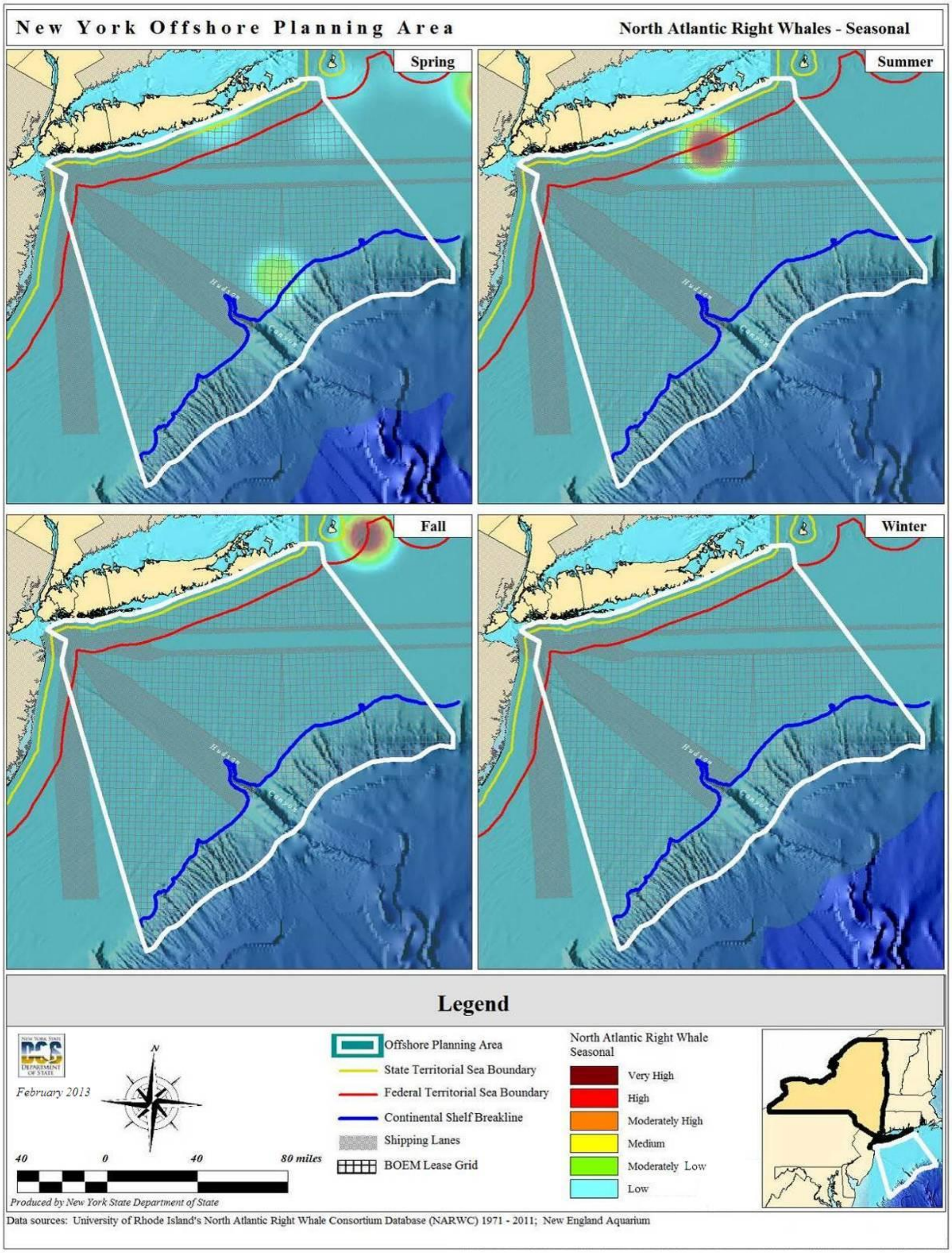

Figure 16: North Atlantic Right Whales – Seasonal Relative Abundance

This map series shows estimated seasonal distribution of North Atlantic right whales as modeled by the NEA using the NARWC Database.

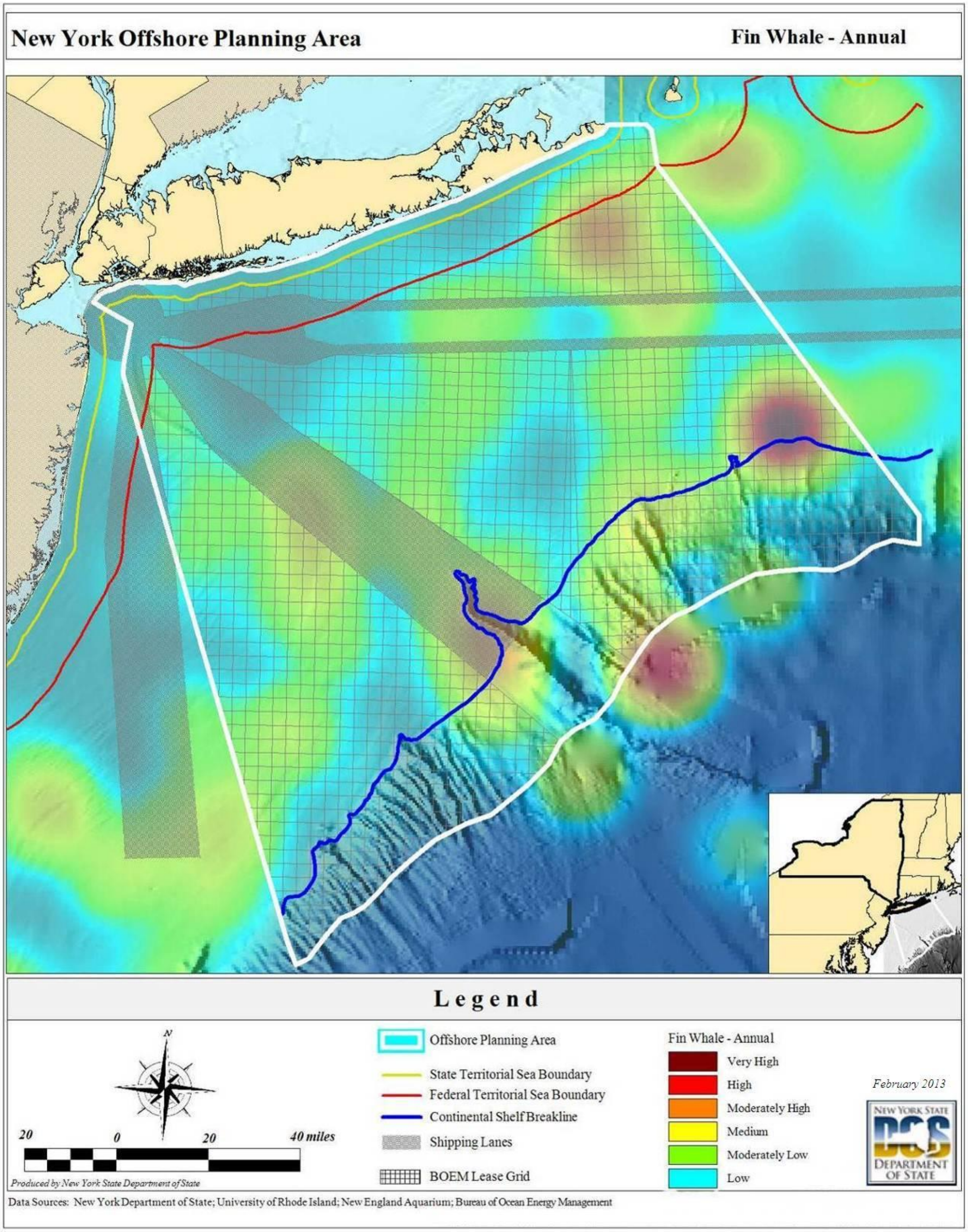

Figure 17: Fin Whales – Annual Relative Abundance
This map shows estimated annual distribution of fin whales as modeled by the NEA using the NARWC Database.

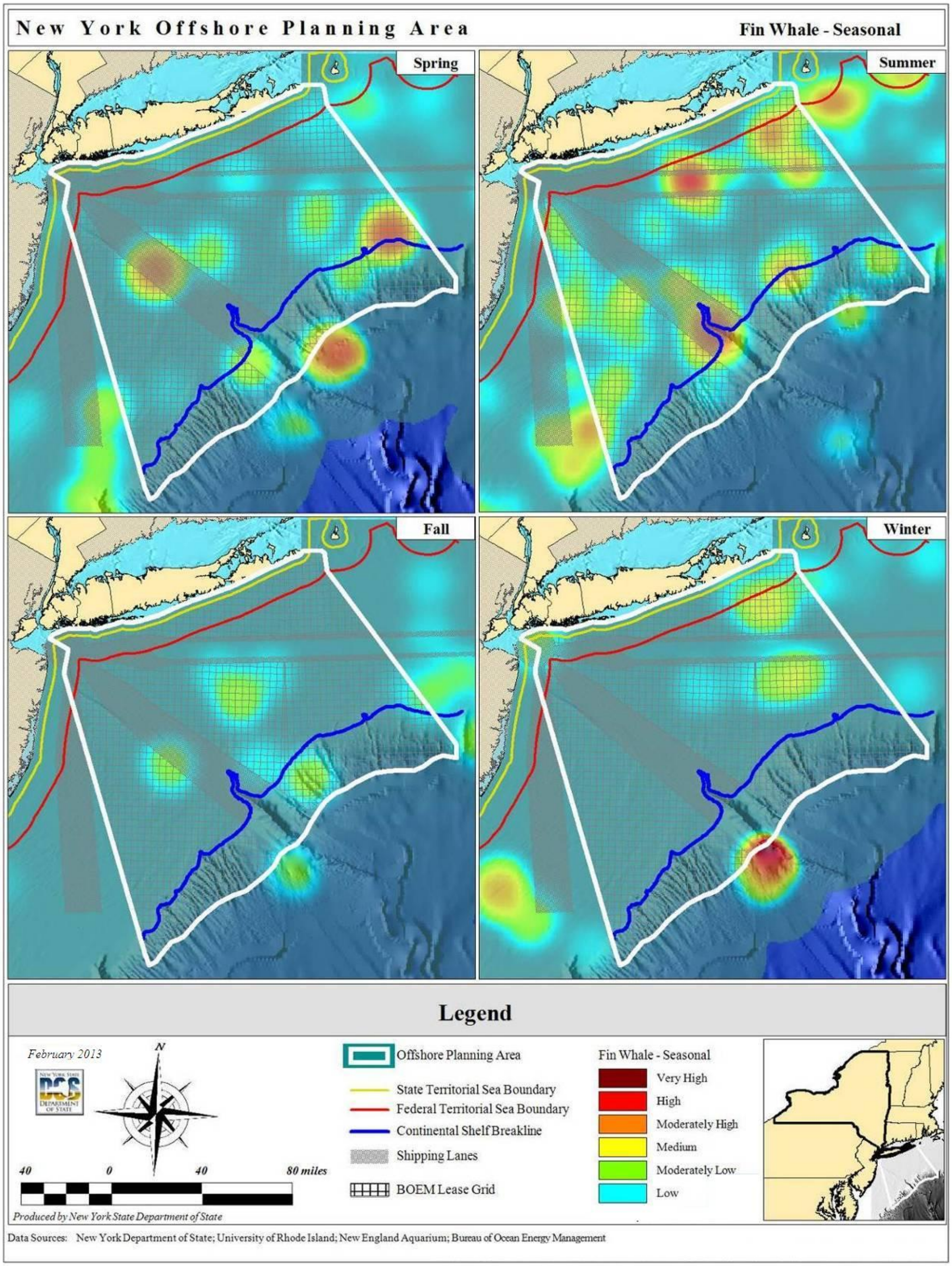

Figure 18: Fin Whales – Seasonal Relative Abundance
This series map shows estimated seasonal distribution of fin whales as modeled by the NEA using the NARWC Database.

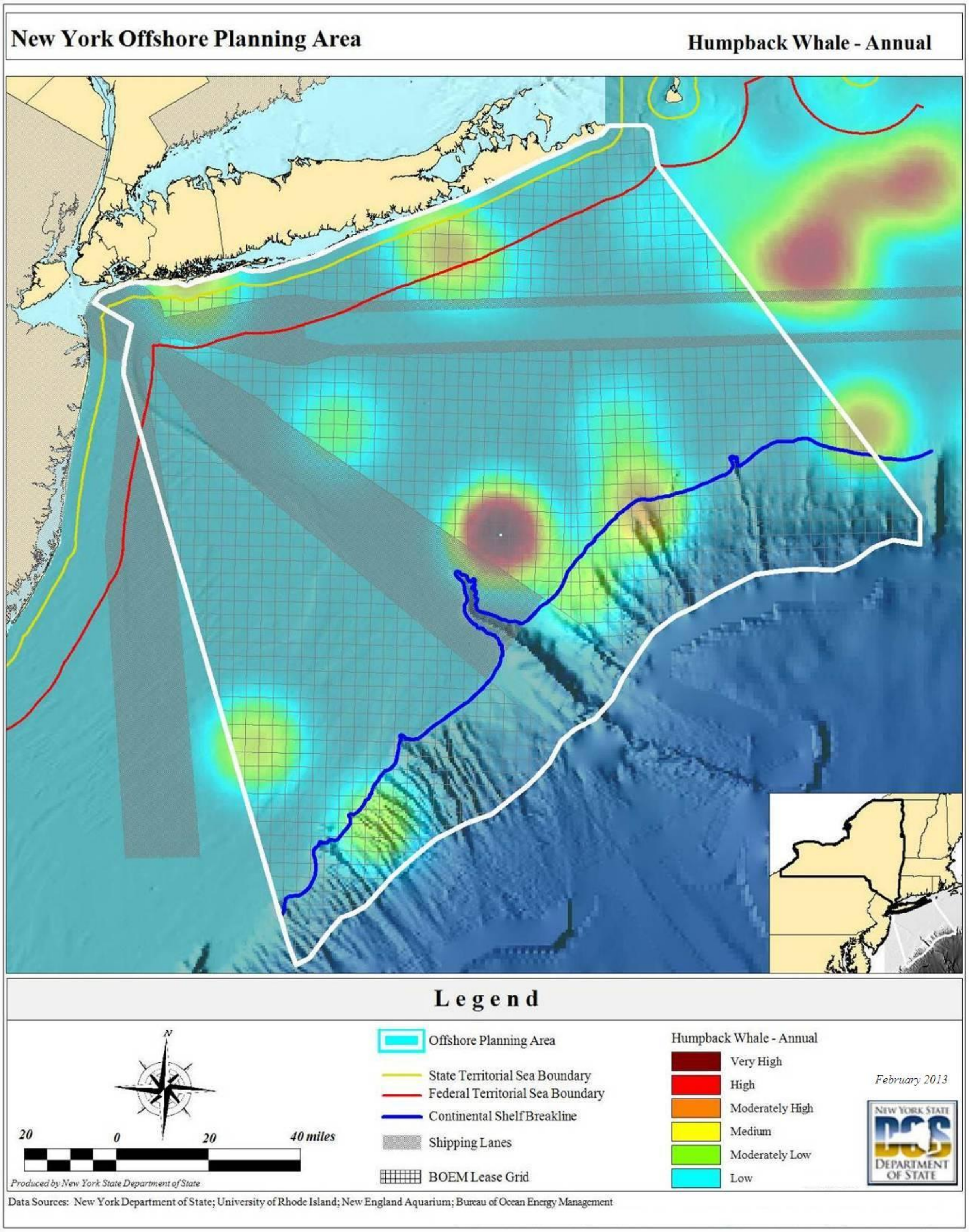

Figure 19: Humpback Whales – Annual Relative Abundance

This map shows estimated annual distribution of humpback whales as modeled by the NEA using the NARWC Database.

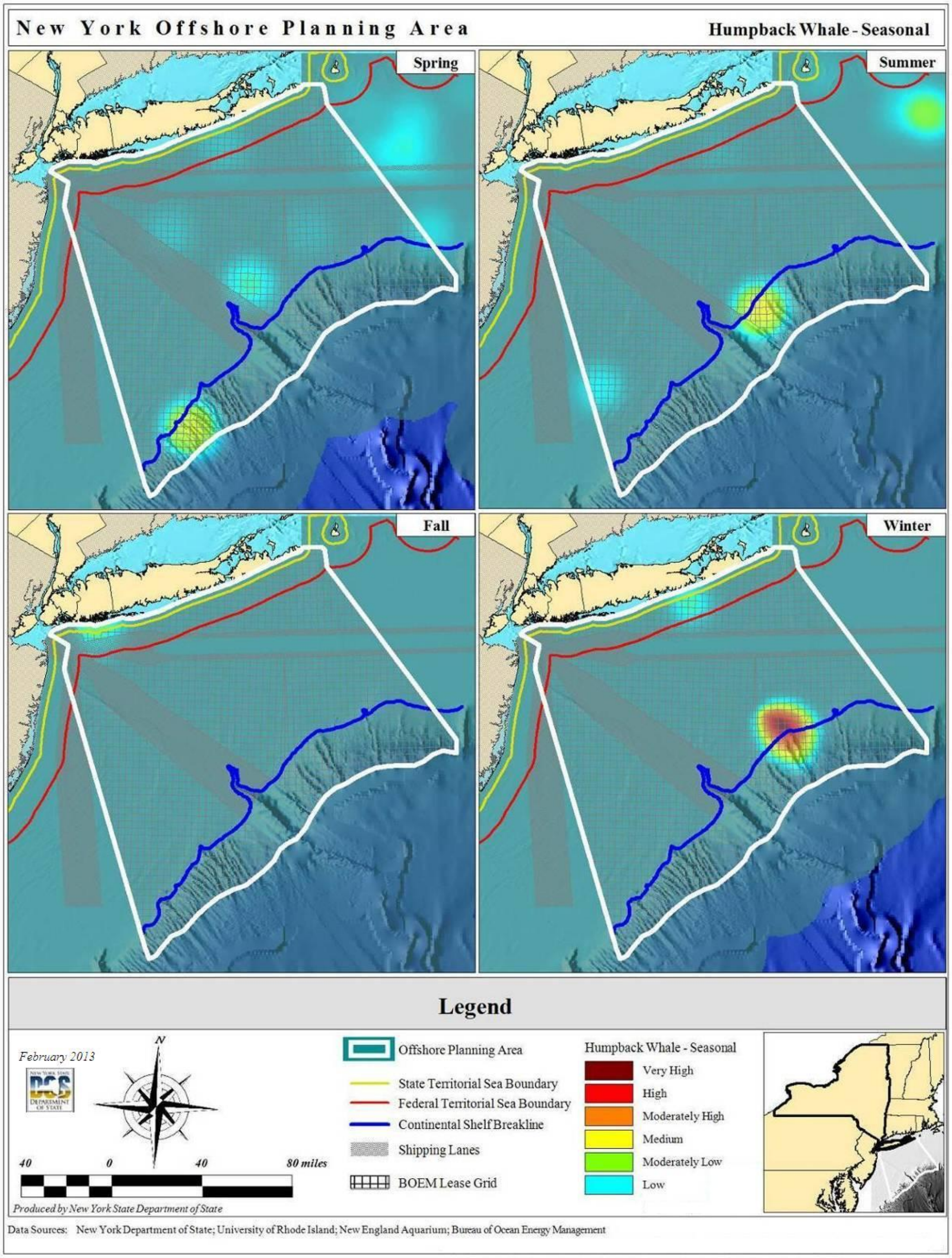

Figure 20: Humpback Whales – Seasonal Relative Abundance
This series map shows estimated seasonal distribution of humpback whales as modeled by the NEA using the NARWC Database.

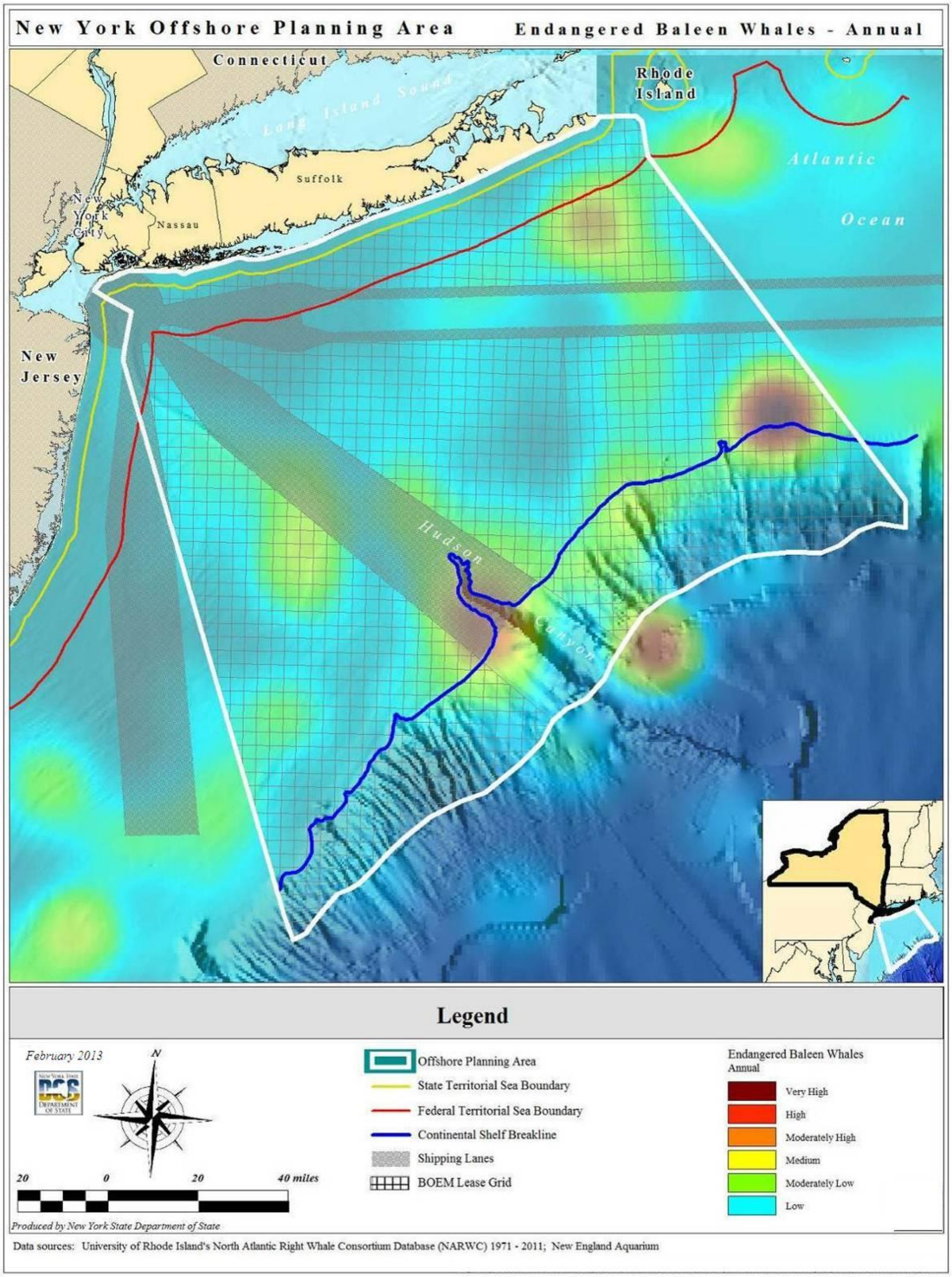

Figure 21: Endangered Baleen Whales – Annual Relative Abundance

This map shows estimated annual distribution of endangered baleen whales as modeled by the NEA using the NARWC Database. The endangered baleen whale grouping includes: fin, humpback, North Atlantic right, and sei whales, plus unidentified members of genus *Balaenoptera*.

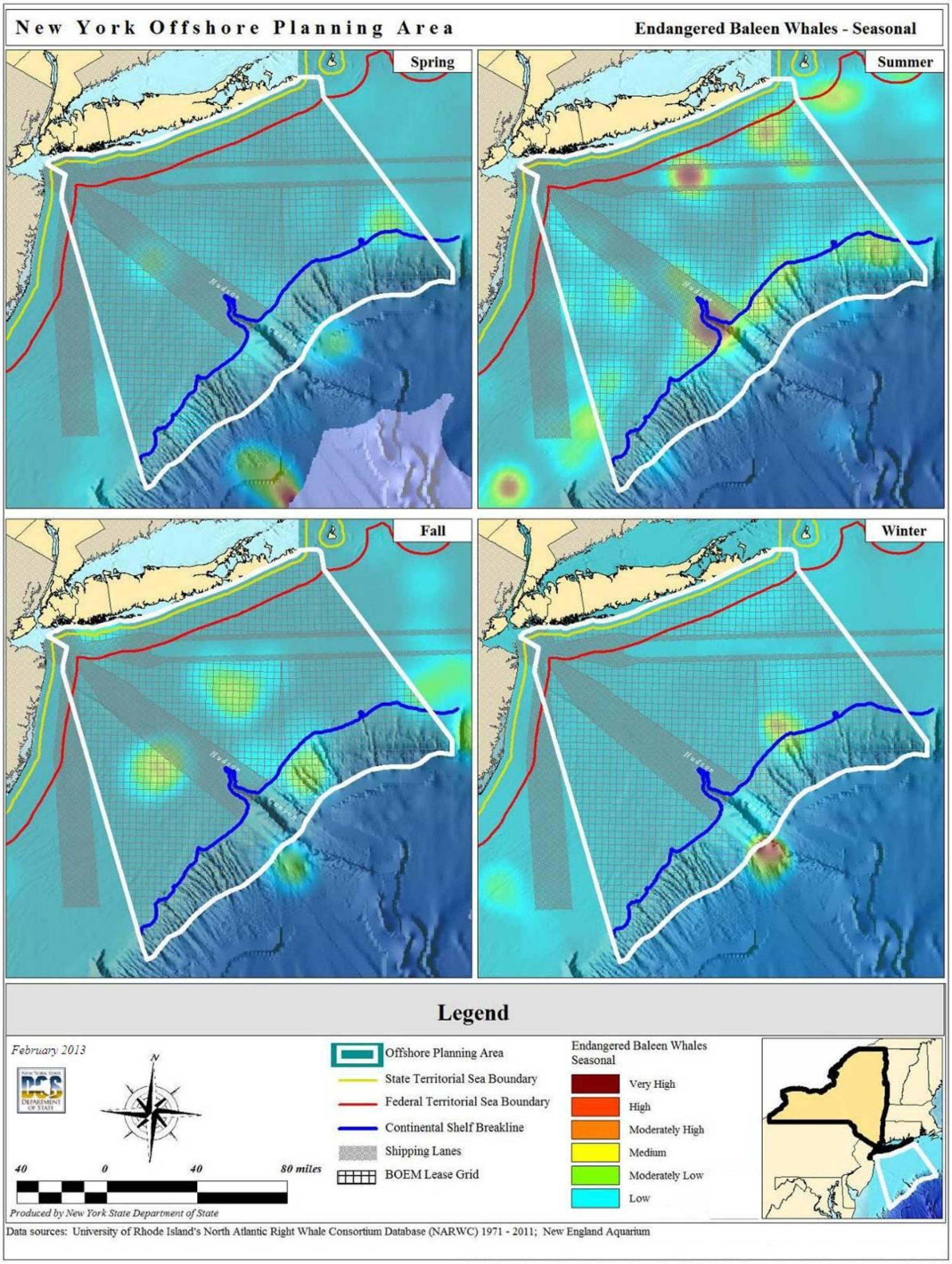

Figure 22: Endangered Baleen Whales – Seasonal Relative Abundance

This series map shows estimated seasonal distribution of endangered baleen whales as modeled by the NEA using the NARWC Database. The endangered baleen whale grouping includes: fin, humpback, North Atlantic right, and sei whales, plus unidentified members of genus *Balaenoptera*.

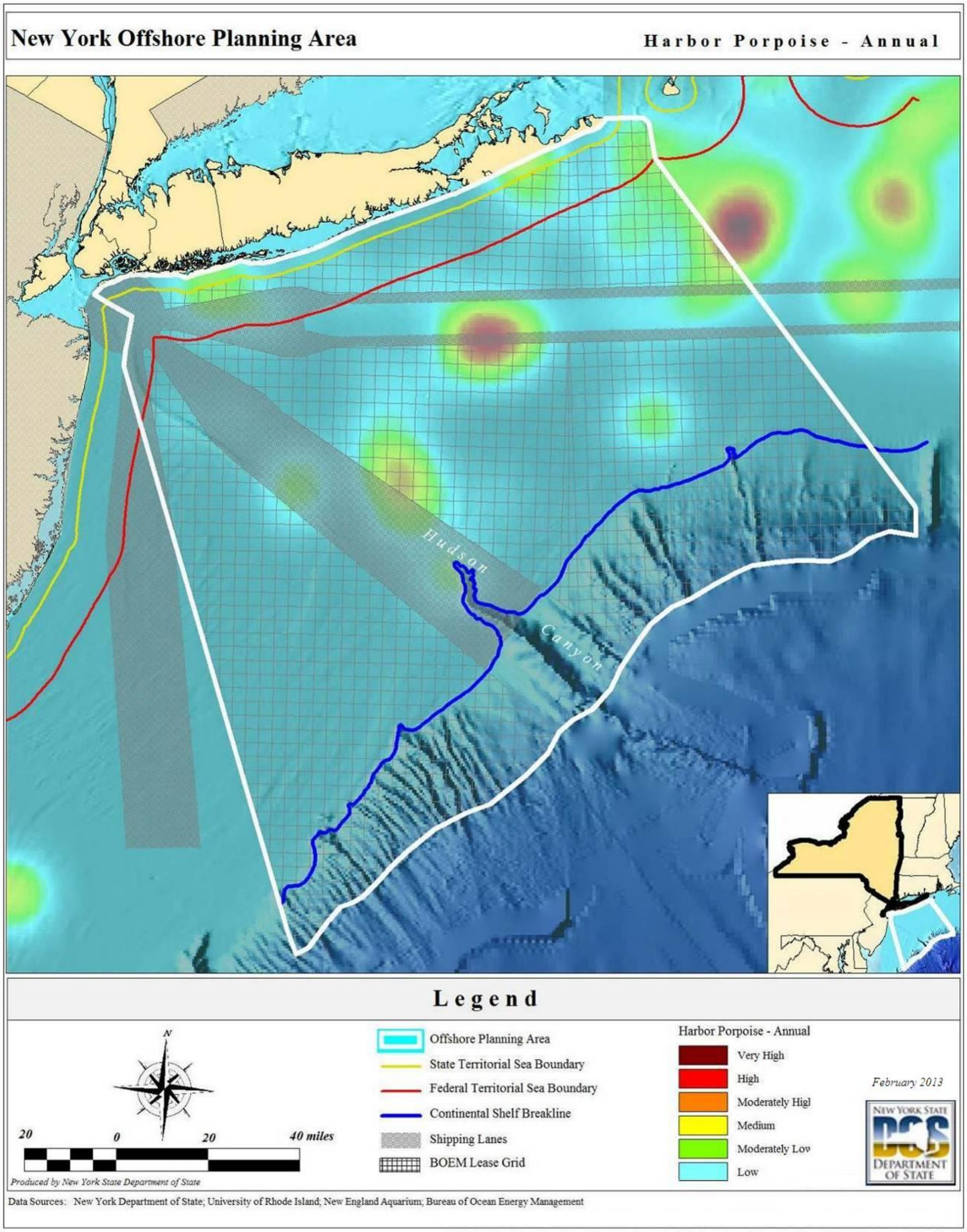

Figure 23: Harbor Porpoises – Annual Relative Abundance

This map shows estimated annual distribution of harbor porpoises as modeled by the NEA using the NARWC Database.

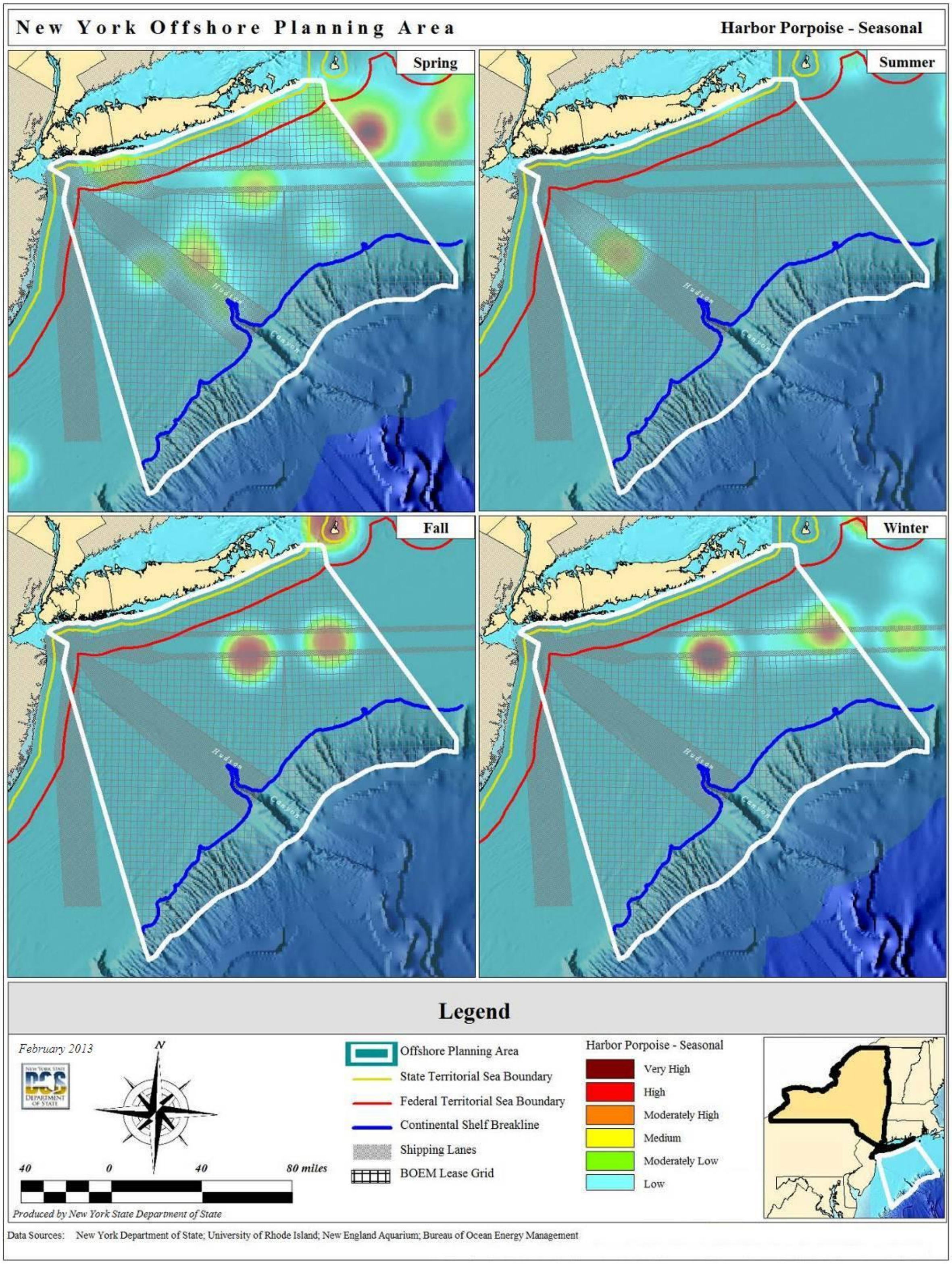

Figure 24: Harbor Porpoises – Seasonal Relative Abundance

This map series shows estimated seasonal distribution of harbor porpoises as modeled by the NEA using the NARWC Database.

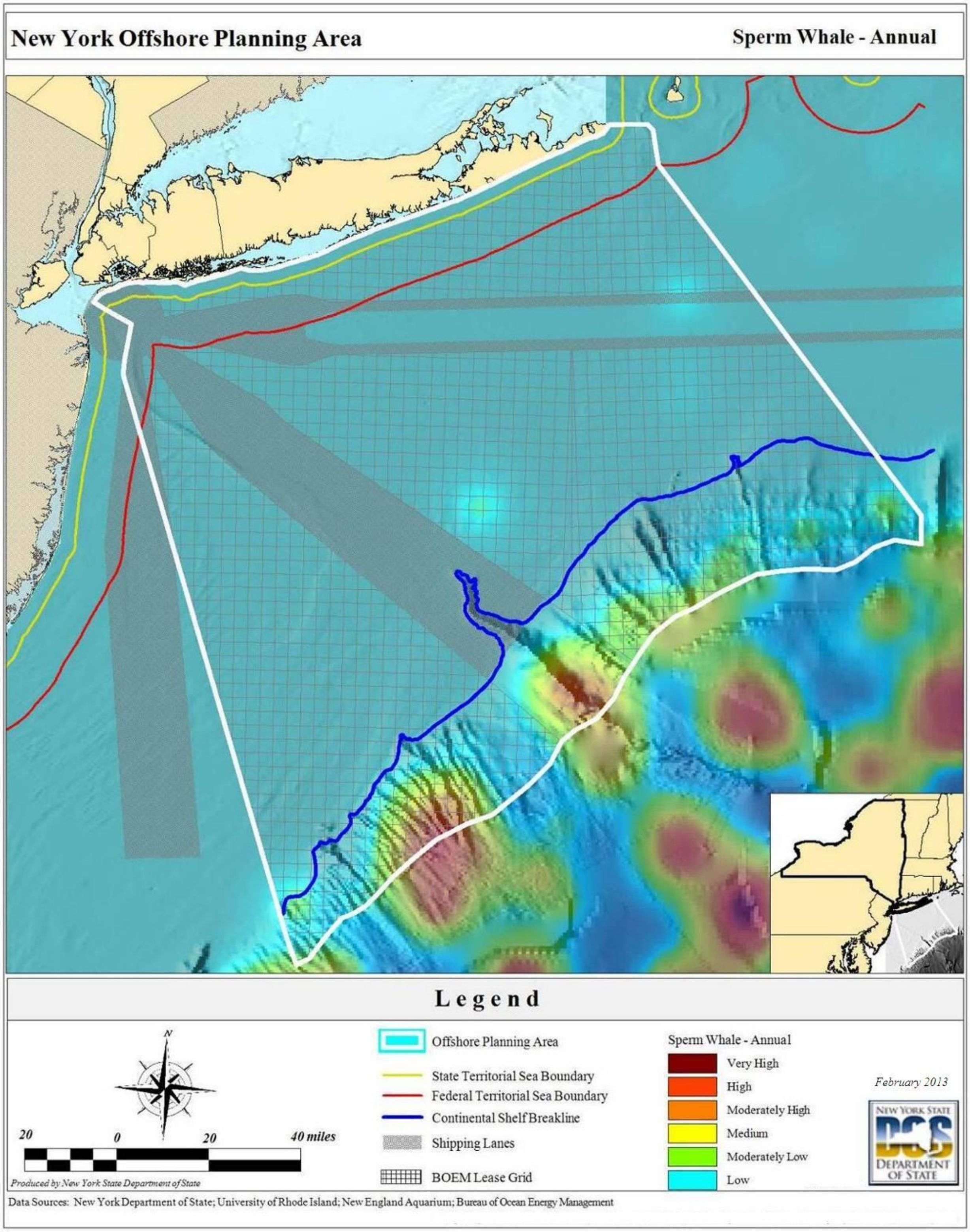

Figure 25: Sperm Whales – Annual Relative Abundance
This map shows estimated annual distribution of sperm whales as modeled by the NEA using the NARWC Database.

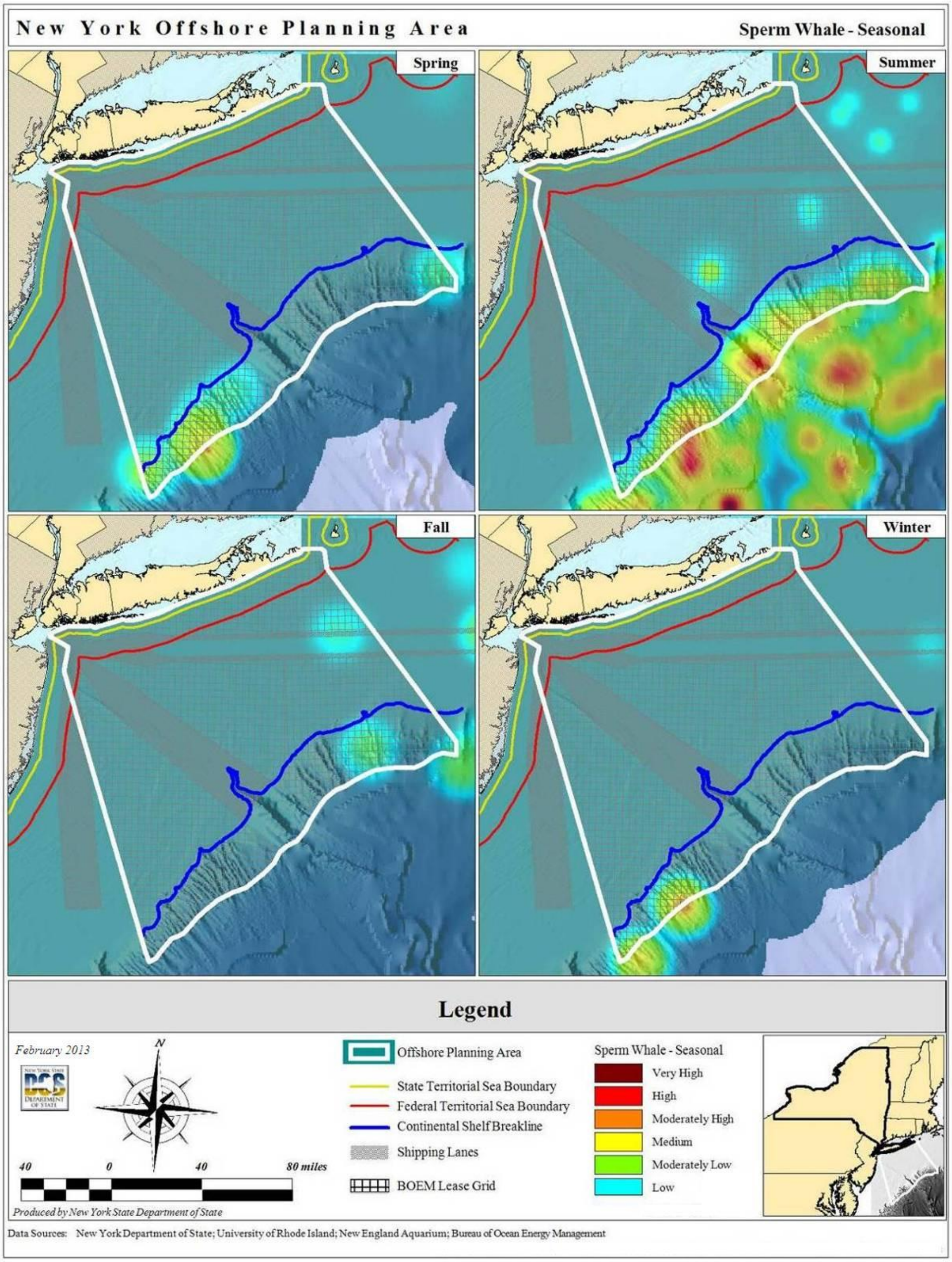

Figure 26: Sperm Whales – Seasonal Relative Abundance
This map series shows estimated seasonal distribution of sperm whales as modeled by the NEA using the NARWC Database.

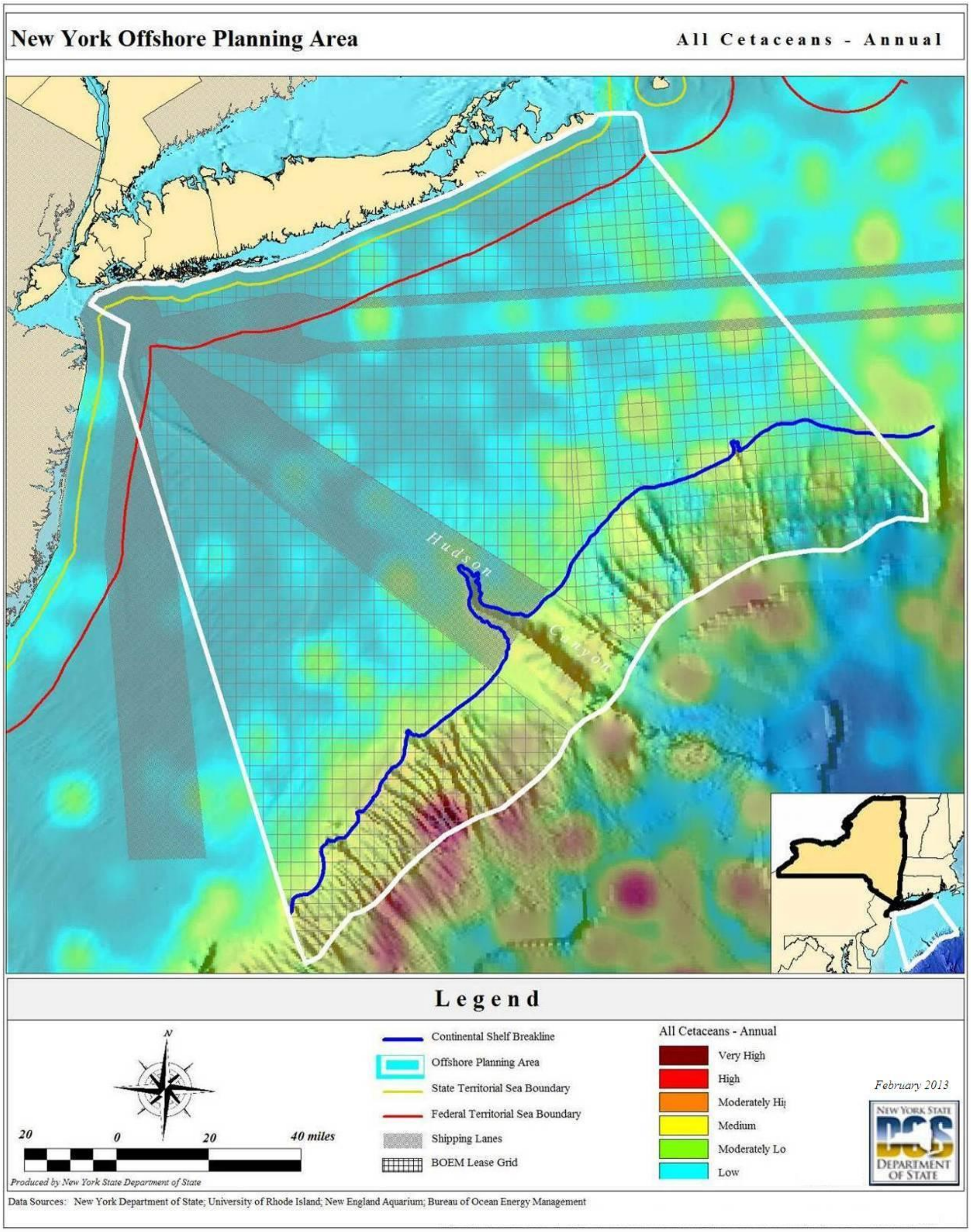

Figure 27: All Cetaceans – Annual Relative Abundance

This map shows estimated annual distribution of all cetaceans as modeled by the NEA using the NARWC Database. The All Cetaceans grouping includes 21 species of toothed (including sperm whales, dolphins, and porpoises) and baleen whales.

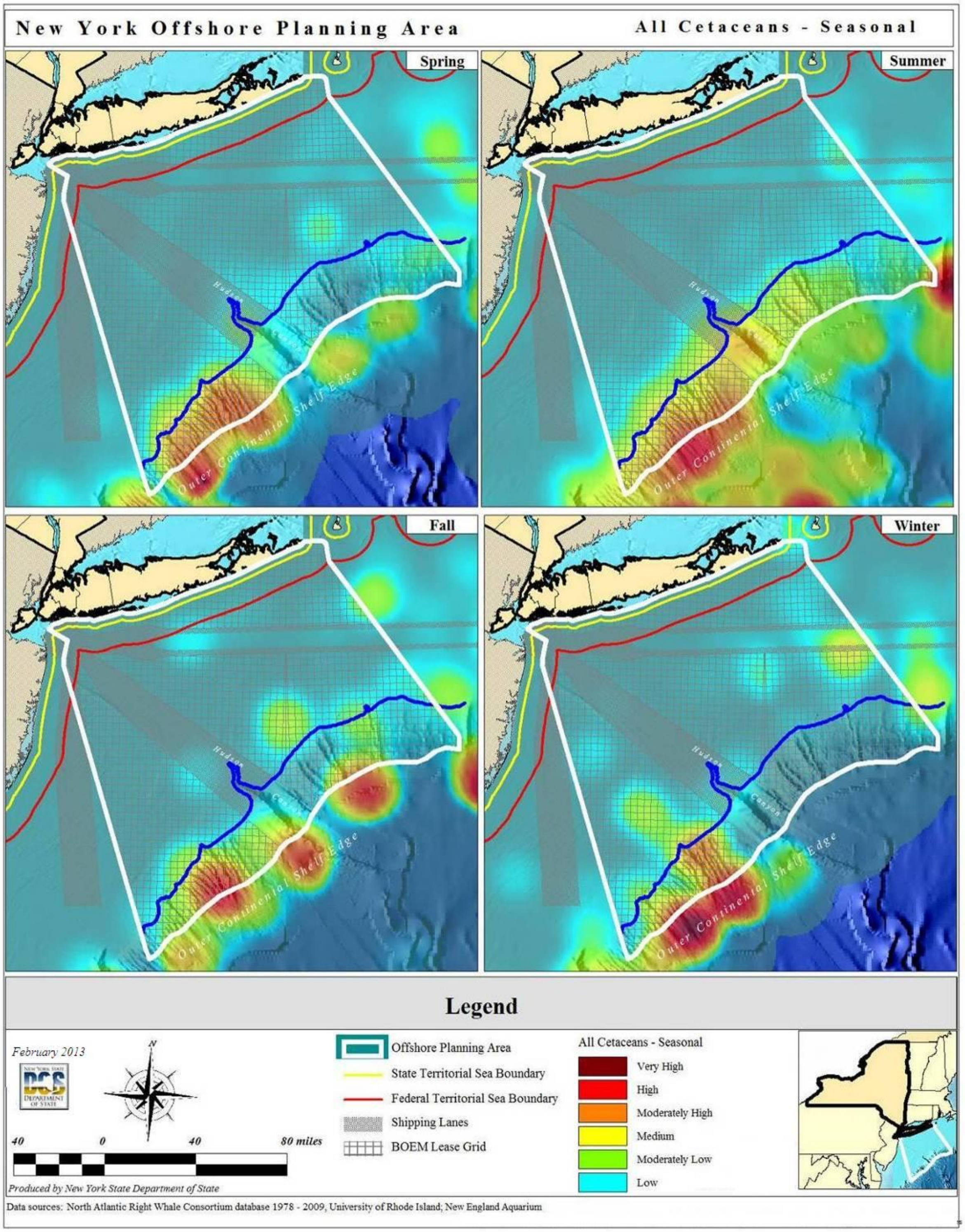

Figure 28: All Cetaceans – Seasonal Relative Abundance

This map series shows estimated seasonal distribution of all cetaceans as modeled by the NEA using the NARWC Database. The All Cetaceans grouping includes 21 species of toothed (including sperm whales, dolphins, and porpoises) and baleen whales.

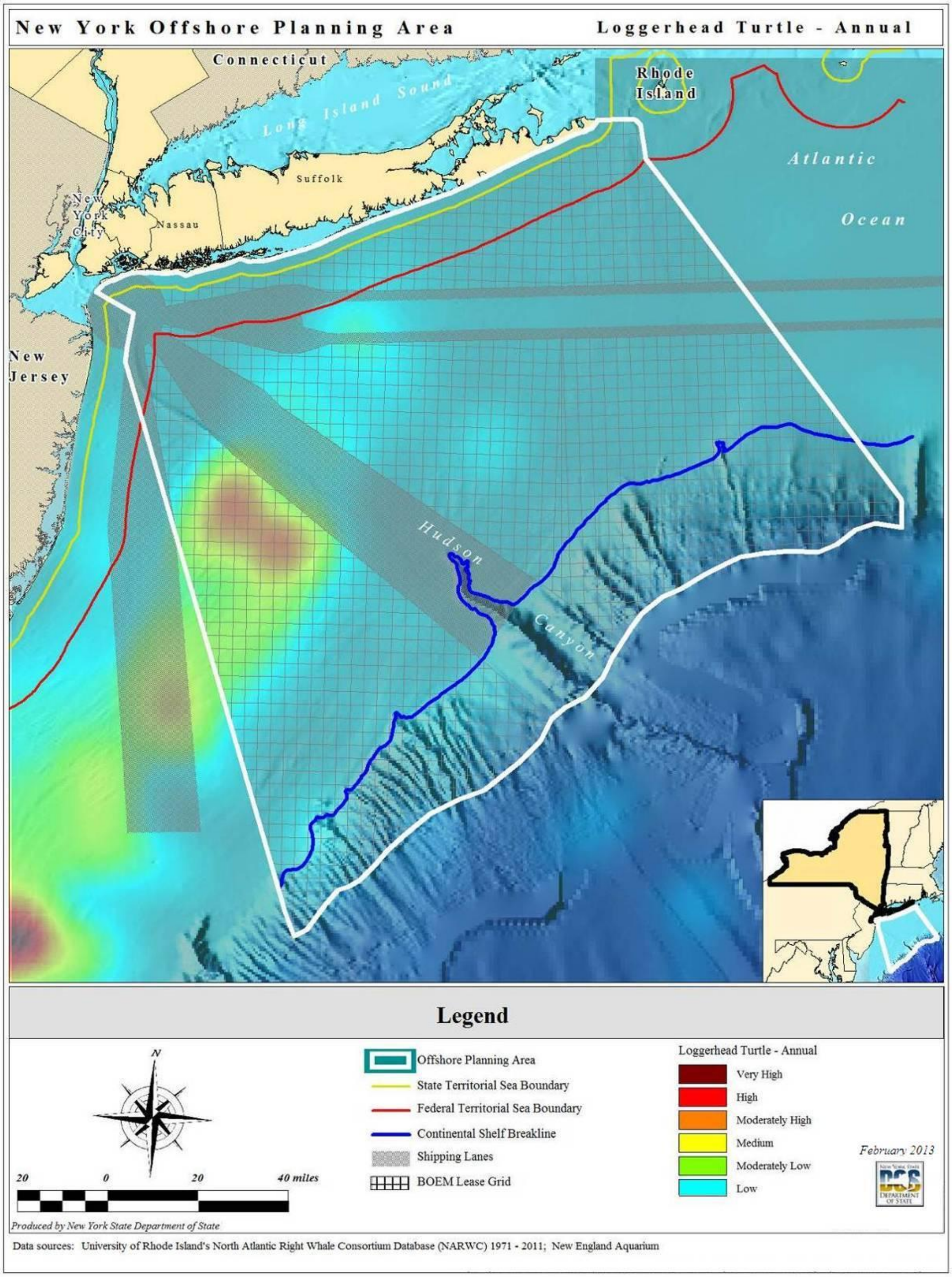

Figure 29: Loggerhead Turtle – Annual Relative Abundance

This map shows estimated annual distribution of loggerhead turtles as modeled by the NEA using the NARWC Database.

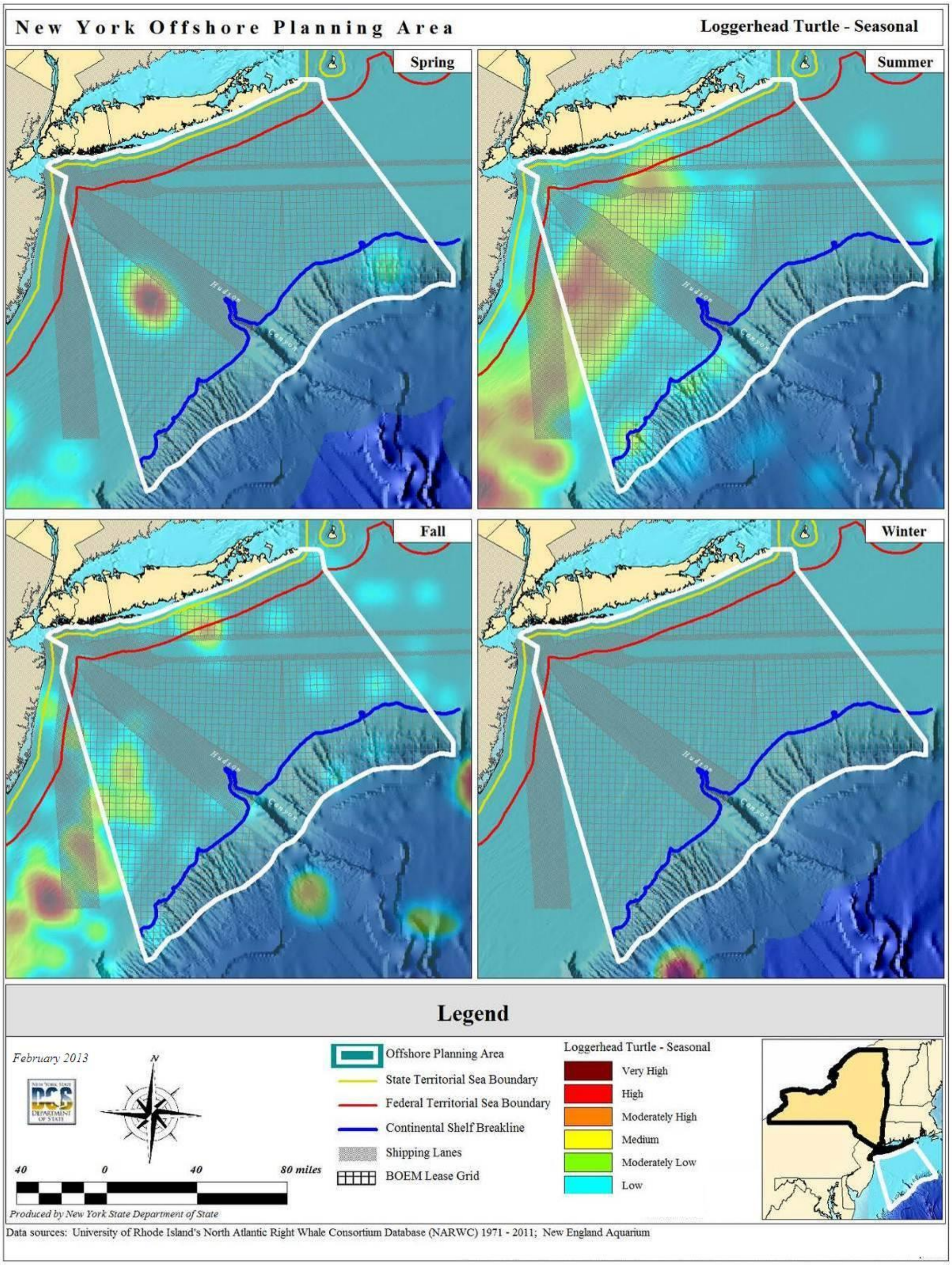

Figure 30: Loggerhead Turtle – Seasonal Relative Abundance

This map series shows estimated seasonal distribution of loggerhead turtles as modeled by the NEA using the NARWC Database.

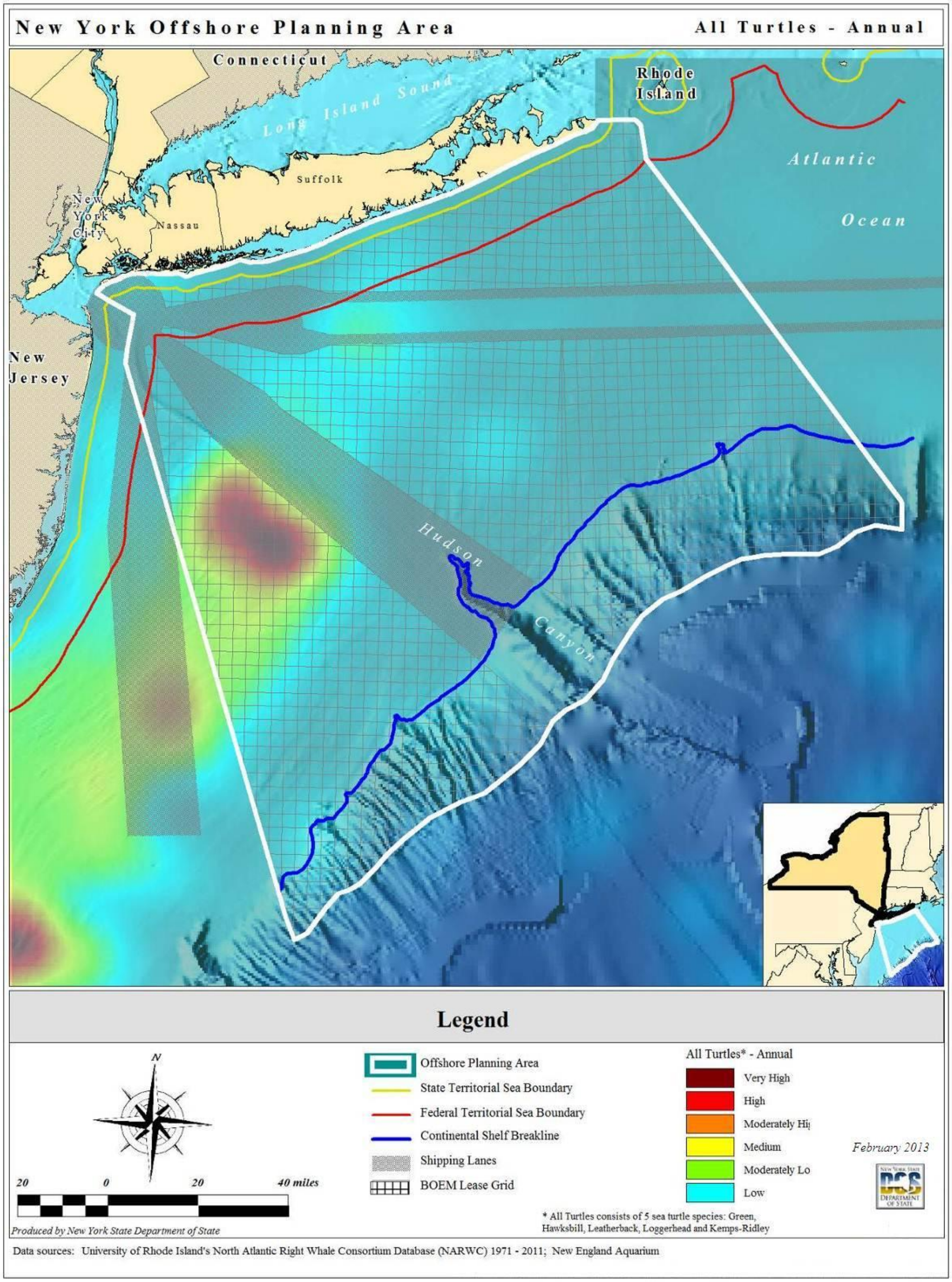

Figure 31: All Turtles – Annual Relative Abundance

This map shows estimated annual distribution of all sea turtles found in the offshore planning area as modeled by the NEA using the NARWC Database. The All Turtles grouping includes: green, hawksbill, leatherback, loggerhead and Kemp's ridley sea turtles.

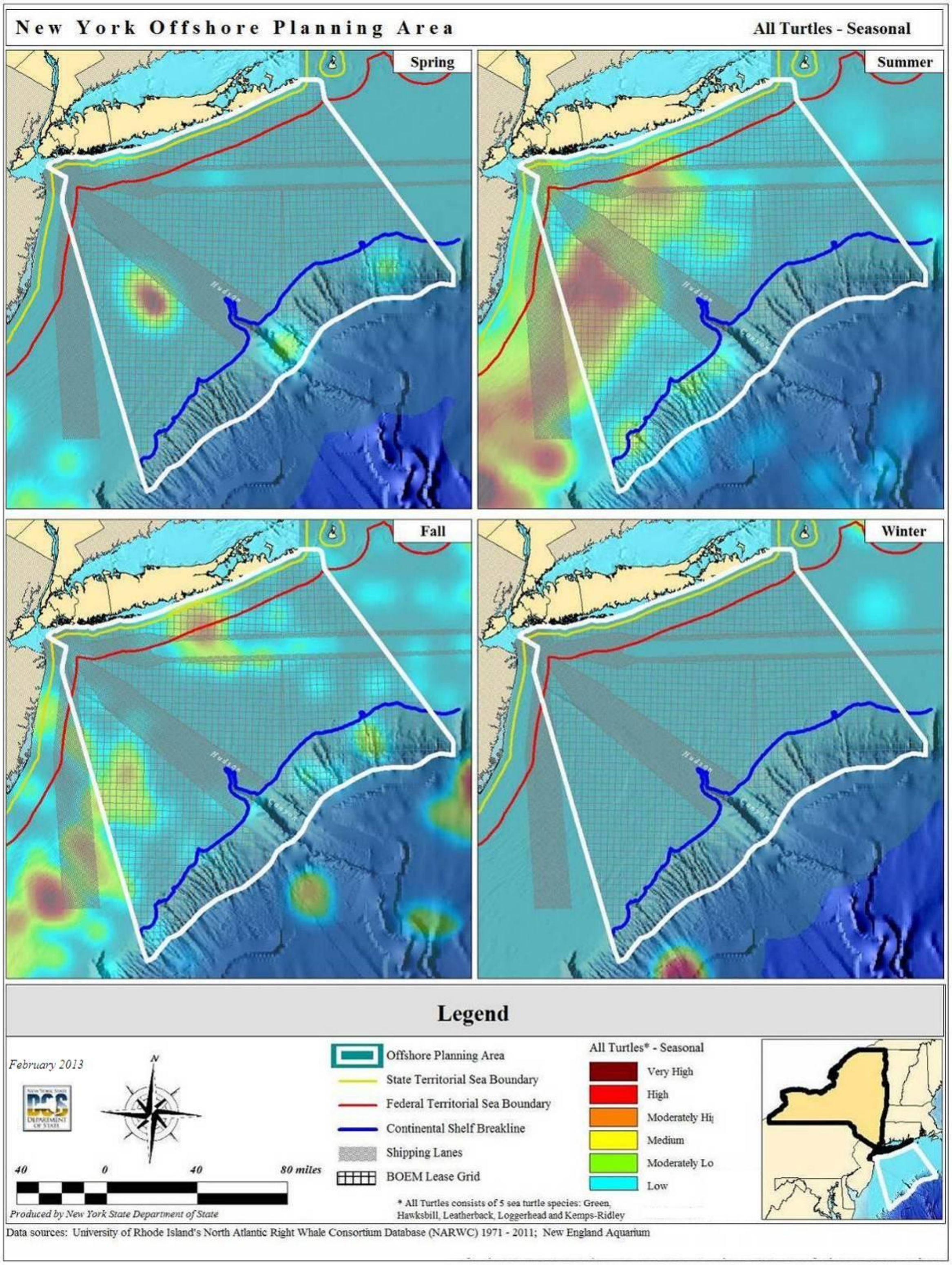

Figure 32: All Turtles – Seasonal Relative Abundance
This map series shows estimated seasonal distribution of all sea turtles as modeled by the NEA using the NARWC Database. The All Turtles grouping includes: green, hawksbill, leatherback, loggerhead and Kemp's ridley sea turtles.

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6. Seabirds

(Figure 33-Figure 48)

Seabird sightings data for the offshore planning region were extracted by NCCOS from the Manomet Bird Observatory's (now the Manomet Center for Conservation Sciences) Cetacean and Seabird Assessment Program (CSAP) database, which contains over 9,000 survey locations. During these surveys a small number of expert observers were placed on research vessels undertaking a wide variety of work, including NMFS groundfish, scallop, and plankton surveys, U.S. Coast Guard (USCG) surveys, and U.S. Environmental Protection Agency surveys. Seabirds were identified to the most specific taxonomic level possible, usually species, and counted within a fixed strip width of 300 m at one side of a ship as it traveled on a straight course at a constant speed (generally 8-12 knots). Observations were separated by season, and for each species or group sighting record in each season, the number of individuals of that species observed during the timed survey was divided by the corresponding survey tract area to yield an index of relative abundance that was standardized by both time and area, resulting in SPUE represented as sightings per 15 minutes per sq. km of transect footprint.

Based on available high-resolution data coverage within the offshore planning area and previous studies of environmental correlates of seabird distribution and abundance, NCCOS identified 11 potential environmental predictor variables which they used to help develop predictive models (Section IV). NCCOS assessed model performance and error via cross-validation, producing numerous statistics for model evaluation.[52]

Fourteen species were modeled individually and remaining species were aggregated into seven broader taxonomic groups, due to lower sightings numbers. Seasonal patterns of abundance were summed to derive annual estimated individual species abundances for each individual species mapped and for grouped species. Abundance estimates are a relative index and should not be confused with absolute population estimates.

NCCOS combined the predicted relative abundances of the 14 seabird species individually mapped to identify "hotspots" of abundance and species diversity. Abundance hotspots are defined as concentrations of large numbers of individual seabirds. They also developed a model of estimated species richness, which was synthesized from a direct count of the number of different seabird species seen at a survey location, and species diversity, where a large variety of seabird species are proportionally well-represented. Thus, species diversity is a function of relative abundance and species richness.

The seabird models predict long-term annual and seasonal spatial distributions of avifauna offshore New York. Model outputs were mapped to show patterns among individual species (Figure 33 through Figure 42) and across species (Figure 43 through Figure 48).

These maps represent the first high-resolution depiction of spatial patterns for marine avifauna of New York.[53] Of particular note, seabird species richness shows a seasonal pattern that may indicate migratory trends (Figure 46). In particular, the continuous concentration of species from the eastern edge of the offshore planning area to the western edge could signal a potential migratory flyway.

Of note, the data used to develop these models do not capture many dynamic aspects of seabird ecology and were collected in the 1980s. Even though shifts in distribution have been documented, modeling required an assumption that the climatological patterns of ocean conditions have not undergone substantial shifts since then. Finally, survey biases (e.g., detectability) are likely to vary between species. These issues underscore the importance of treating the measures of relative abundance presented here as proxies for underlying patterns.

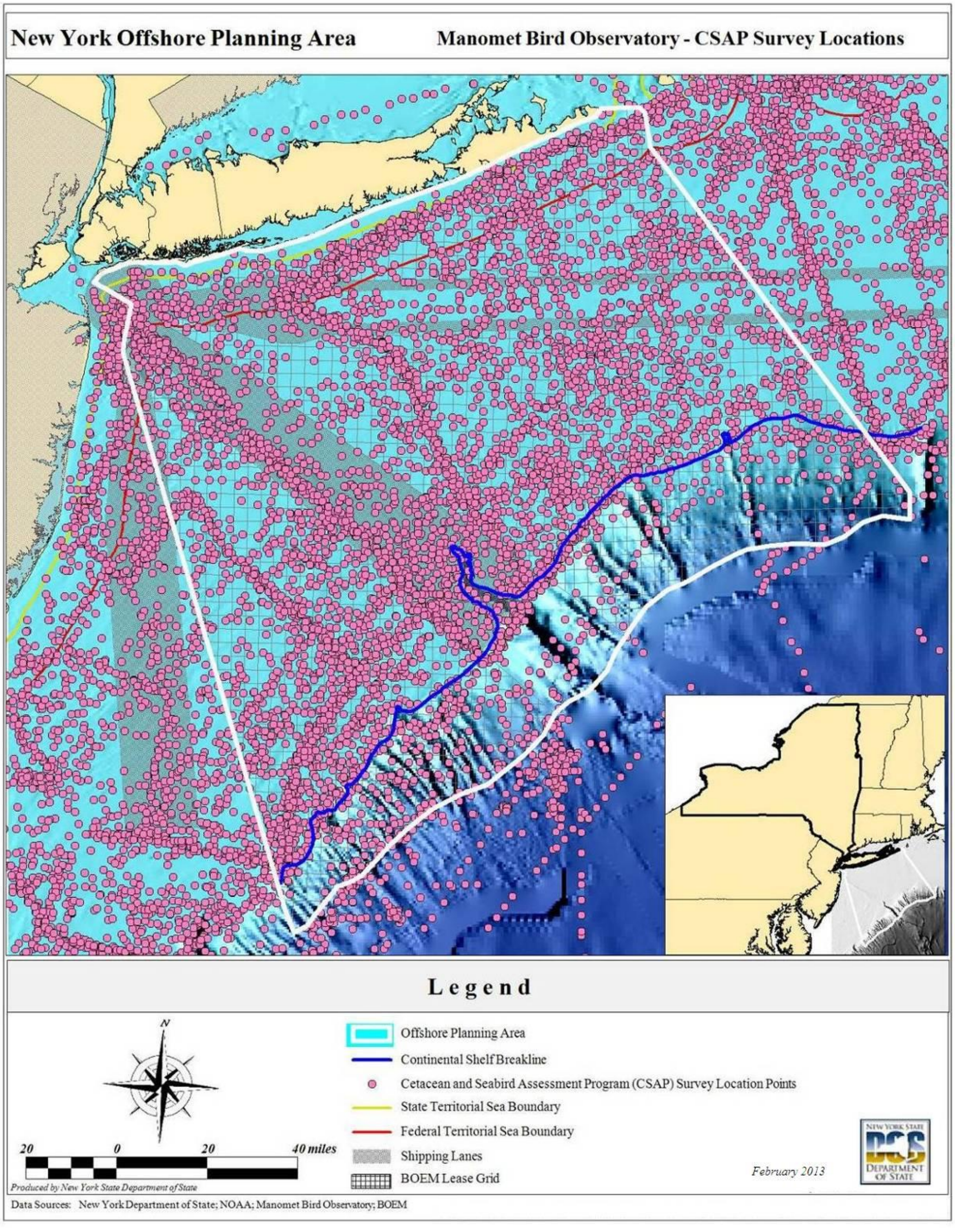

Figure 33: Manomet Bird Observatory – Cetacean and Seabird Assessment Program Survey
This map shows the survey locations for the CSAP database within the offshore planning area and depicts the uneven spatial distribution of the survey effort.

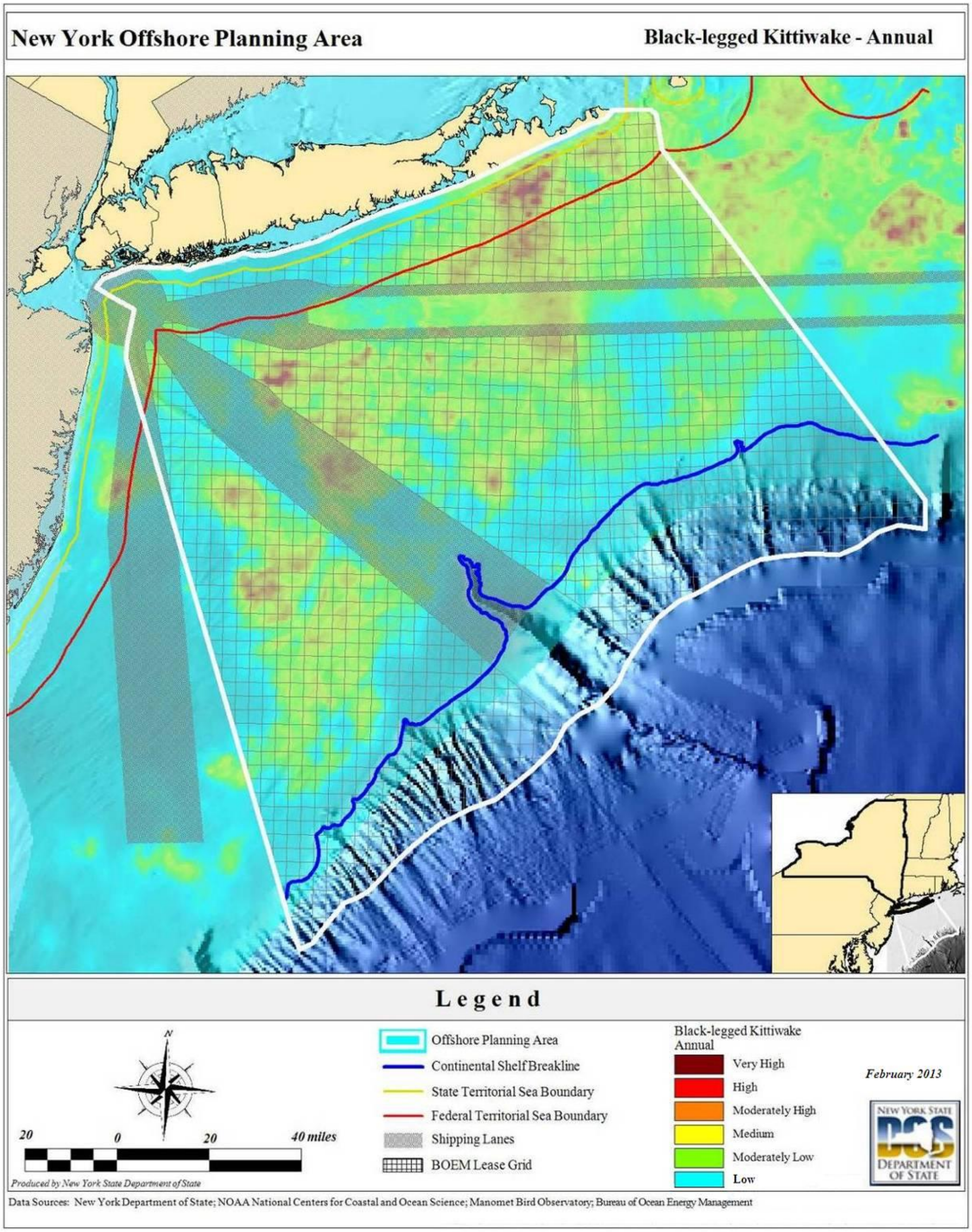

Figure 34: Black-Legged Kittiwake – Annual Predicted Relative Abundance

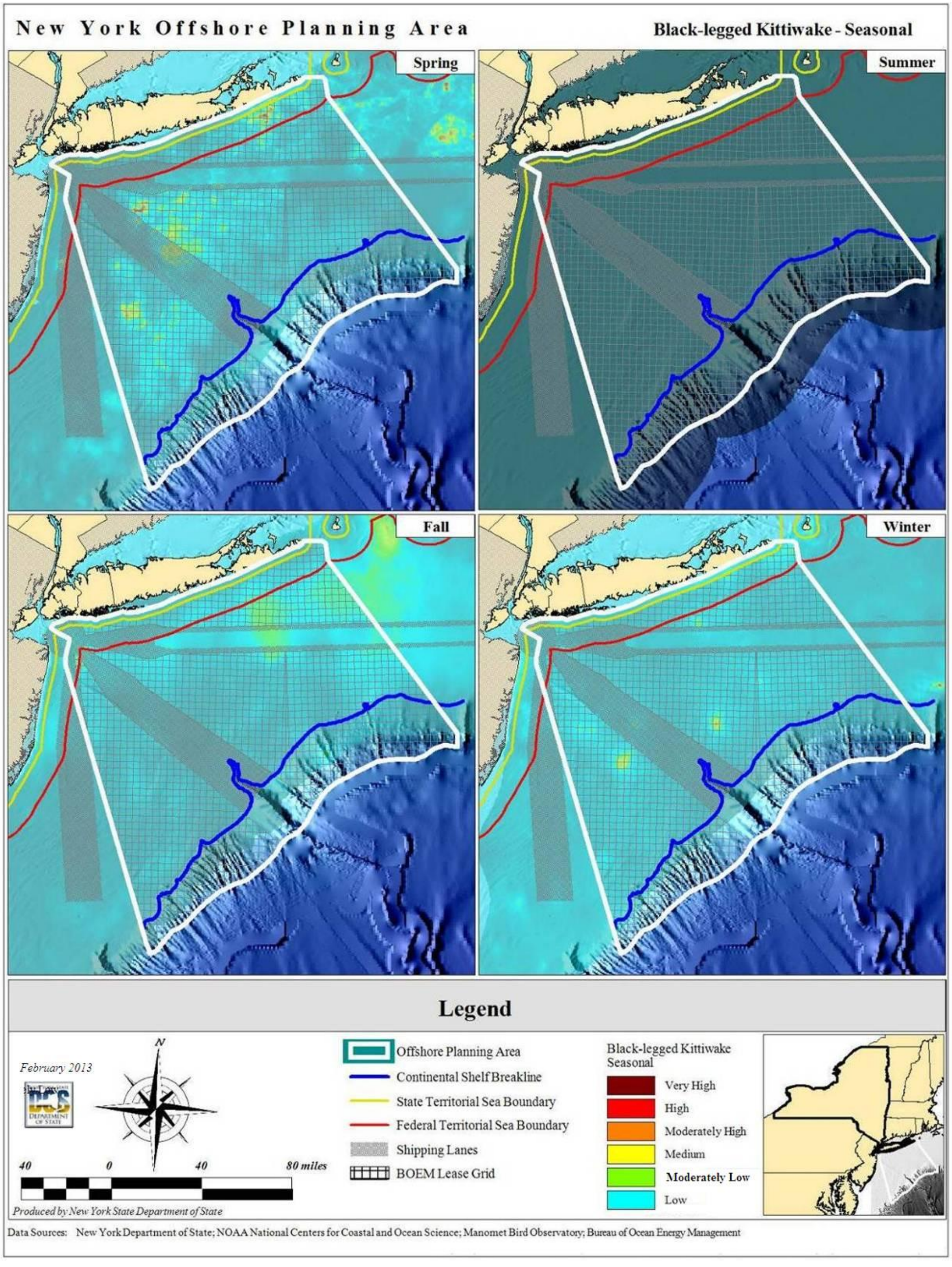

Figure 35: Black-Legged Kittiwake – Seasonal Predicted Relative Abundance

N.B., the summer seasonal distribution was not modeled due to the low number of observations.

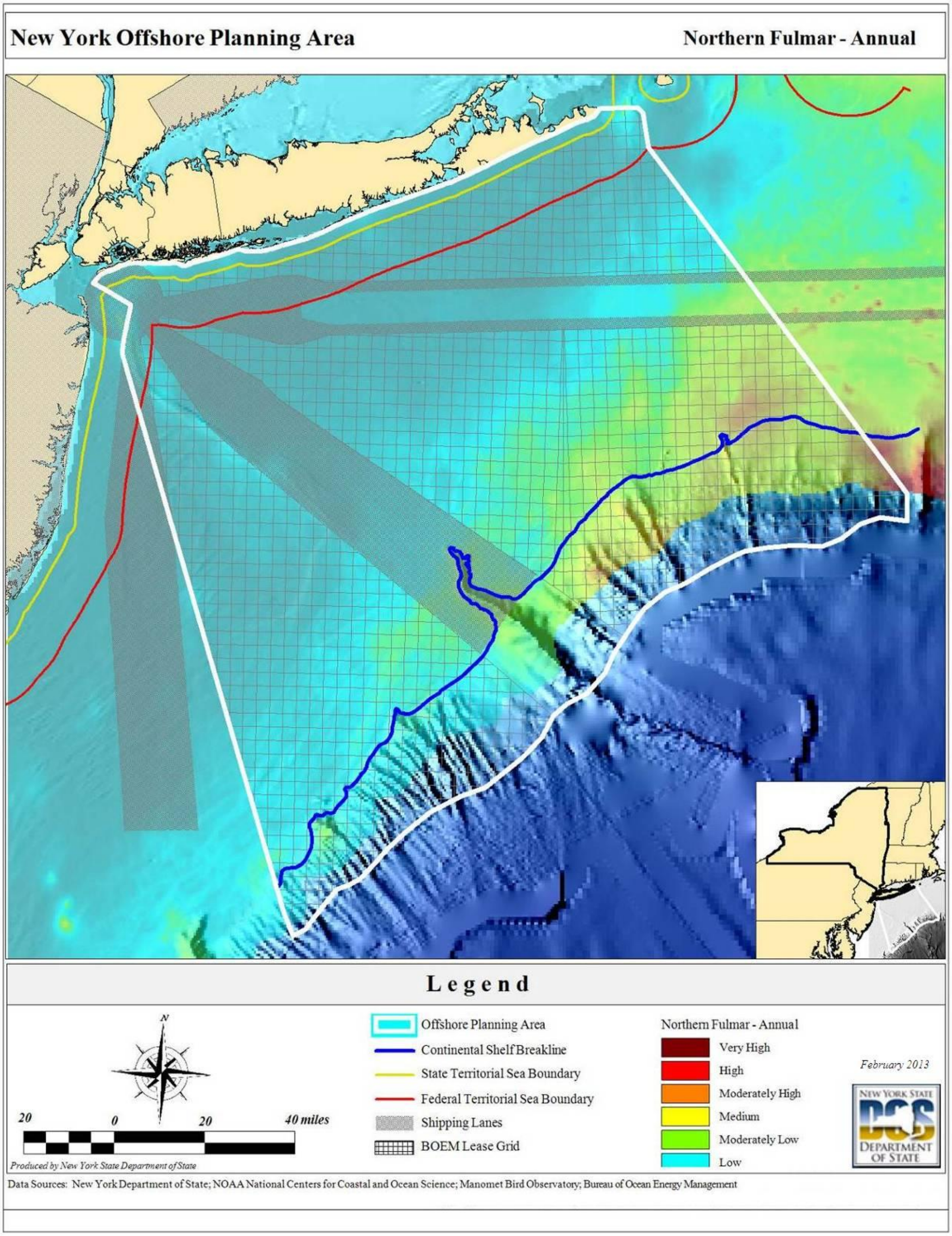

Figure 36: Northern Fulmar – Annual Predicted Relative Abundance

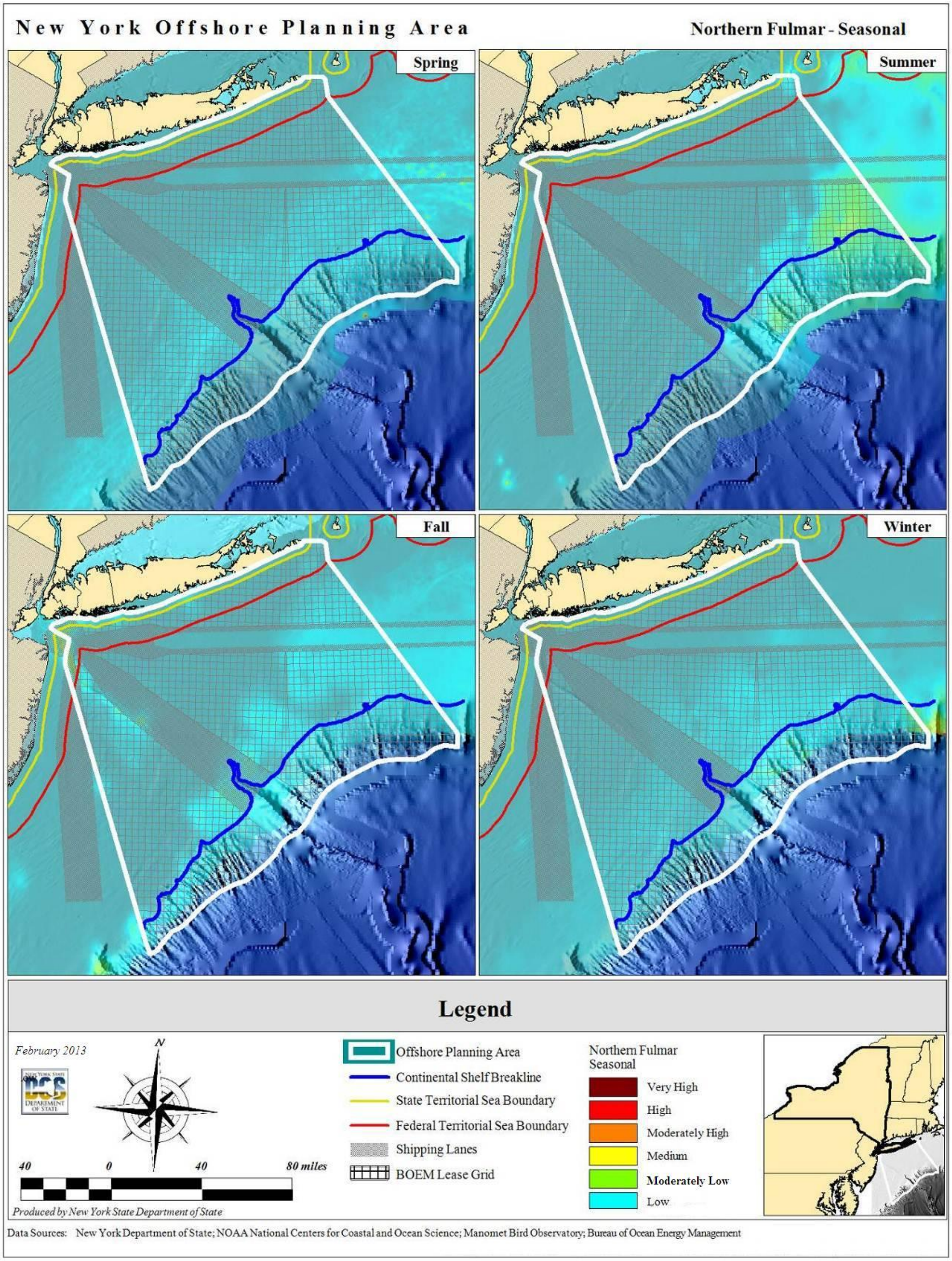

Figure 37: Northern Fulmar – Seasonal Predicted Relative Abundance

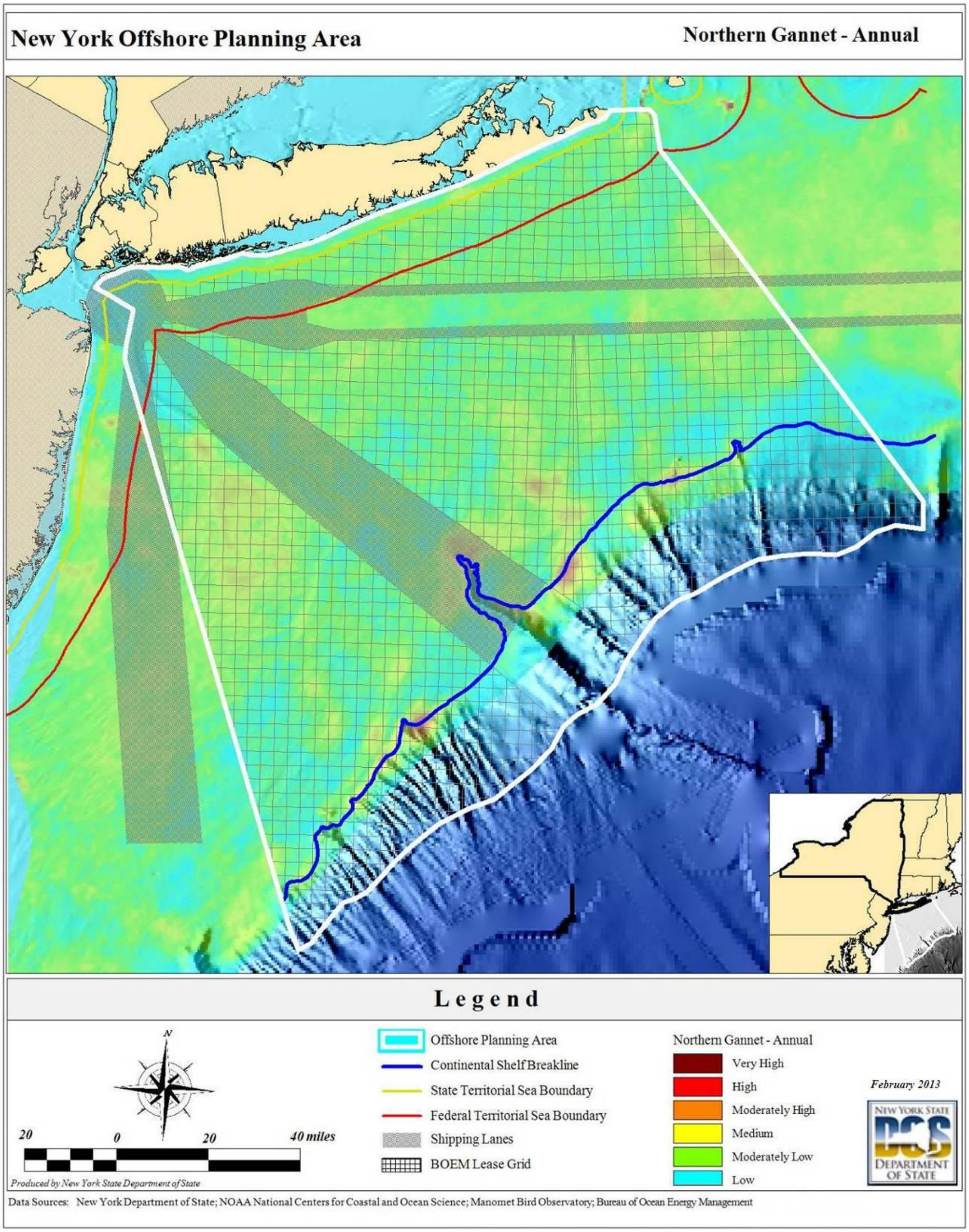

Figure 38: Northern Gannet – Annual Predicted Relative Abundance

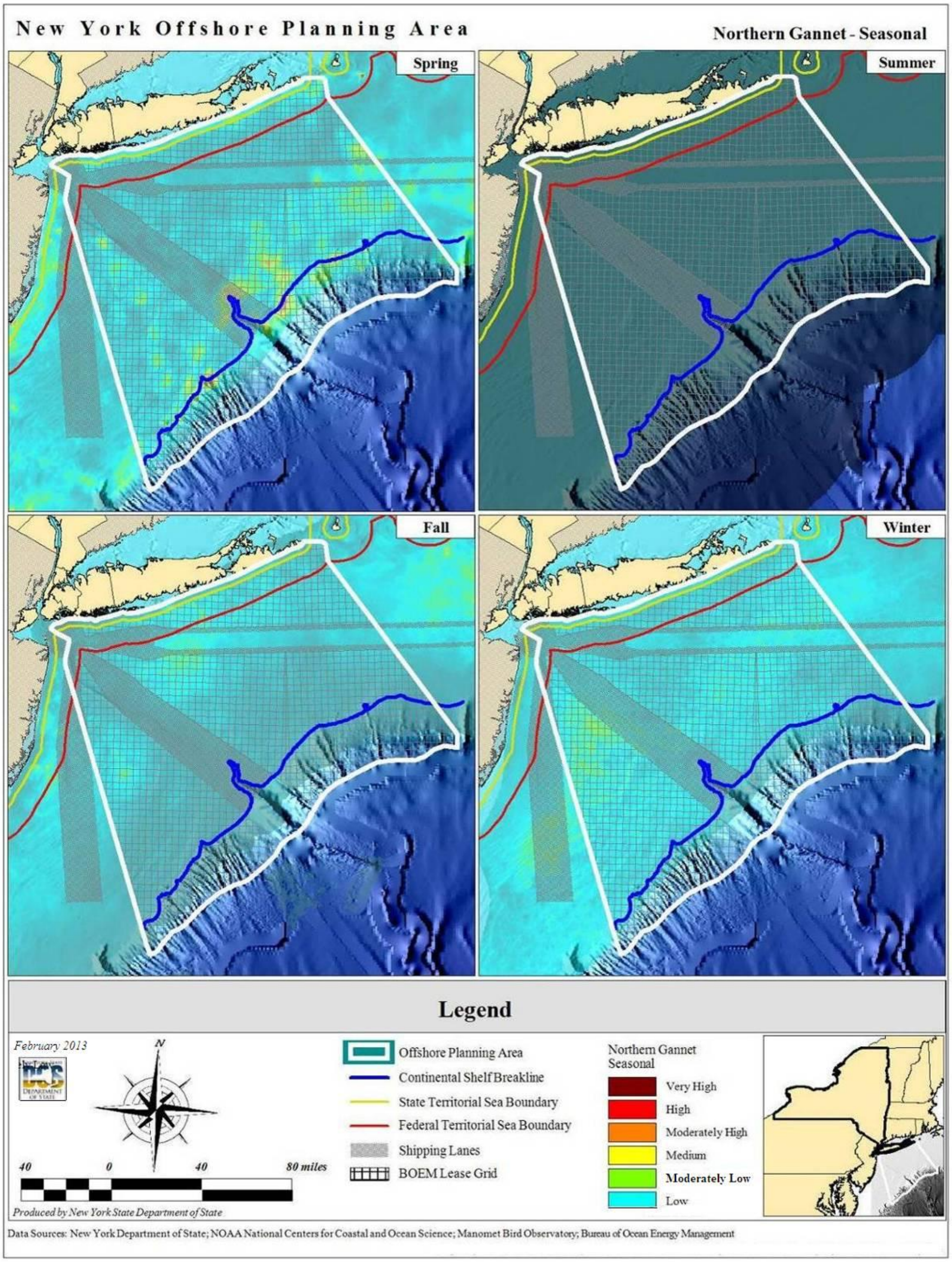

Figure 39: Northern Gannet – Seasonal Predicted Relative Abundance

N.B., the summer seasonal distribution was not modeled due to the low number of observations.

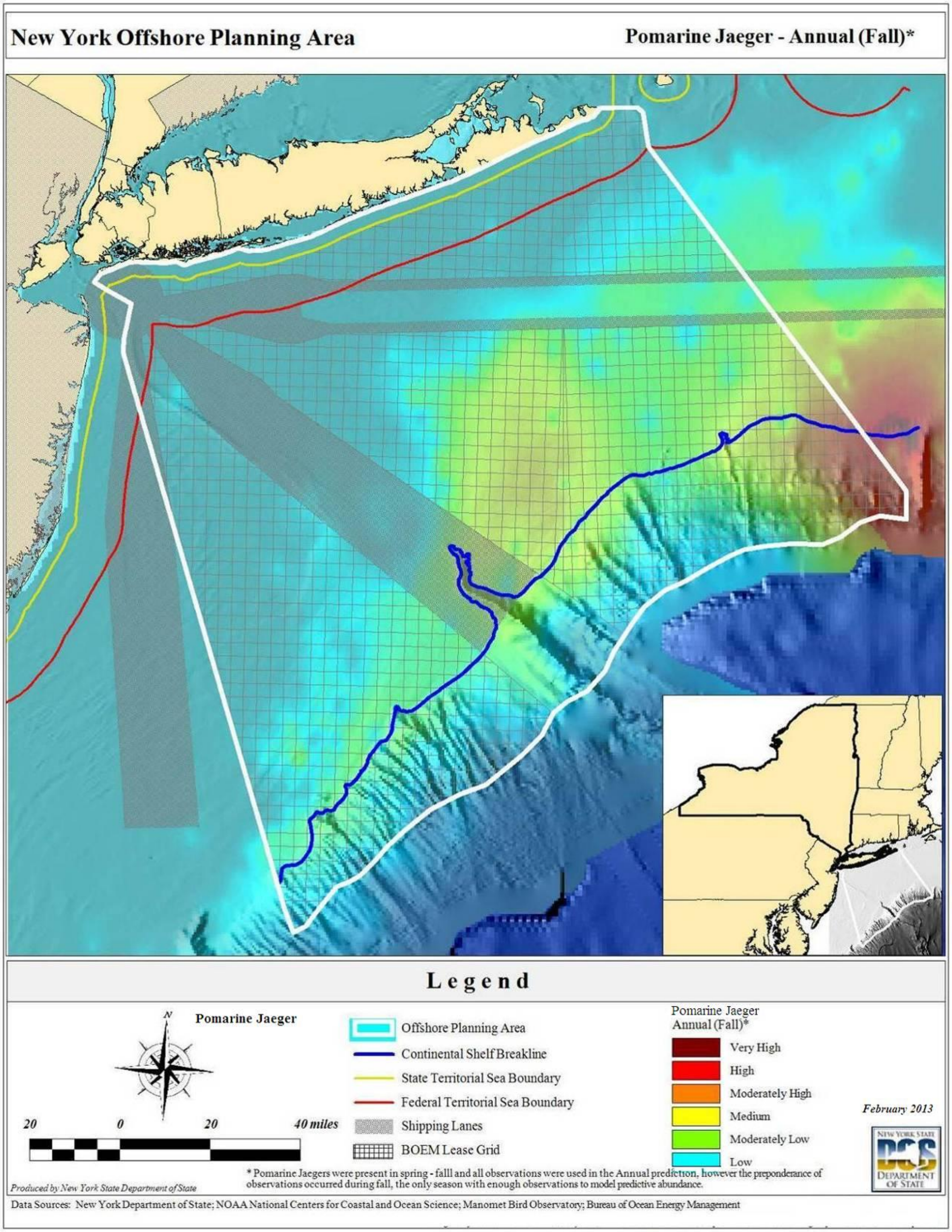

Figure 40: Pomarine Jaeger – Annual (Fall) Predicted Relative Abundance

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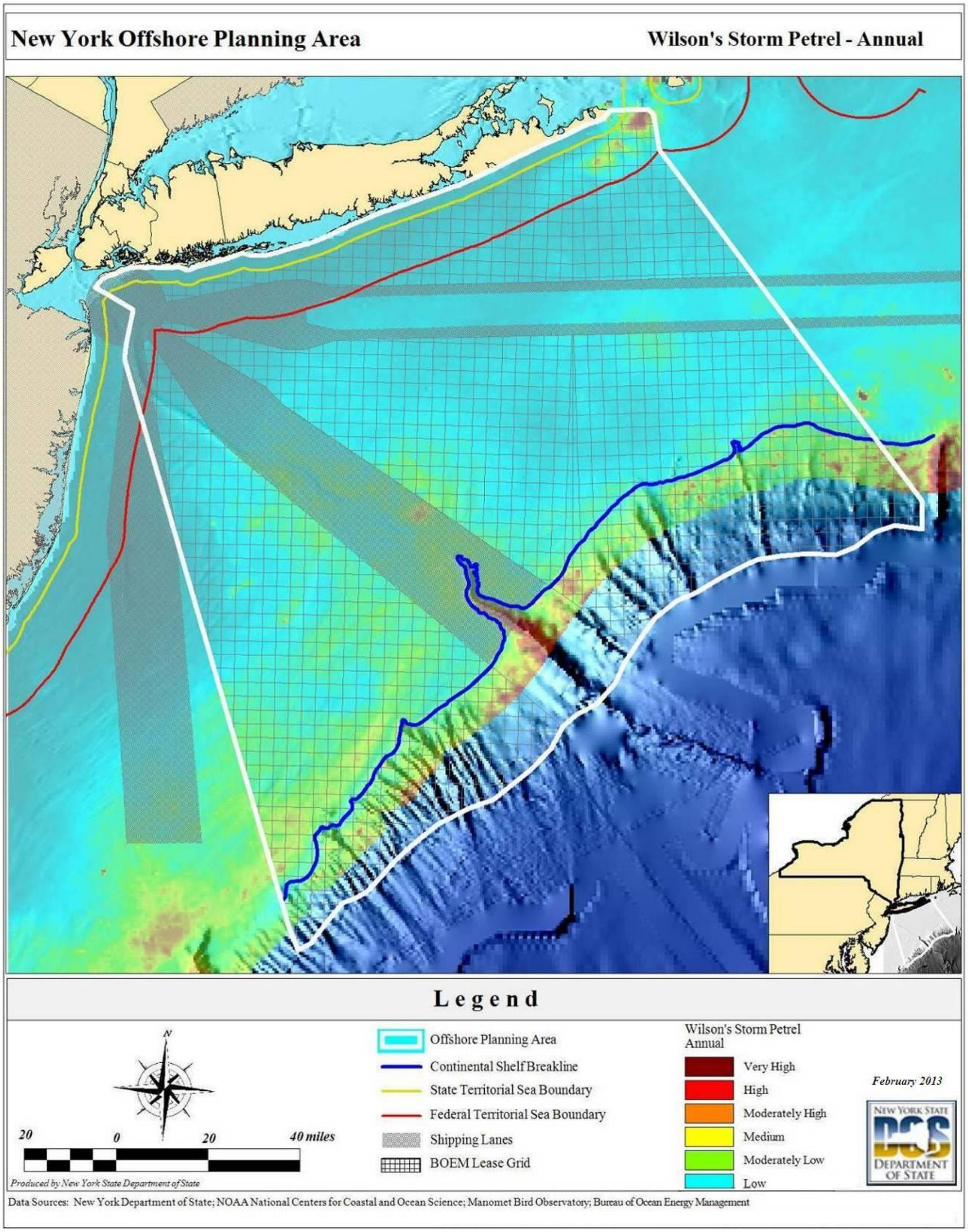

Figure 41: Wilson's Storm Petrel – Annual Predicted Relative Abundance

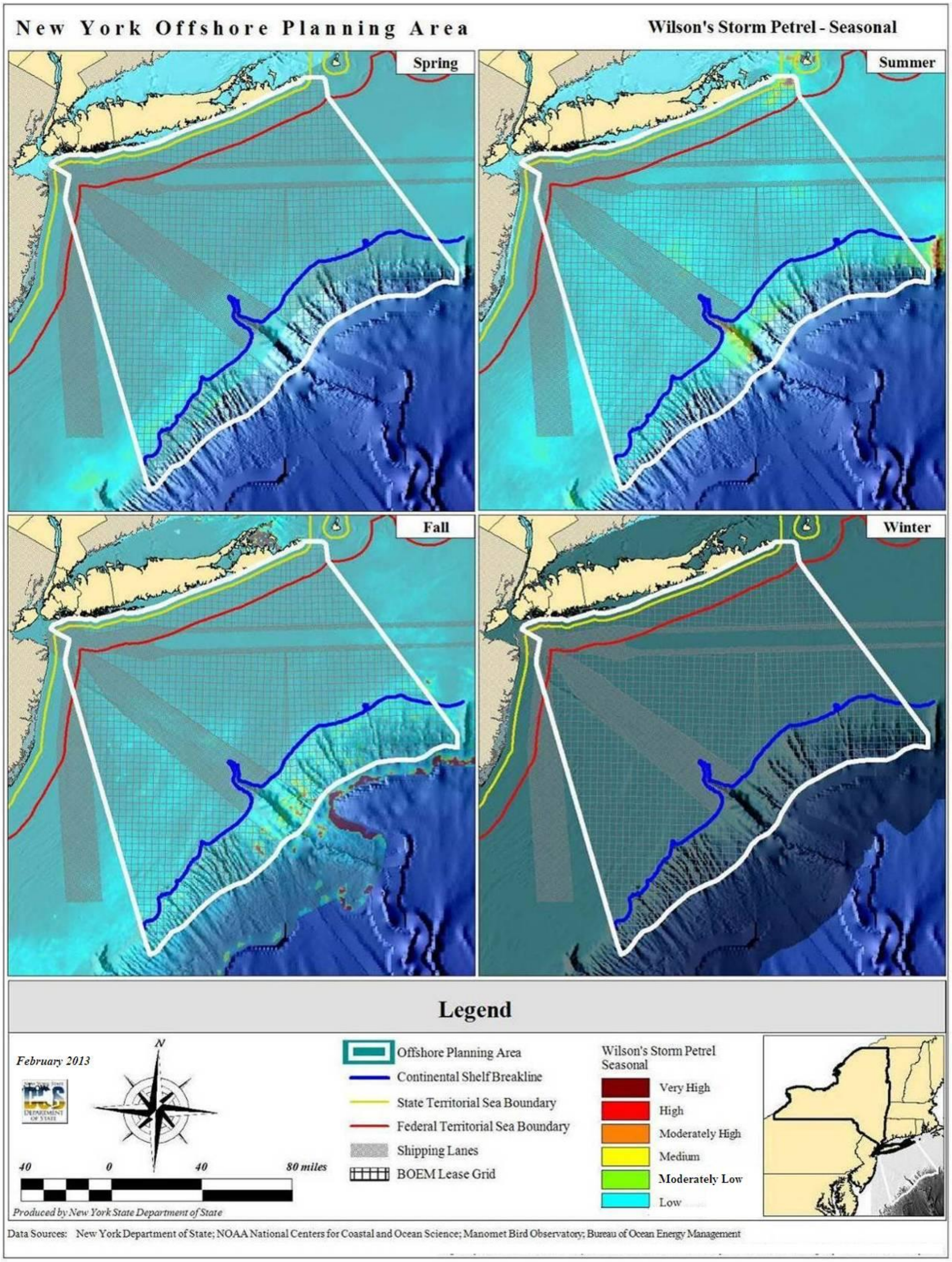

Figure 42: Wilson's Storm Petrel – Seasonal Predicted Relative Abundance
N.B., the winter seasonal distribution was not modeled due to lack of data.

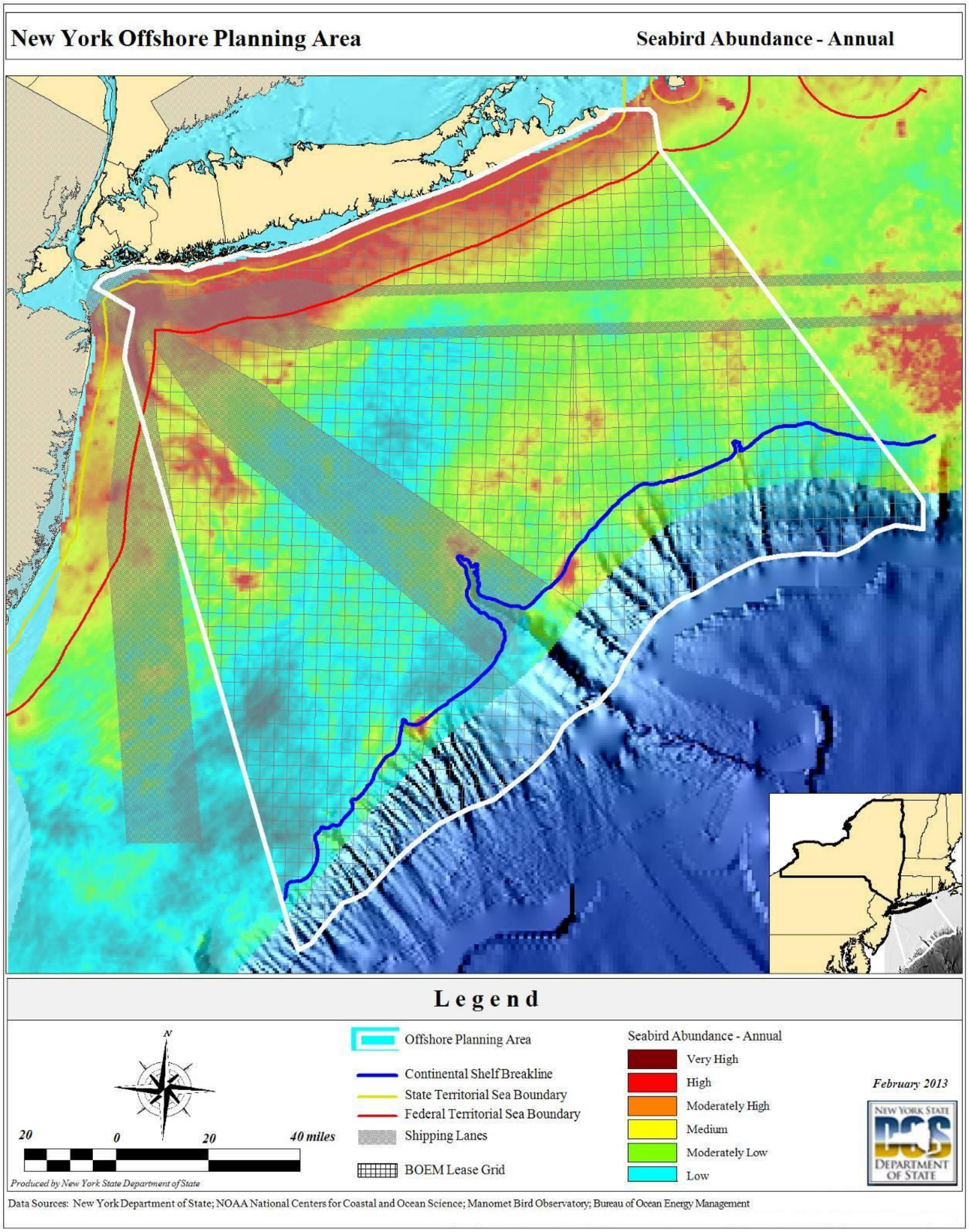

Figure 43: Predicted Seabird Abundance – Annual
This map shows predicted annual relative abundance in the offshore planning area for a grouping of 14 species of seabirds as modeled by NCCOS using the CSAP database.

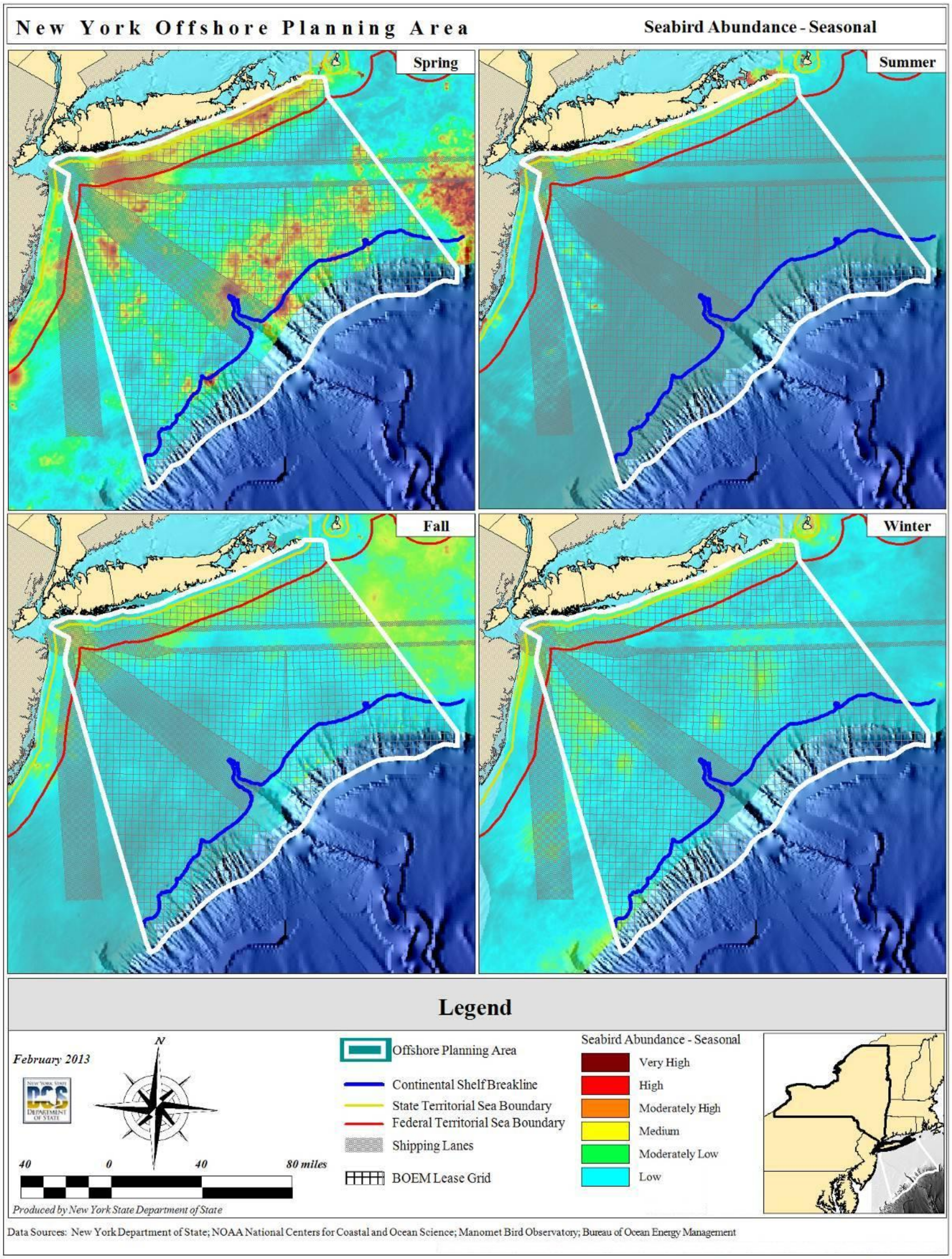

Figure 44: Predicted Seabird Abundance – Seasonal

This map series shows predicted seasonal relative abundance in the offshore planning area for a grouping of 14 species of seabirds as modeled by NCCOS using the CSAP database.

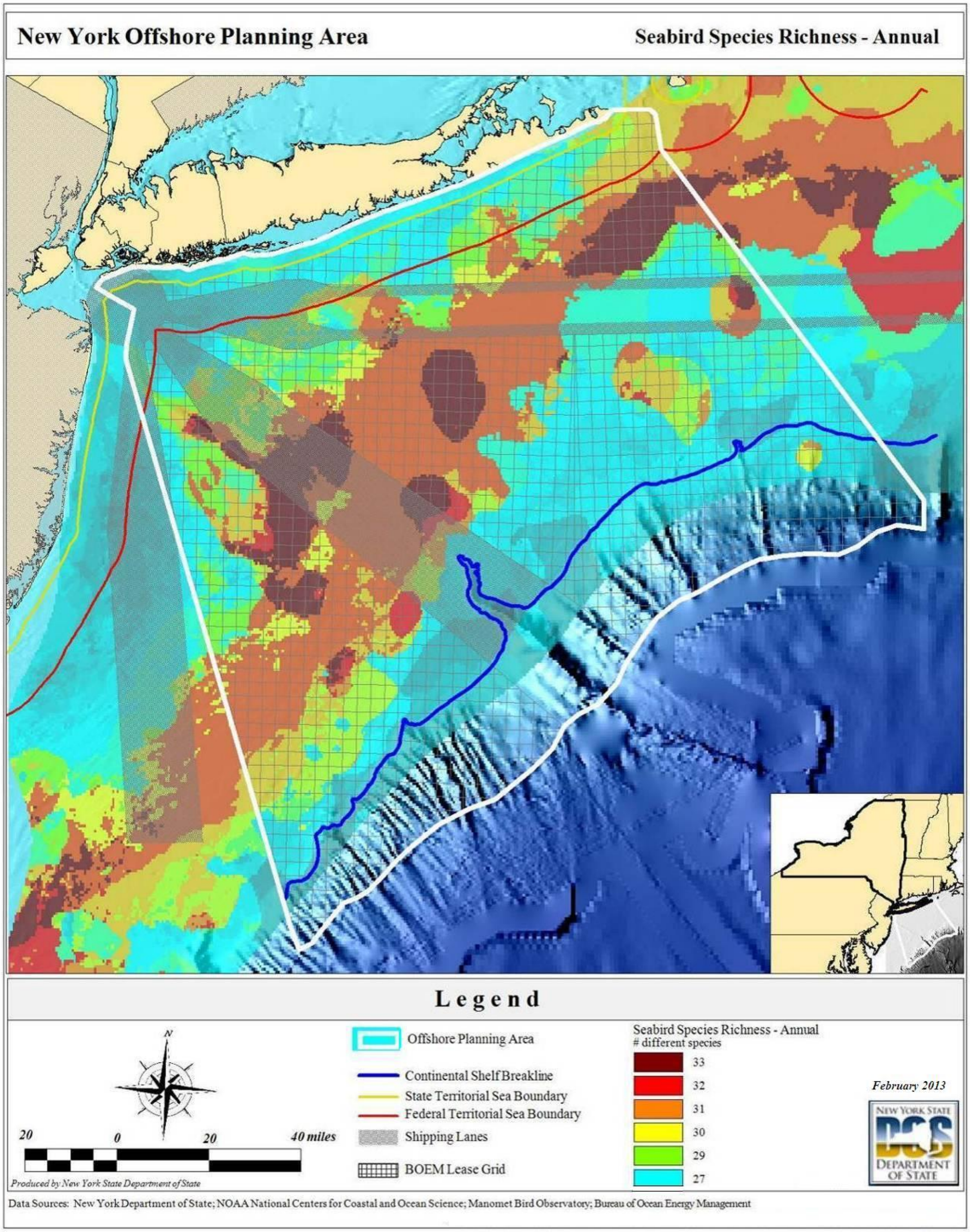

Figure 45: Predicted Seabird Species Richness – Annual

This map shows predicted annual species richness in the offshore planning area for all species of seabirds as modeled by NCCOS using the CSAP database.

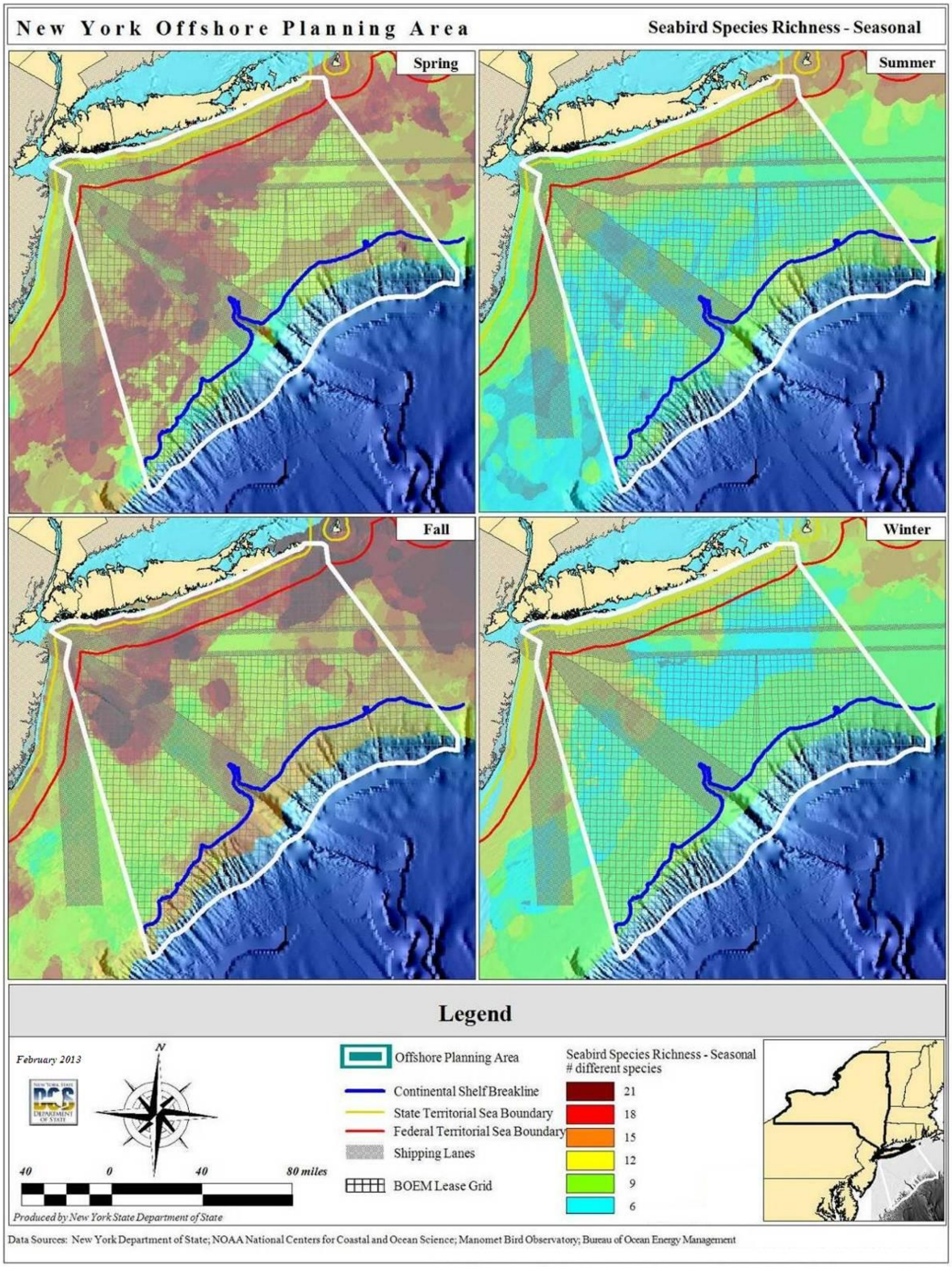

Figure 46: Predicted Seabird Species Richness – Seasonal

This map series shows predicted seasonal species richness in the offshore planning area for all species of seabirds as modeled by NCCOS using the CSAP database.

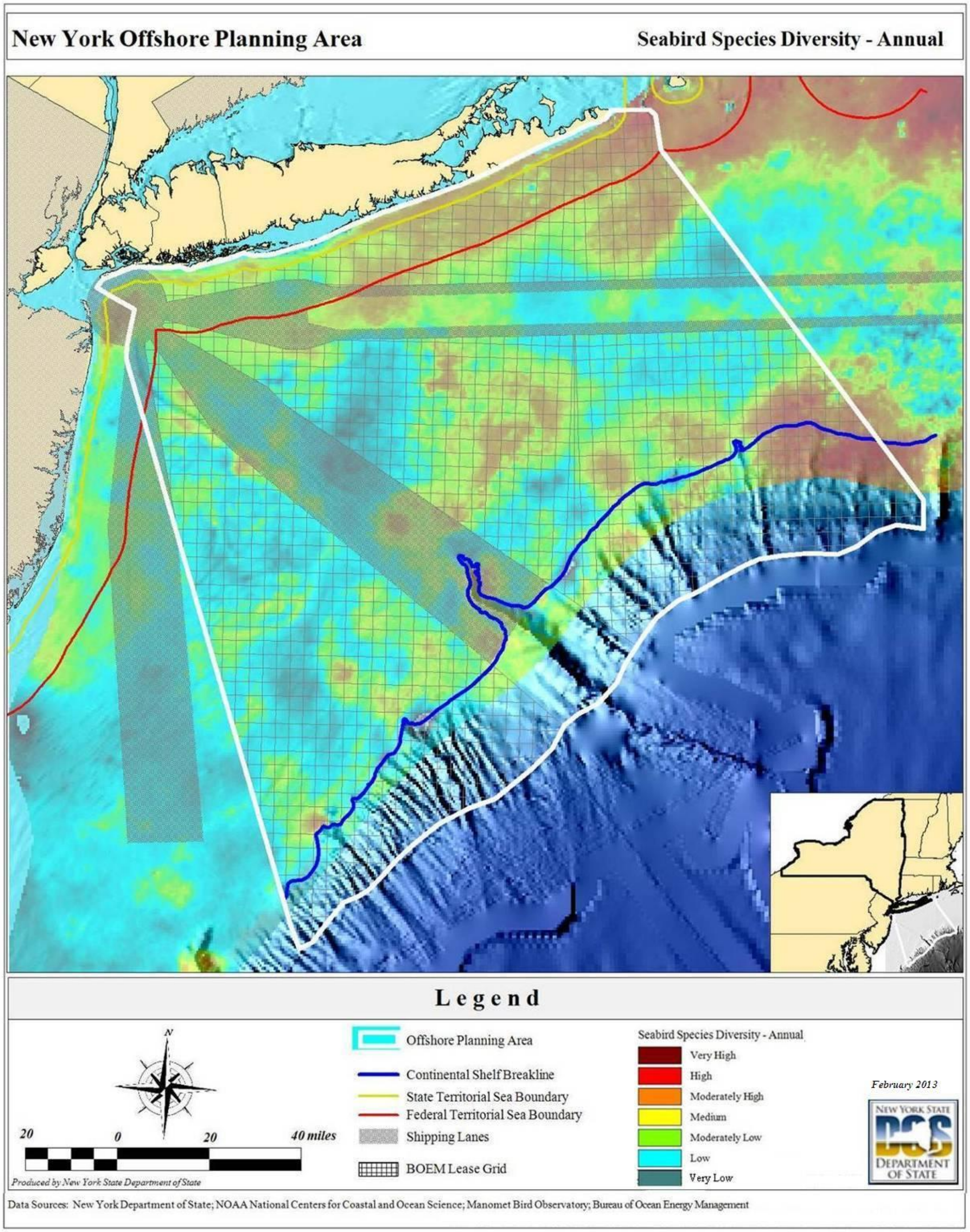

Figure 47: Predicted Seabird Species Diversity – Annual

This map shows predicted annual species diversity in the offshore planning area for seabirds as modeled by NCCOS using the CSAP database.

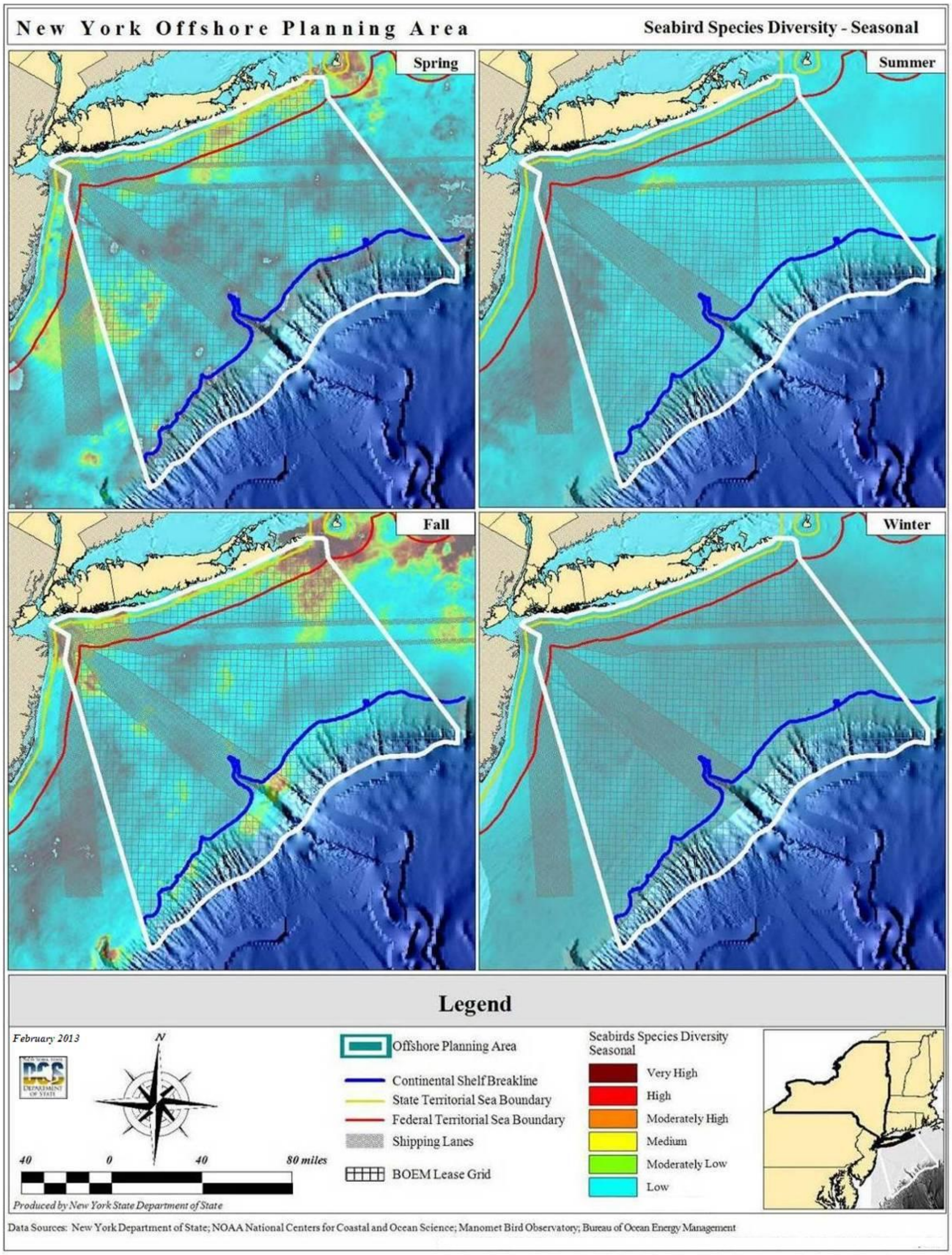

Figure 48: Seabird Species Predicted Diversity – Seasonal
This map series shows predicted seasonal species diversity in the offshore planning area for seabirds as modeled by NCCOS using the CSAP database.

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7. Groundfish

(Figure 49-Figure 51)

The NOAA Northeast Fisheries Science Center (NEFSC) has been conducting biannual fisheries-independent bottom trawl surveys since 1963. The starting locations ("station") of each tow were assigned based on a stratified random sampling design, and strata were defined in 1963 based on water depth, latitude, and historical fishing patterns. The number of stations allotted to a stratum was proportional to its area. Each tow proceeded at approximately 3.5 knots for 30 minutes, using #36 Yankee trawl (or similar trawling gear). This methodology may favor species which are more easily caught by bottom trawling. Once onboard, fish were weighed, measured, sexed, and identified to the species level.[54]

Stone Environmental, Inc. obtained trawl stations and catch records from NEFSC from 1975-2009.[55] They calculated species abundance (number of individuals) at each station and summarized it by five-year intervals, season (spring/fall), and life stage (juvenile/adult). Life stage categories were defined based on published estimates of length at maturity.[56]

DOS received these pre-processed data from Stone Environmental and selected 14 species important to New York's coastal resources for modeling (Section IV). DOS modeled abundance as a function of 11 environmental predictor variables, consistent with the variables used by NCCOS to model seabirds[57] based on previous studies of environmental correlates of fish abundance. DOS also developed "persistence" (i.e., presence over time) maps for six selected groundfish species. Groundfish data were aggregated in five-year increments over a 35-year period (1975 – 2010). Each five-year increment was summed to count the number of increments for which a selected species age group (adult or juvenile) was found by season (fall or spring).

Groundfish predicted abundance models were used to show patterns in distribution based on seasons or life stages (Figure 49 through Figure 51). The species displayed here illustrate the importance of offshore habitat areas in supporting New York's fisheries. More information on the most commercially- and recreationally-valuable fish species for New York can be found in the Stone Environmental report and are the subject of ongoing survey and modeling work.

Given the inherent difficulties in modeling dynamic species from limited survey data, cross-validation statistics suggest that models' overall performance was fair, with individual model performance varying considerably between species, season, and life stage combinations. Statistical analyses suggested models successfully described some but not all variation in the data. The relationships between groundfish abundance and environmental predictors were in most cases statistically significant.

In some cases dates for trawl surveys and predictor variables differ by as much as 32 years. Long-term averages were used to smooth out the differences. Predictors and the relationships between predictors and abundance were assumed to have remained constant from 1975-2009.

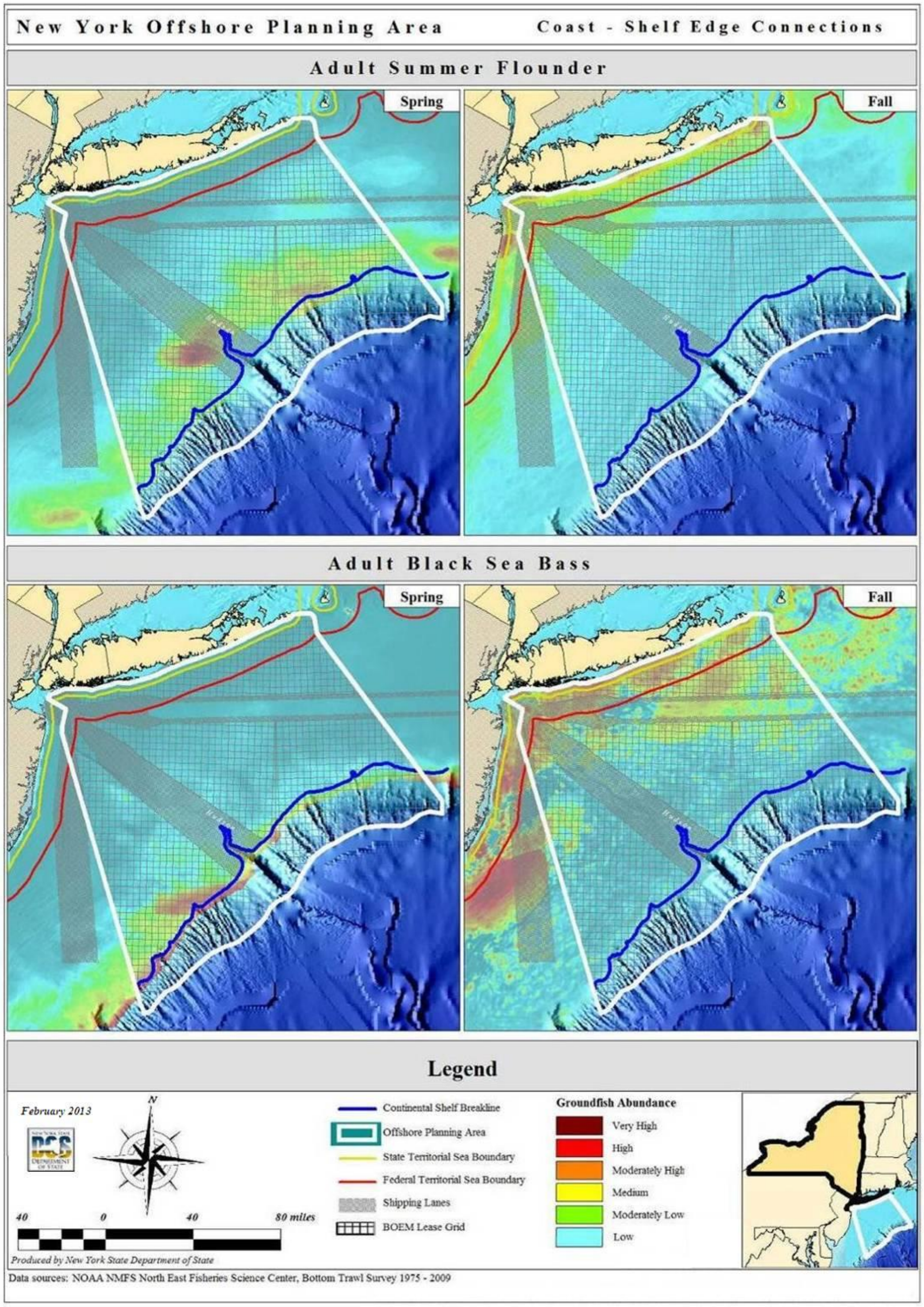

Figure 49: Coast – Shelf Edge Connections

This map series shows predicted relative abundance of adult Summer Flounder and adult Sea Bass, two important species to New York fishers, as modeled by DOS using the NEFSC groundfish survey data. Clear life history patterns can be seen connecting coastal areas of New York with the continental shelf edge. For both species, adults can be seen utilizing the shelf edge in spring and nearshore areas in fall.

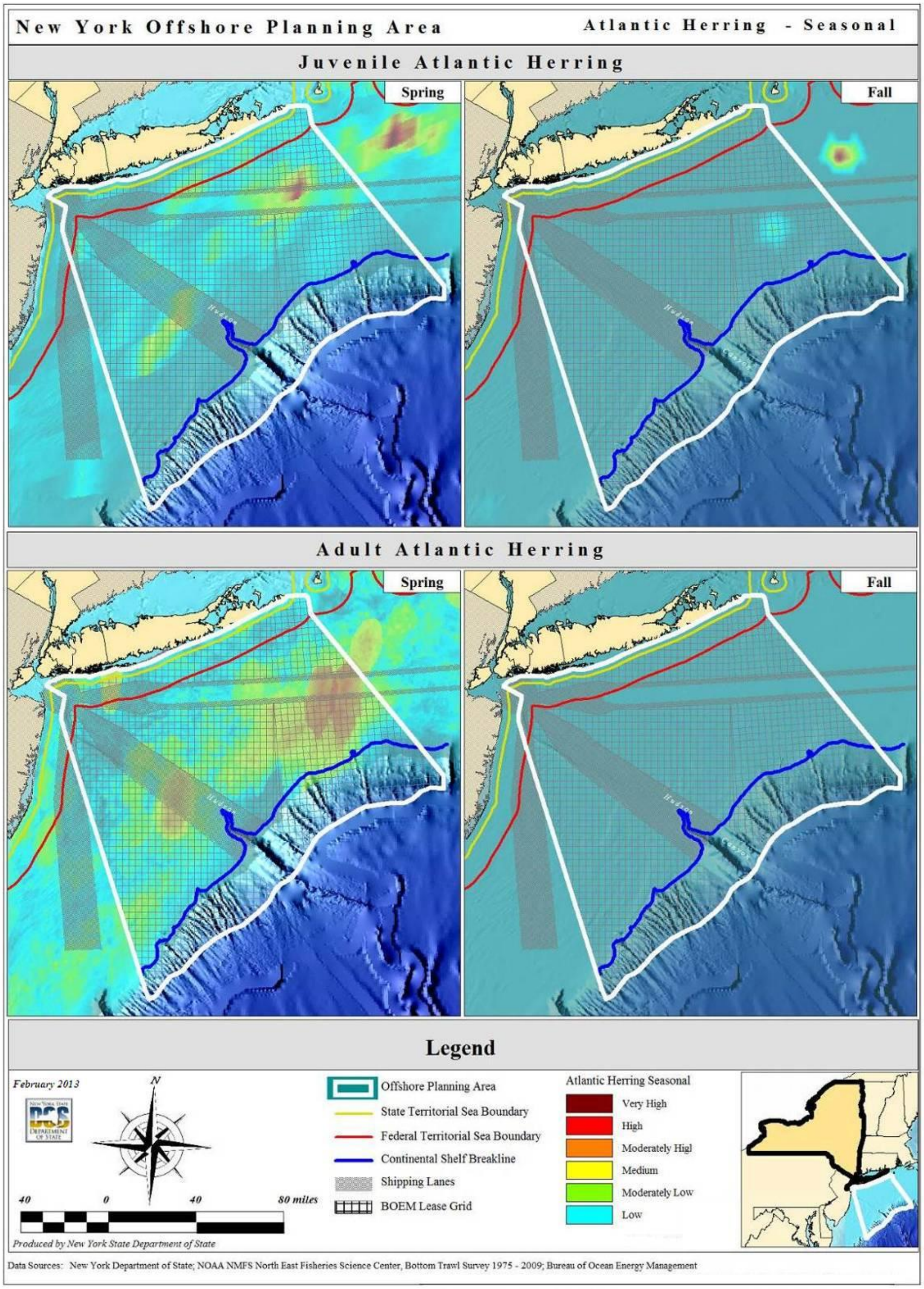

Figure 50: Atlantic Herring

This map series shows predicted relative abundance of Atlantic Herring, an important species to New York fishers, as modeled by DOS using the NEFSC groundfish survey data. Both juvenile and adults of this species are predicted to be widespread throughout the offshore planning area during spring months.

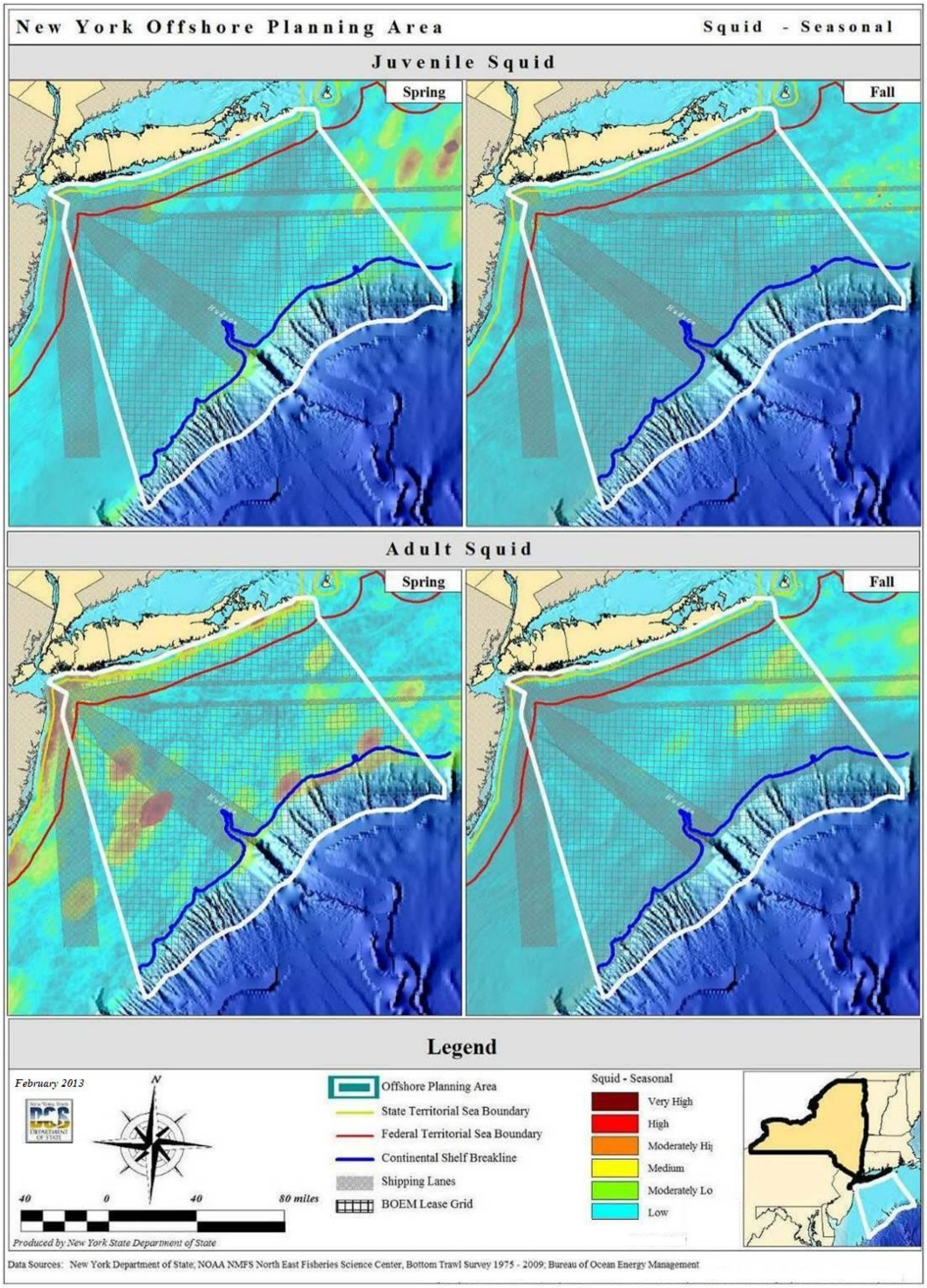

Figure 51: Squid

This map series shows predicted relative abundance of squid, an important species to New York fishers, as modeled by DOS using the NEFSC groundfish survey data. Abundance and distribution patterns represent use of the entire offshore planning area by both juvenile and adult life stages. Of particular note is adult usage in spring when concentrations are seen along the shelf edge and on a bathymetric rise just south of the Hudson Shelf Valley.

E. Human Uses

New Yorkers rely on the ocean for a variety of uses, including: commercial activities that support vital ocean-based industries; recreational activities that support New Yorkers' quality of life and may have substantial direct or indirect economic impact on coastal communities; and traditional uses important to the culture and history of tribal nations. DOS used accessible, participatory methods to obtain and create geographic information on the location of ocean uses (Section IV).

The recreational boating community is the largest single group of ocean users not included in the scope of this study. Information on recreational boating activities is being sought through a separate project being conducted in coordination with coastal New England States. Recreational boater survey data will be incorporated by DOS in future updates to the study data layers available online.[58]

1. Recreational and Tribal Uses
(Figure 52)

DOS staff worked with NOAA's Coastal Services Center (CSC) to design and develop participatory geographic information system (pGIS) training materials that described protocols for ocean use data collection and reporting back to DOS. Leaders from 30 partner organizations and other knowledgable individuals were invited to participate in one of five offshore use workshops: two each in Riverhead and Baldwin, and one in Manhattan. Over several months, workshop participants collected ocean use information from their peers, and the marked-up charts with corresponding information tables were returned to DOS, representing over 130 records of new ocean use information.

DOS digitized the geographic information provided by ocean users and created an aggregate dataset, including linked attribute data characterizing each mapped use area. DOS staff returned to the organizations that provided ocean use information, to "ground truth" the individual and aggregate information as organized by DOS. This was an opportunity for the organizations to modify or improve the data and resulted in some additions and corrections.

DOS received significant input from a wide range of non-commercial and recreational users. The resulting map shows that New Yorkers' non-commercial ocean activities occur predominantly in proximity to major public access points (e.g., beaches) and coastal communities (Figure 52). Much of the geographic area of uses is concentrated within approximately 12 nautical miles of the shore, though uses do extend to the edge of the offshore planning area in the vicinity of the Hudson Canyon.

Long Island currently is home to one federally recognized tribe, the Shinnecock Indian Nation, and one state recognized tribe, the Unkechaug Indian Nation. DOS provided on-site briefings to the leaderships of both tribes and received ocean use information from the Shinnecock Indian Nation. The Shinnecocks identified ocean uses occur within a narrow coastal band of the larger study area.

As a result of the series of questions prepared by DOS and CSC, and the positive response from workshop participants, DOS has more detailed information that supports each data layer and provides a more in-depth overview of the mapped activity. Creating the dataset in this way allows access to details such as the use of a given area, when the use occurs, and how often it occurs. This offshore use information is depicted on maps and includes both non-commercial uses (e.g., wildlife viewing, surfing, boating, diving) and commercial fishing data gathered through the separate outreach conducted by Cornell Cooperative Extension of Suffolk County (CCE). These metadata are part of a new offshore use dataset and will provide an important basis for more detailed future analysis of the potential effects of specific proposed projects and activities.

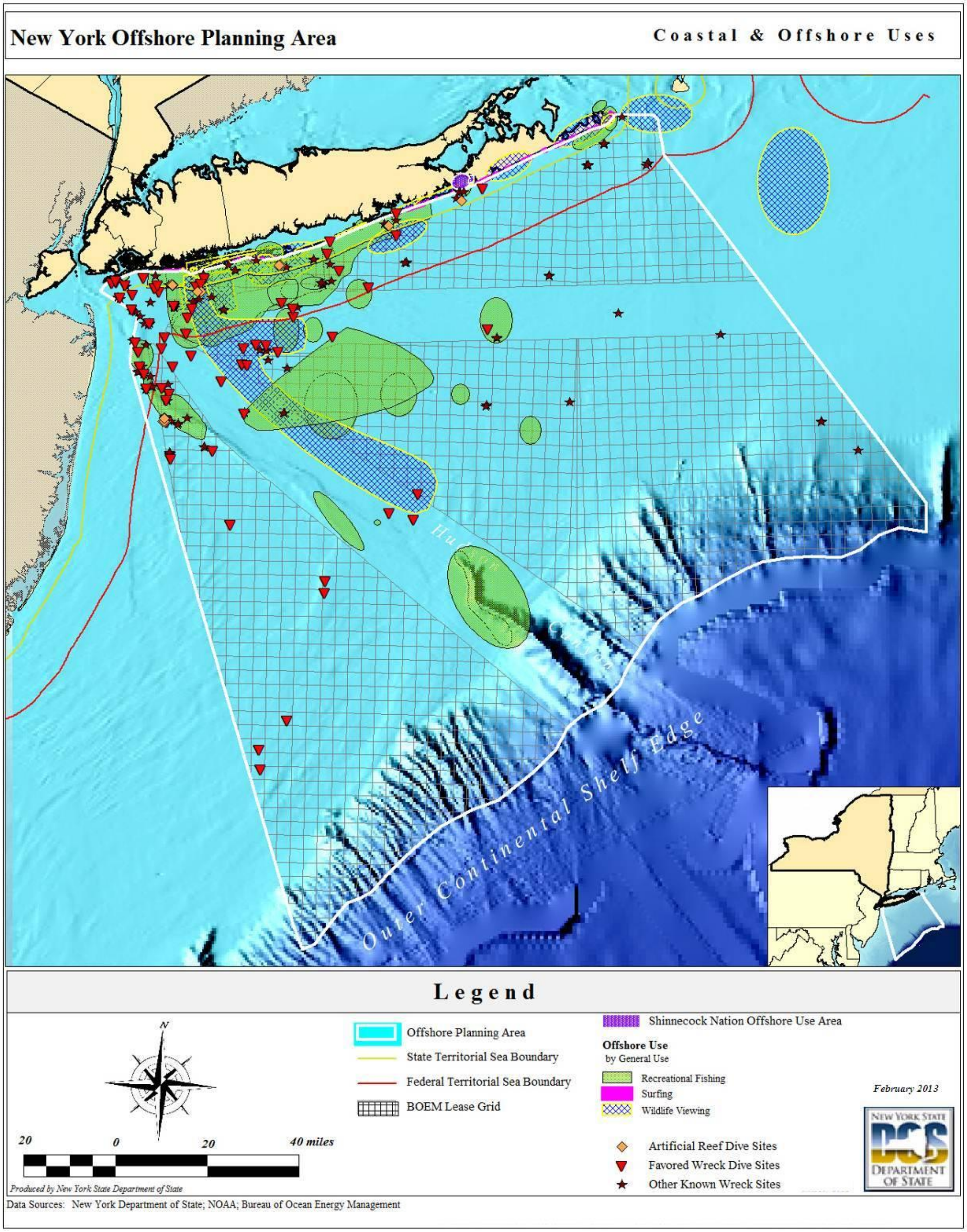

Figure 52: Coastal and Offshore Uses

This map aggregates the information collected from ocean user groups who participated in DOS's offshore uses workshops. Many of the uses, such as recreational fishing, wildlife viewing along the Hudson Shelf Valley, and diving activities, are concentrated near the shore.

2. Commercial Fishing
*(Figure 53-
Figure 76)*

Owners and operators of commercial fishing vessels with federal permits provide information to the NEFSC on when and where catch occurs. This information, called Vessel Trip Reporting (VTR) data, is grouped spatially into 10-minute squares and aggregated by gear type to protect the confidentiality of individual vessels and fishing locations. The data can reveal patterns or hotspots of fishing activity, albeit at relatively coarse resolution. The NEFSC provided VTR data to DOS in two categories: "effort", which is the number of days dedicated to fishing in a particular 10 minute square; and "landings",[59] which in commercial fishing is tallied in pounds of fish caught and in boat-for hire fishing is tallied as actual number of fish caught. In consultation with NEFSC staff, DOS separated the data into five classes,[60] summarizing the distribution of the data into more easily-interpreted classes while retaining major patterns in the distribution.

Through the NEFSC, NMFS has commercial fisheries data that span decades.[61] The NEFSC supplied DOS with VTR data for seven different commercial fishing gear types for the period 2001–2010[62] including dredge, otter trawl, gillnet, long-line, pot, seine and a category for "other" types (Figure 53: Dredge Gear Effort through Figure 60). DOS also received information from NEFSC on Charter and Party Boat[63] catch (Figure 61 through Figure 64).

The information in these VTR data is not limited to licensed commercial fishers based in New York or commercial fishers bringing fish to New York ports. Rather, these VTR data capture all federally-licensed vessels fishing in this reporting area. For this reason, the VTR data give a general picture of the areas of greatest overall value to commercial fishing offshore New York.

DOS supplemented the federal fishing data with new data gathered directly from licensed commercial fishers and charter boat captains[64]. DOS used the same pGIS protocols as above (Section II.D.1), focusing the approach on individual fishers rather than hosting group workshops. This survey was the first of its kind for New York's commercial fishers, and spanned six ports running the length of Long Island. Response rates varied depending on gear type. Overall, the commercial fishing and boat-for-hire data include 111 records, representing a substantial portion of New York's federally-licensed active fishers. Interviews were conducted by CCE and tailored to the type and breadth of commercial fishing activities located at each port. Individual commercial fishers' contributions were protected as research data via Cornell University, thereby addressing fishers' concerns about maintaining the confidentiality of their use data. To further protect the confidentiality of individual fishers, CCE created aggregate maps that identify, locate, and characterize commercial fishing in DOS's offshore planning area.

Using the VTR data from NEFSC and information from consultation with commercial fishers, DOS compared the identified locations of fishing activity across the two different data sets.

VTR data were used as the underlying base layer, and information provided by New York commercial fishers in the CCE interviews was displayed as the top layer to highlight those areas identified as important to New York's fishing industry.

Figure 65 shows areas fished in the offshore planning area by general gear type: fixed, mobile and boat-for-hire. Seasonal trends of commercial fishing use are apparent in Figure 66 and Figure 67, exhibiting pot and trawl gear respectively. As seen in Figure 68 through Figure 71 for four representative gear types -dredge, long line, gillnet and trawl- the VTR data and the fishers' data appear to be well-correlated. Maps were also created to show where and how many individually-reported commercial fishing areas overlapped (

Figure 72 through

Figure 76).

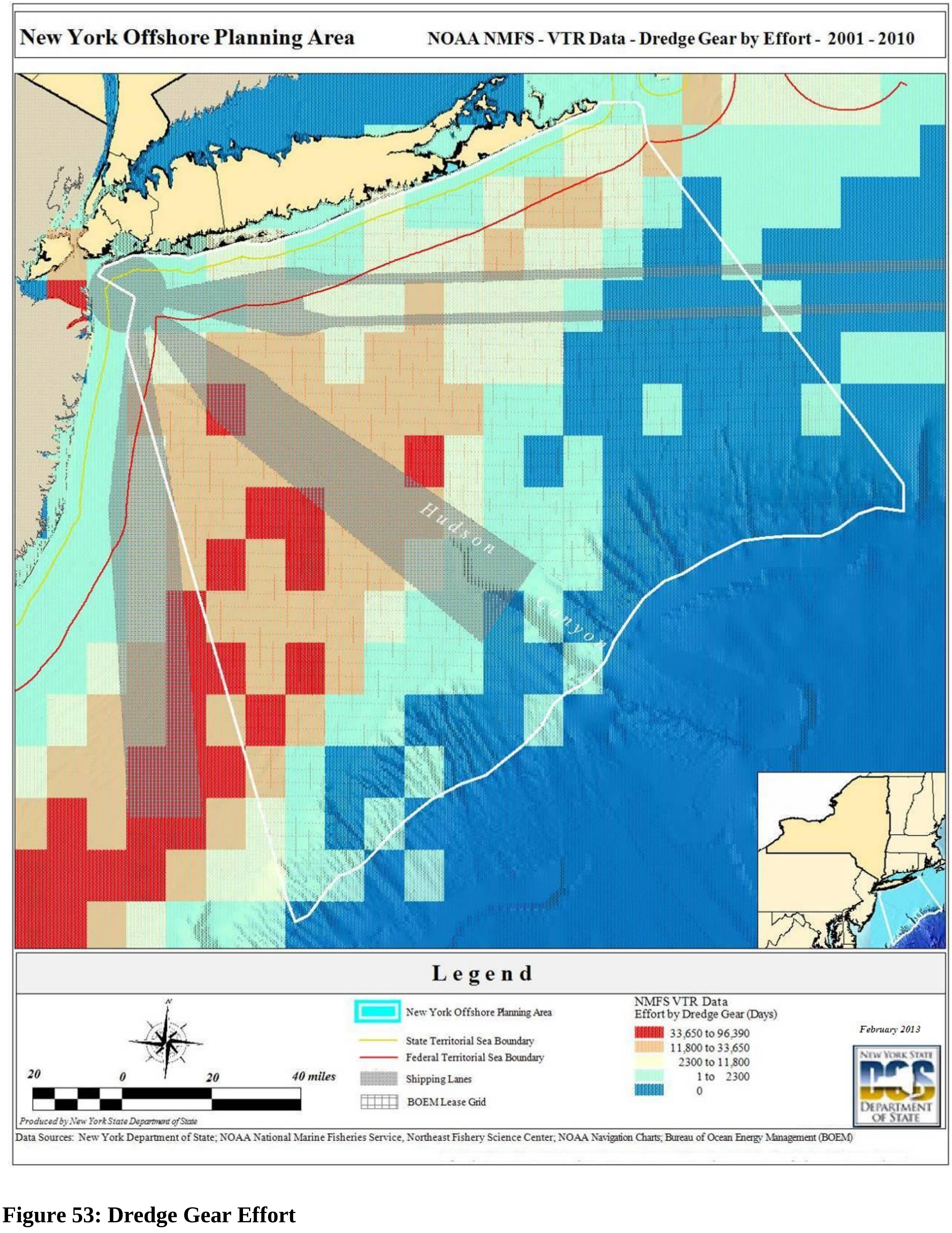

Figure 53: Dredge Gear Effort

This map uses NMFS NEFSC VTR data to show commercial fishing dredge gear effort (days), summed over a 10-year period.

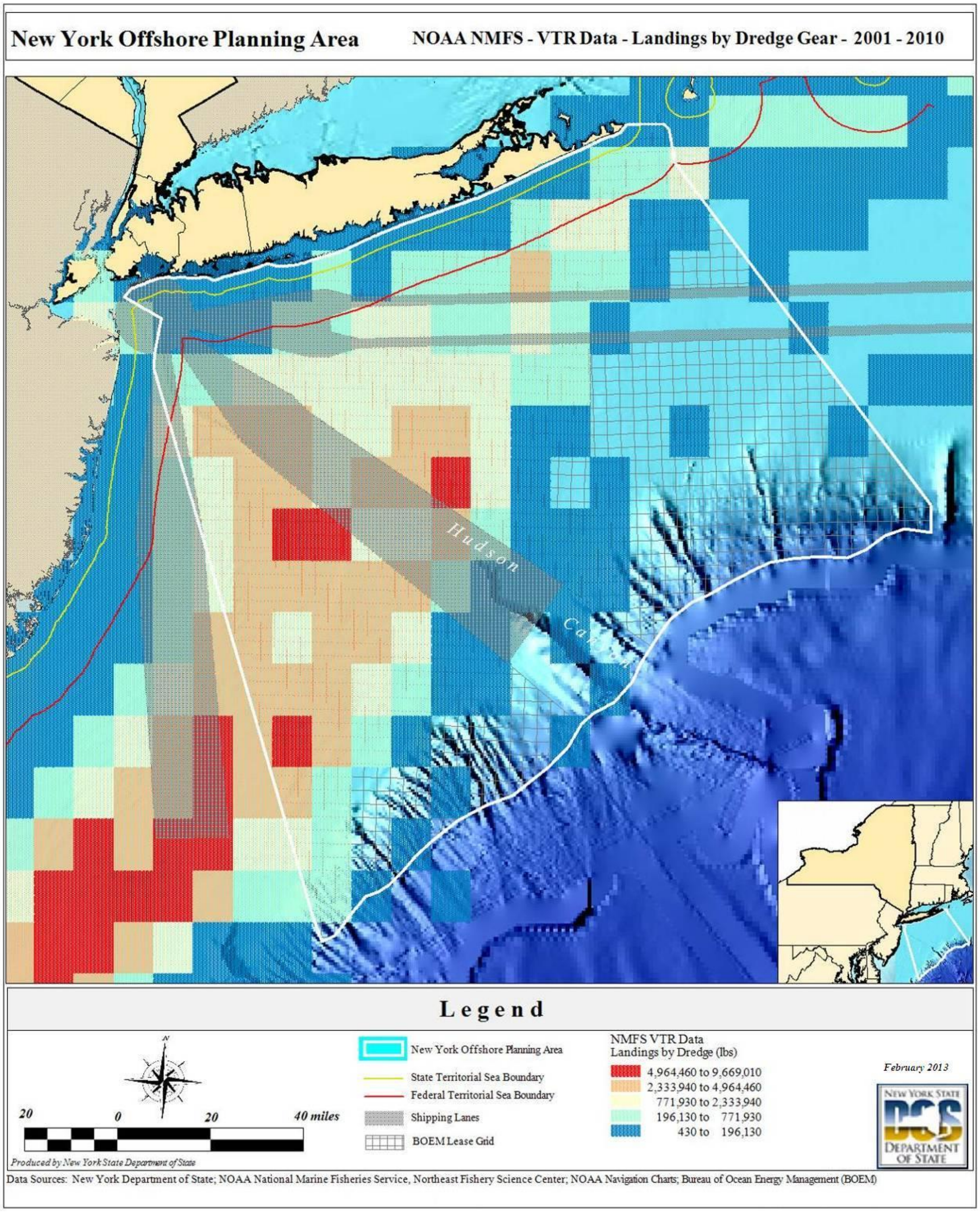

Figure 54: Landings by Dredge Gear – 2001-2010
This map uses NMFS NEFSC VTR data to show commercial fishing dredge gear landings (pounds), summed over a 10-year period.

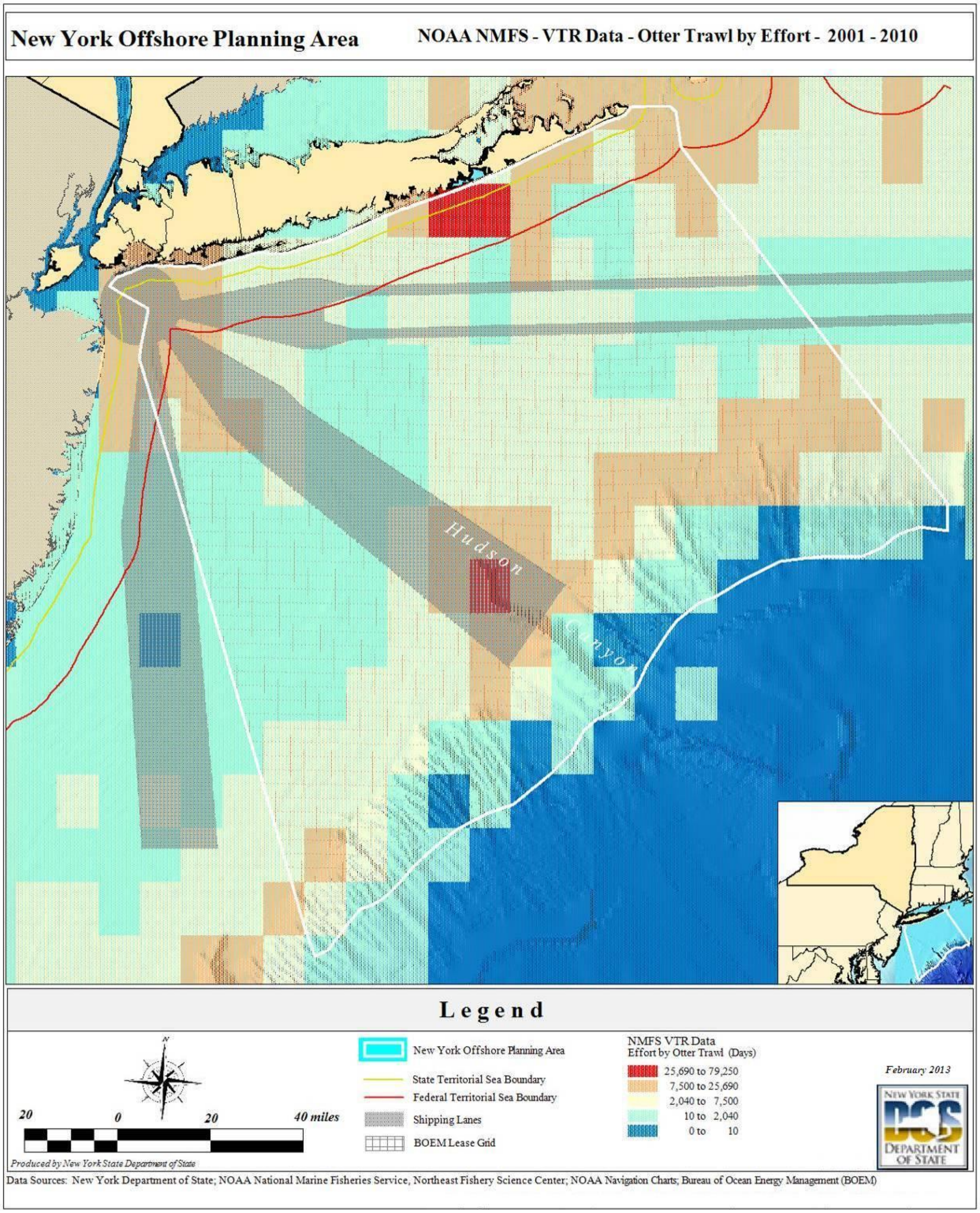

Figure 55: Otter Trawl by Effort – 2001-2010

This map uses NMFS NEFSC VTR data to show commercial fishing otter trawl effort (days), summed over a 10-year period.

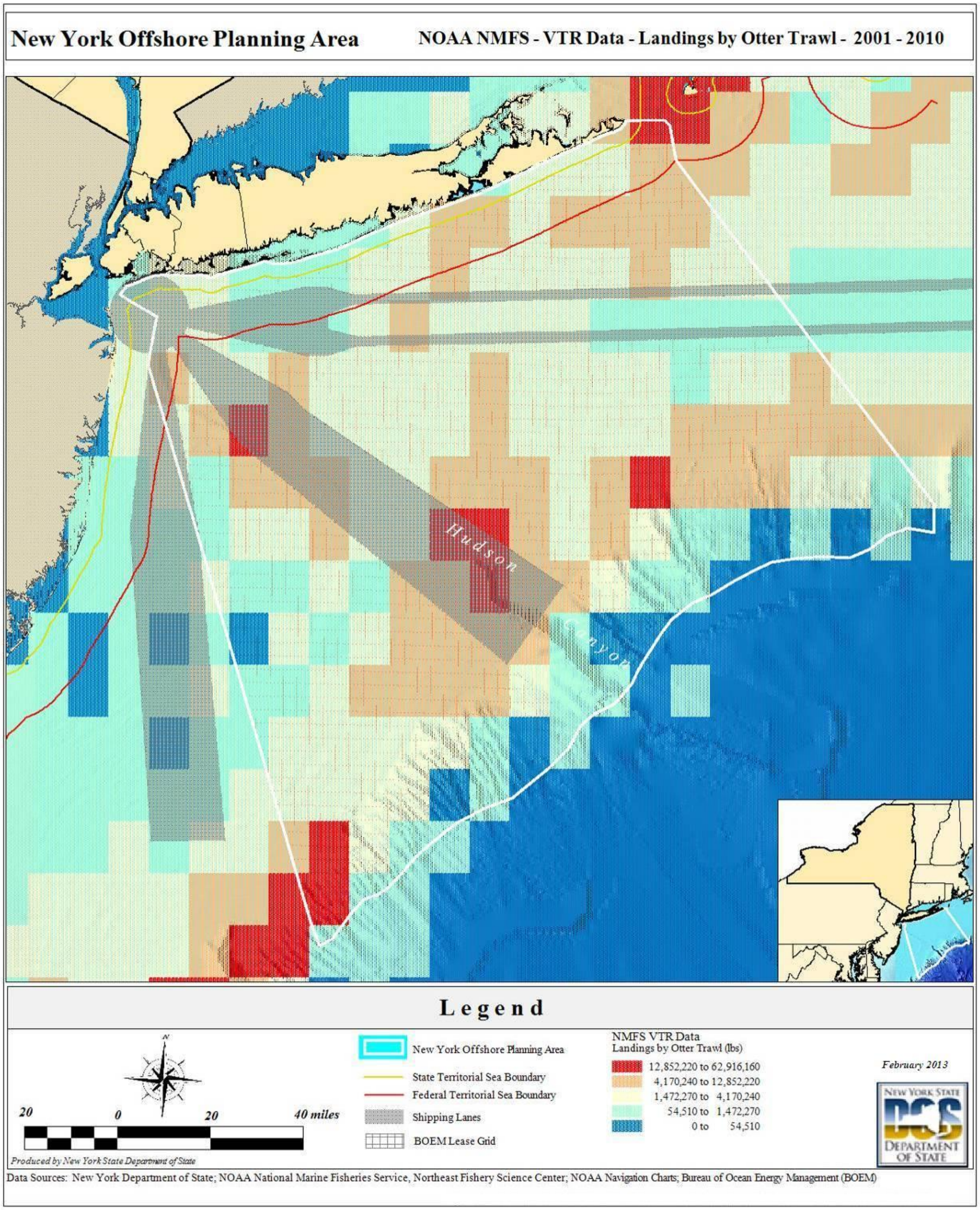

Figure 56: Landings by Otter Trawl – 2001-2010

This map uses NMFS NEFSC VTR data collected to show commercial fishing otter trawl landings (pounds), summed over a 10-year period.

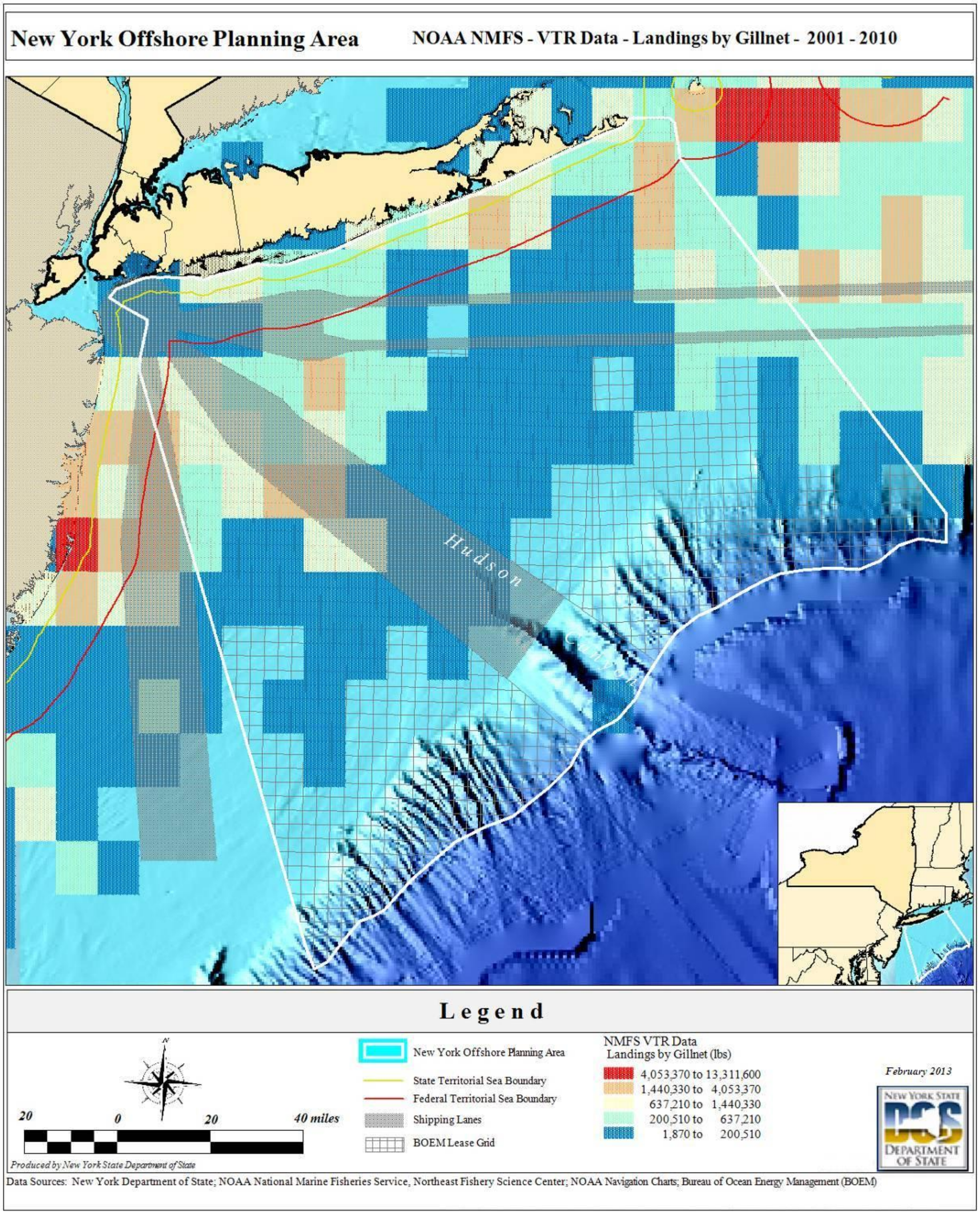

Figure 57: Landings by Gillnet – 2001-2010

This map uses NMFS NEFSC VTR data to show commercial fishing gillnet landings (pounds), summed over a 10-year period.

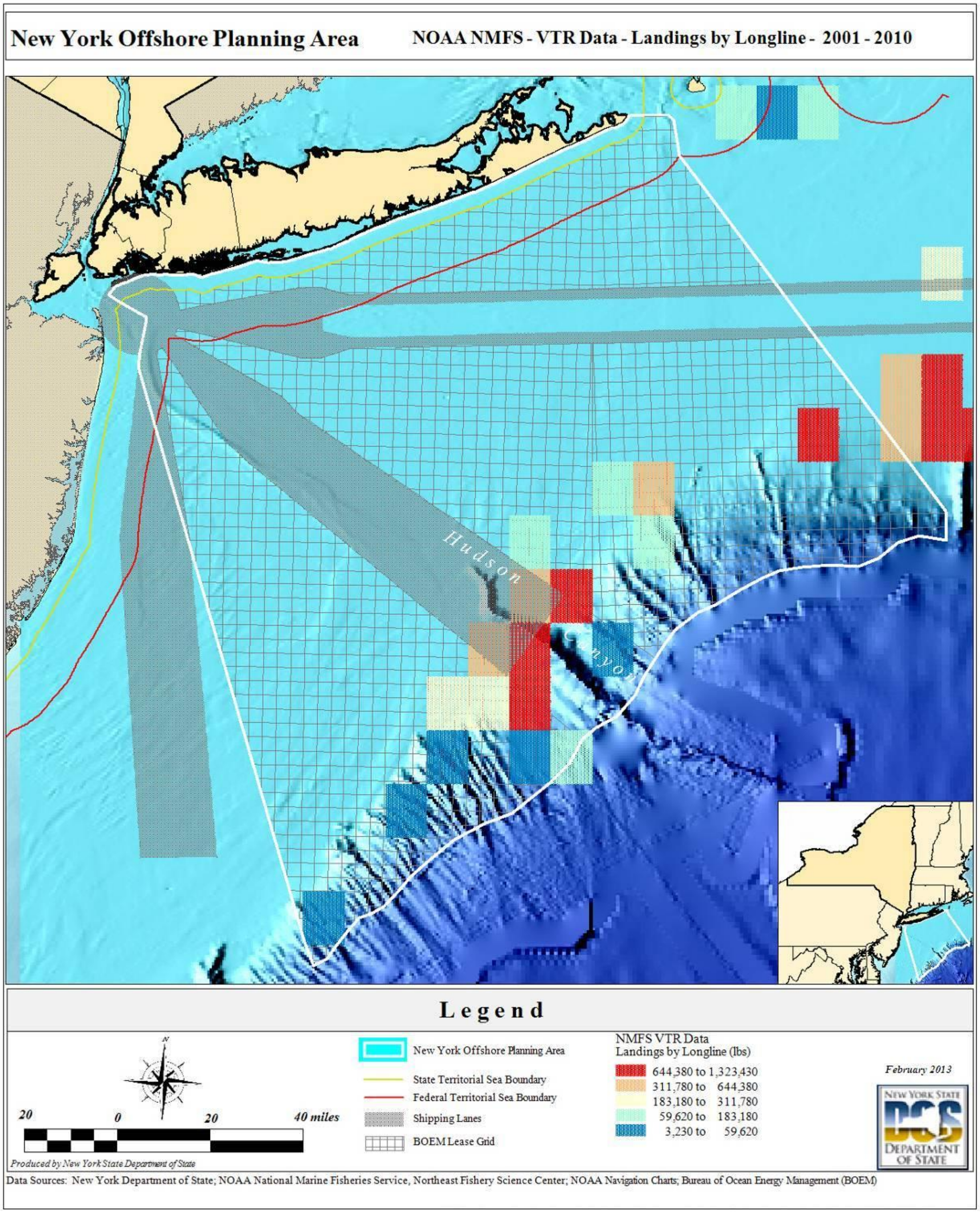

Figure 58: Landings by Longline – 2001-2010
This map uses NMFS NEFSC VTR data to show commercial fishing landings (pounds) by longline, summed over a 10-year period.

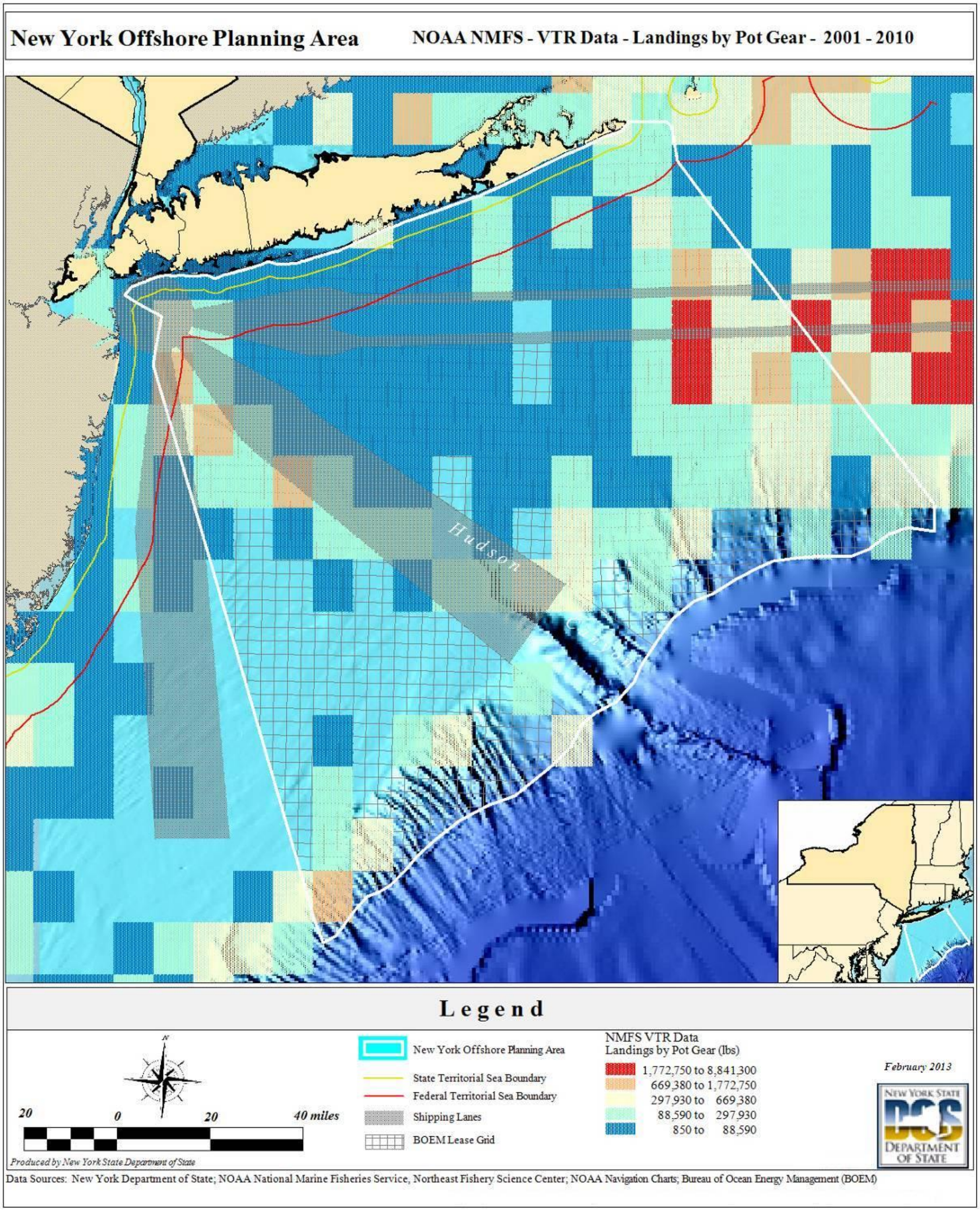

Figure 59: Landings by Pot Gear – 2001-2010
This map uses NMFS NEFSC VTR data to show commercial fishing pot gear landings (pounds), summed over a 10-year period.

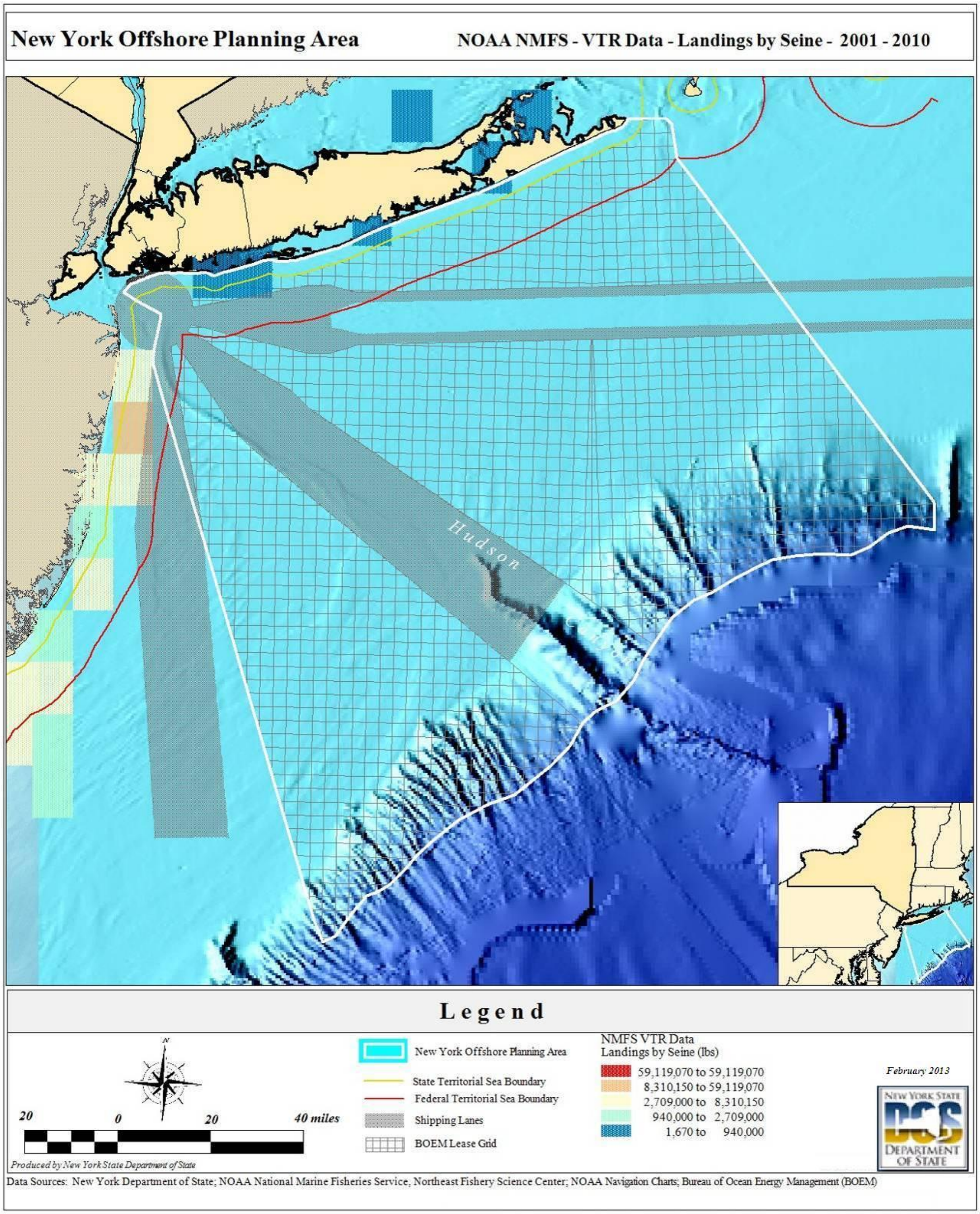

Figure 60: Landings by Seine – 2001-2010

This map uses NMFS NEFSC VTR data to show commercial fishing landings (pounds) by seine, summed over a 10-year period. Seine fishing is limited to nearshore areas.

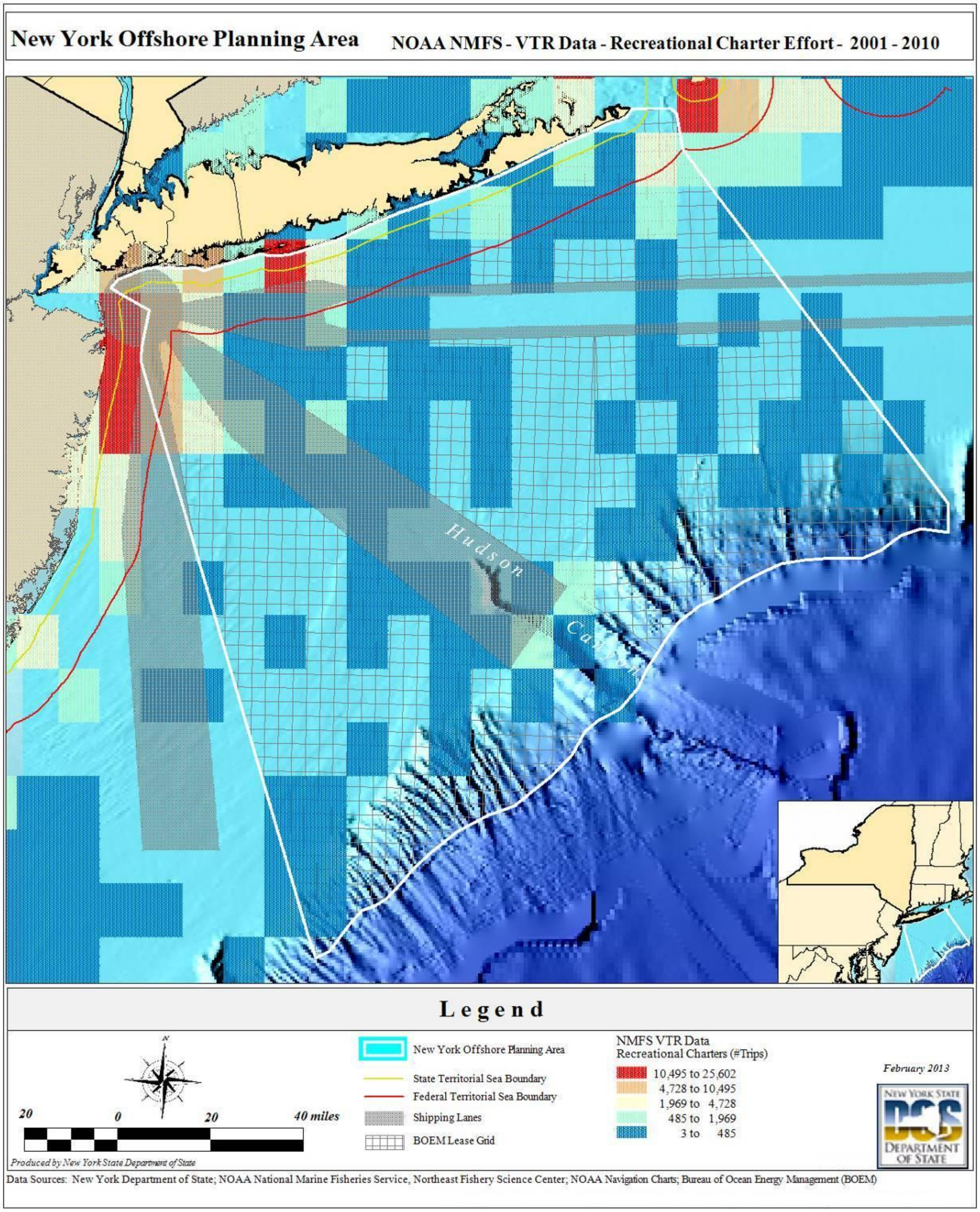

Figure 61: Recreational Charter Effort – 2001-2010

This map uses NMFS NEFSC VTR data to show recreational charter effort (# of trips), summed over a 10-year period.

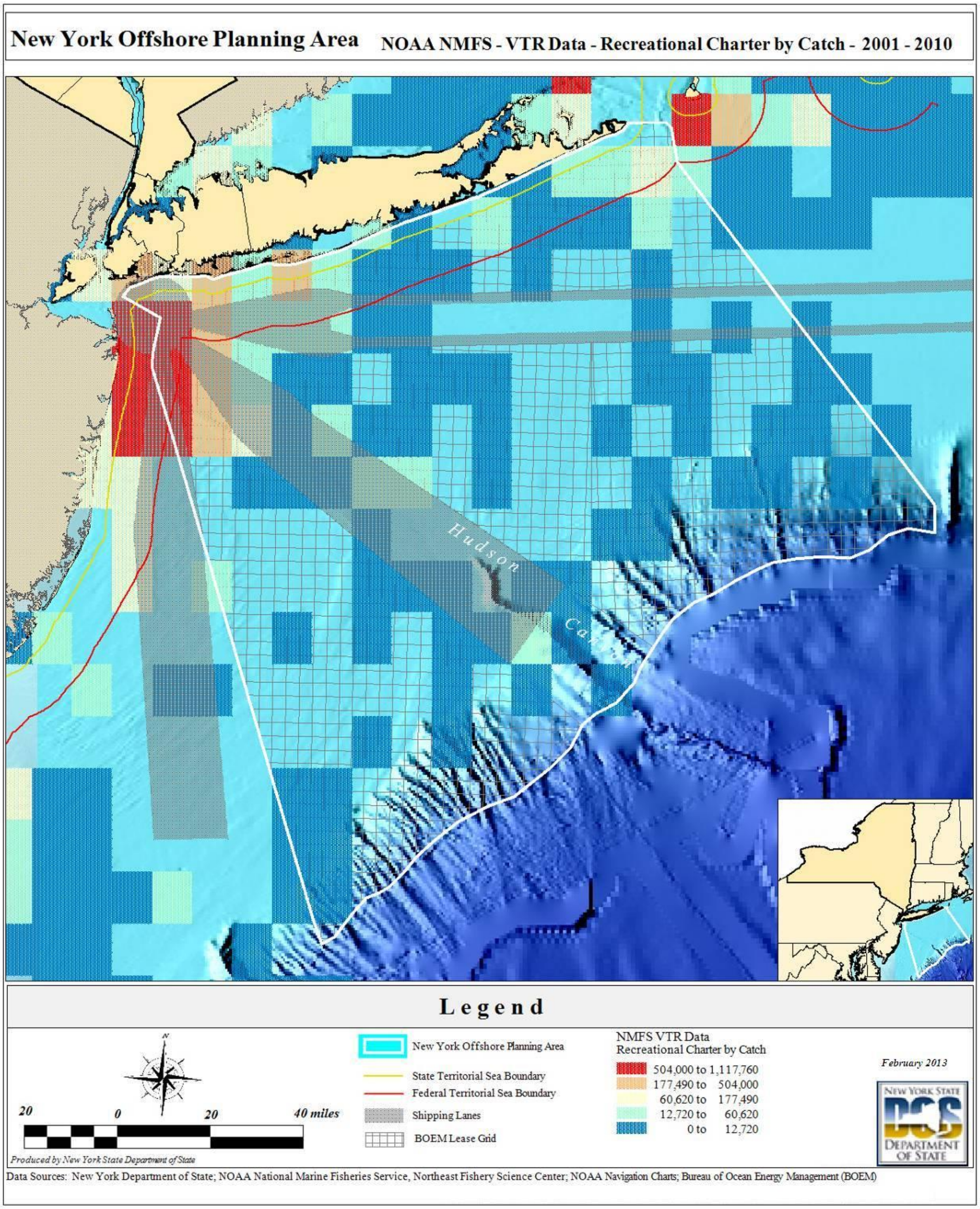

Figure 62: Recreational Charter by Catch – 2001-2010

This map uses NMFS NEFSC VTR data to show recreational fishing catch (pounds), summed over a 10-year period.

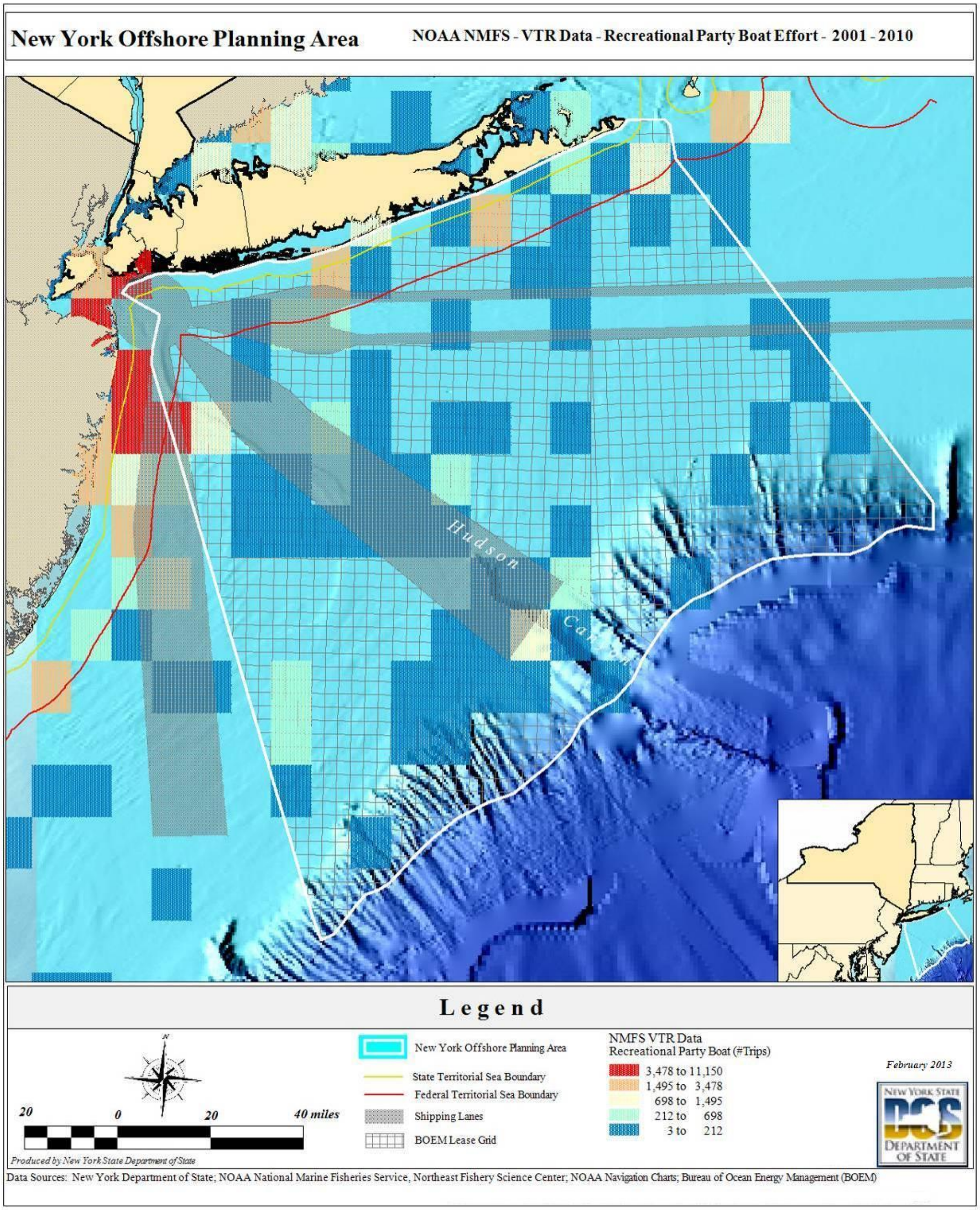

Figure 63: Recreational Party Boat Effort – 2001-2010

This map uses NMFS NEFSC VTR data to show recreational party boat effort (# of trips), summed over a 10-year period.

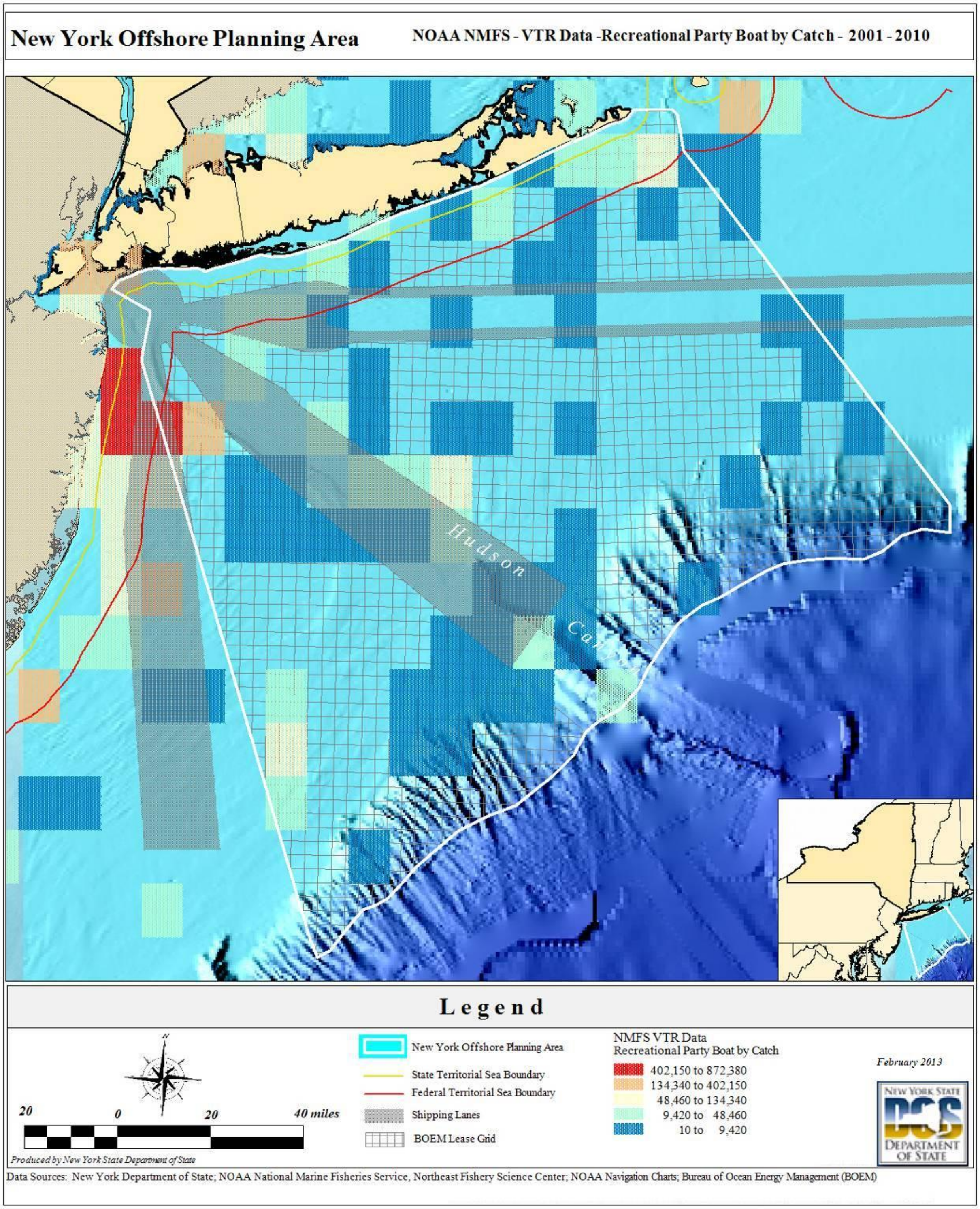

Figure 64: Recreational Party Boat by Catch – 2001-2010

This map uses NMFS NEFSC VTR data to show recreational party boat catch (pounds), summed over a 10-year period.

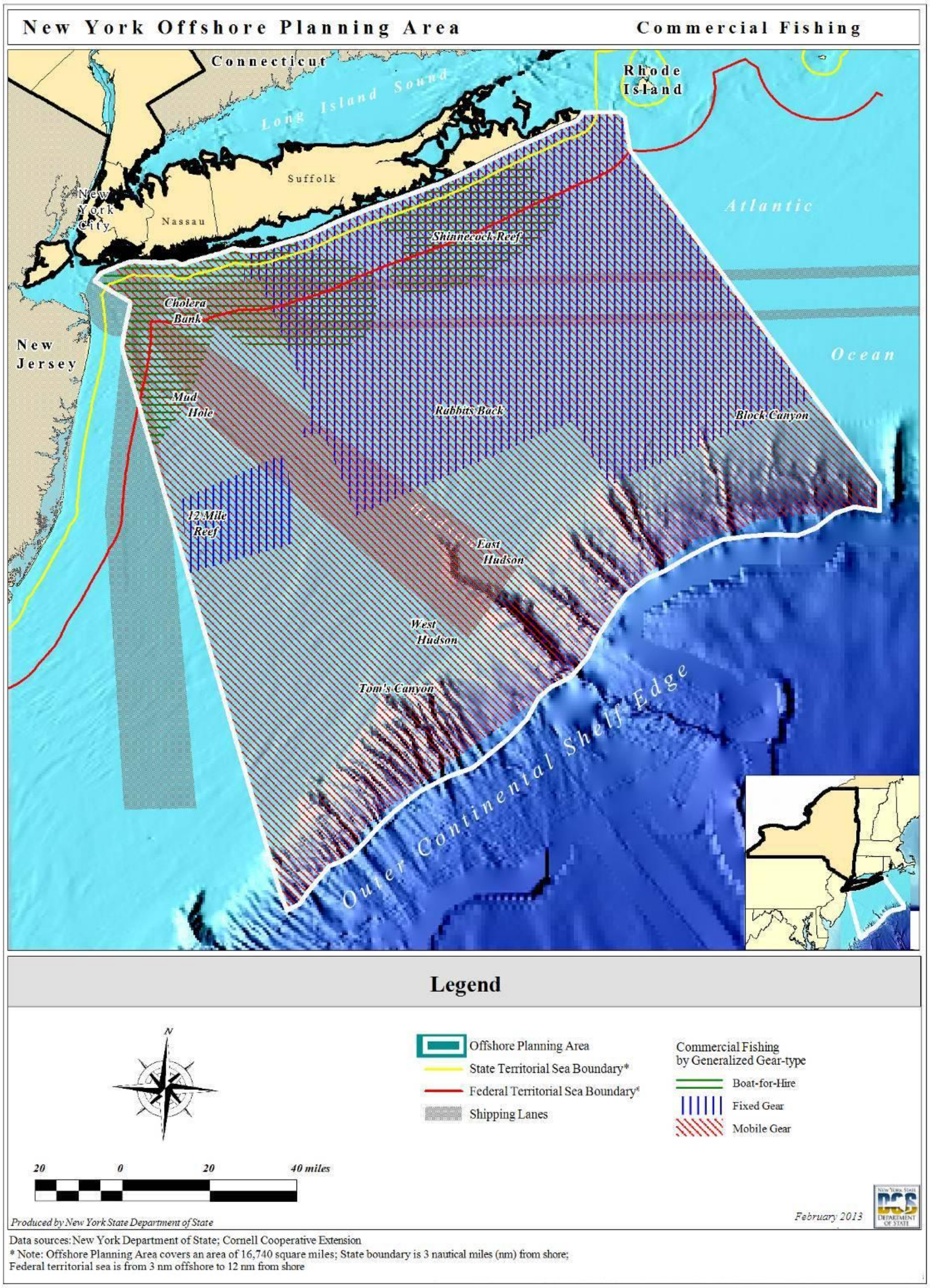

Figure 65: Commercial Fishing

This map aggregates information collected from New York-based commercial fishers who participated in one-on-one information gathering sessions with CCE. Mobile gear (e.g., trawls, long line, dredge, etc.) occurs throughout the offshore planning area, fixed gear (anchored to the bottom) is depth-limited, and boat-for-hire (Charter and Party boat) fishing occurs mostly within 20 miles from shore.

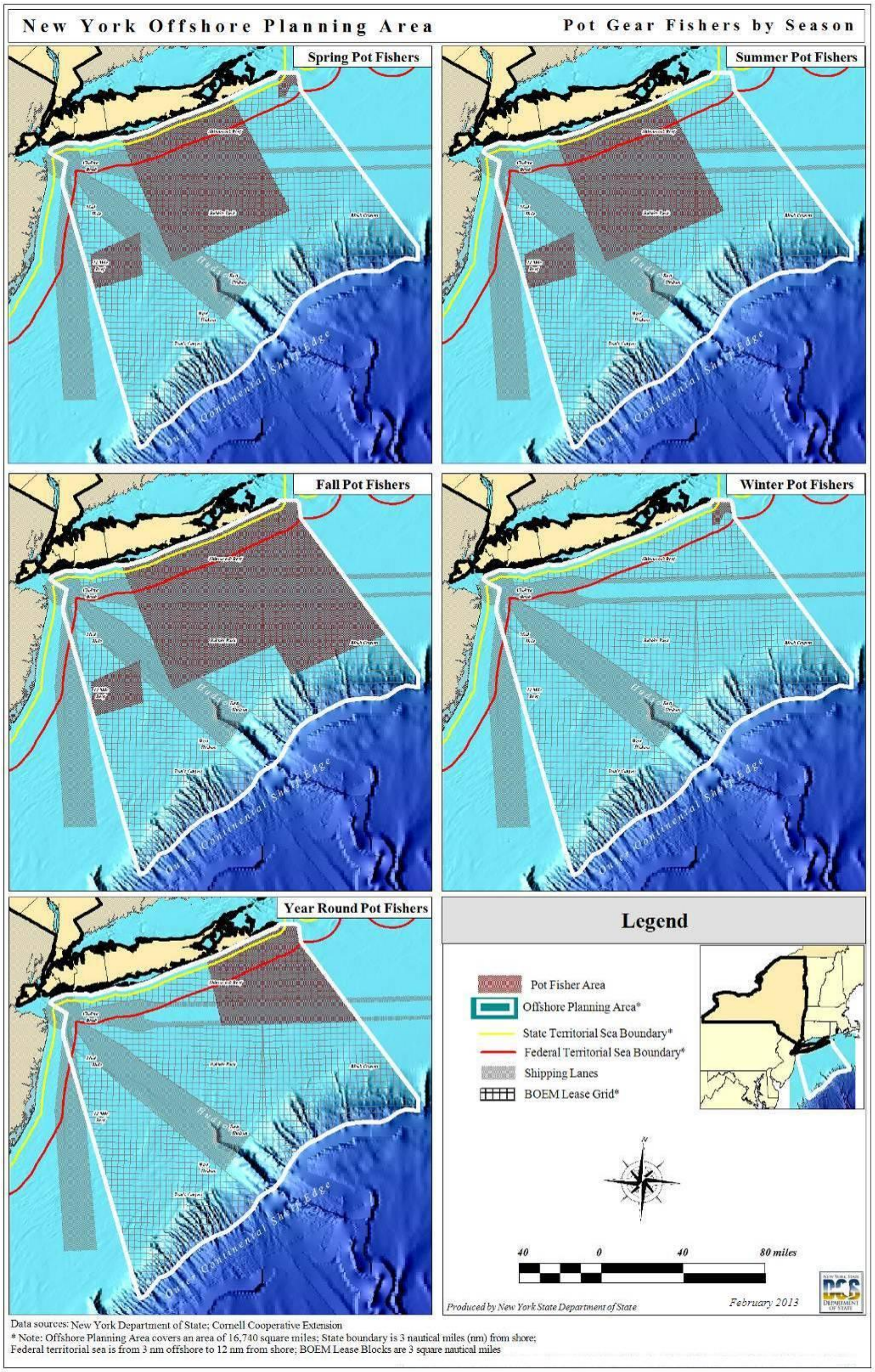

Figure 66: Commercial Fishing – Pot Gear Fishers by Season

This map aggregates information collected from New York-based commercial fishers using pot gear (e.g., lobster traps, fish traps, etc.) who participated in information gathering sessions with CCE.

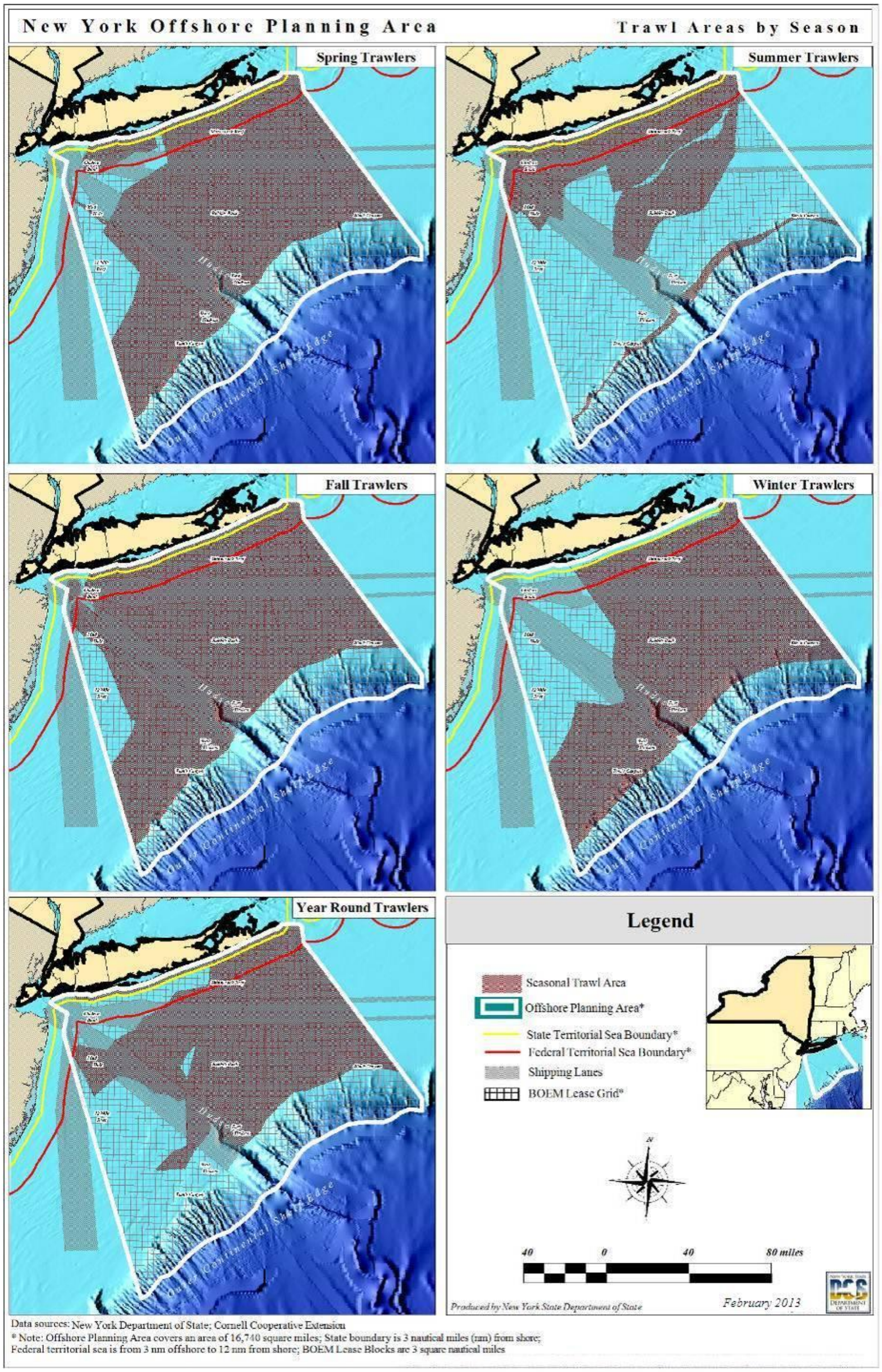

Figure 67: Commercial Fishing – Trawl Areas by Season

This map aggregates information collected from New York-based commercial fishers using trawl gear. In addition to seasonal trawling information above, some trawlers identified themselves as year-round users, shown in the bottom left map.

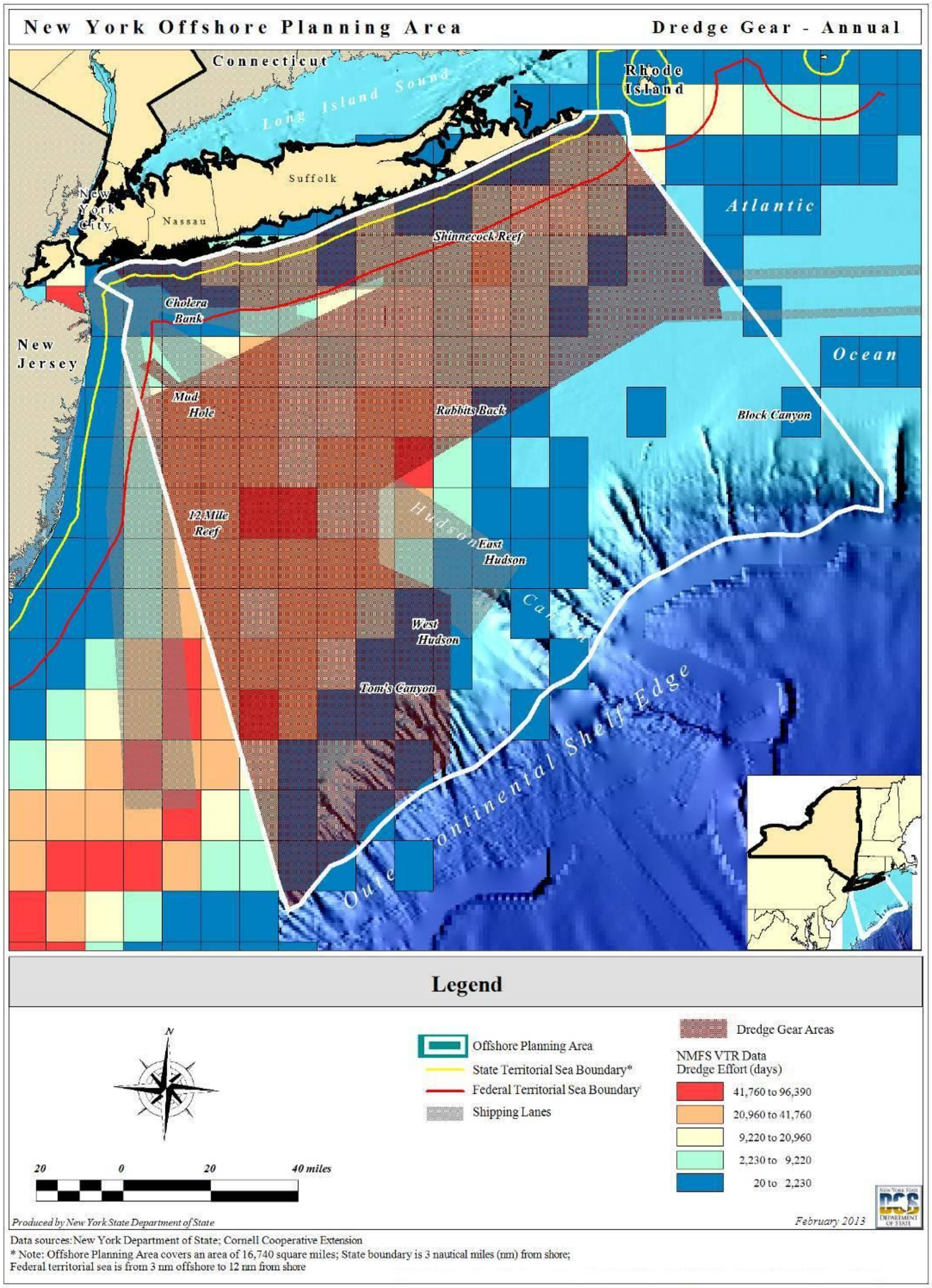

Figure 68: Commercial Fishing – Dredge Gear – Annual

This map aggregates information collected from New York-based commercial fishers using dredge gear who participated in one-on-one information gathering sessions with CCE and combines it with NMFS NEFSC VTR data.

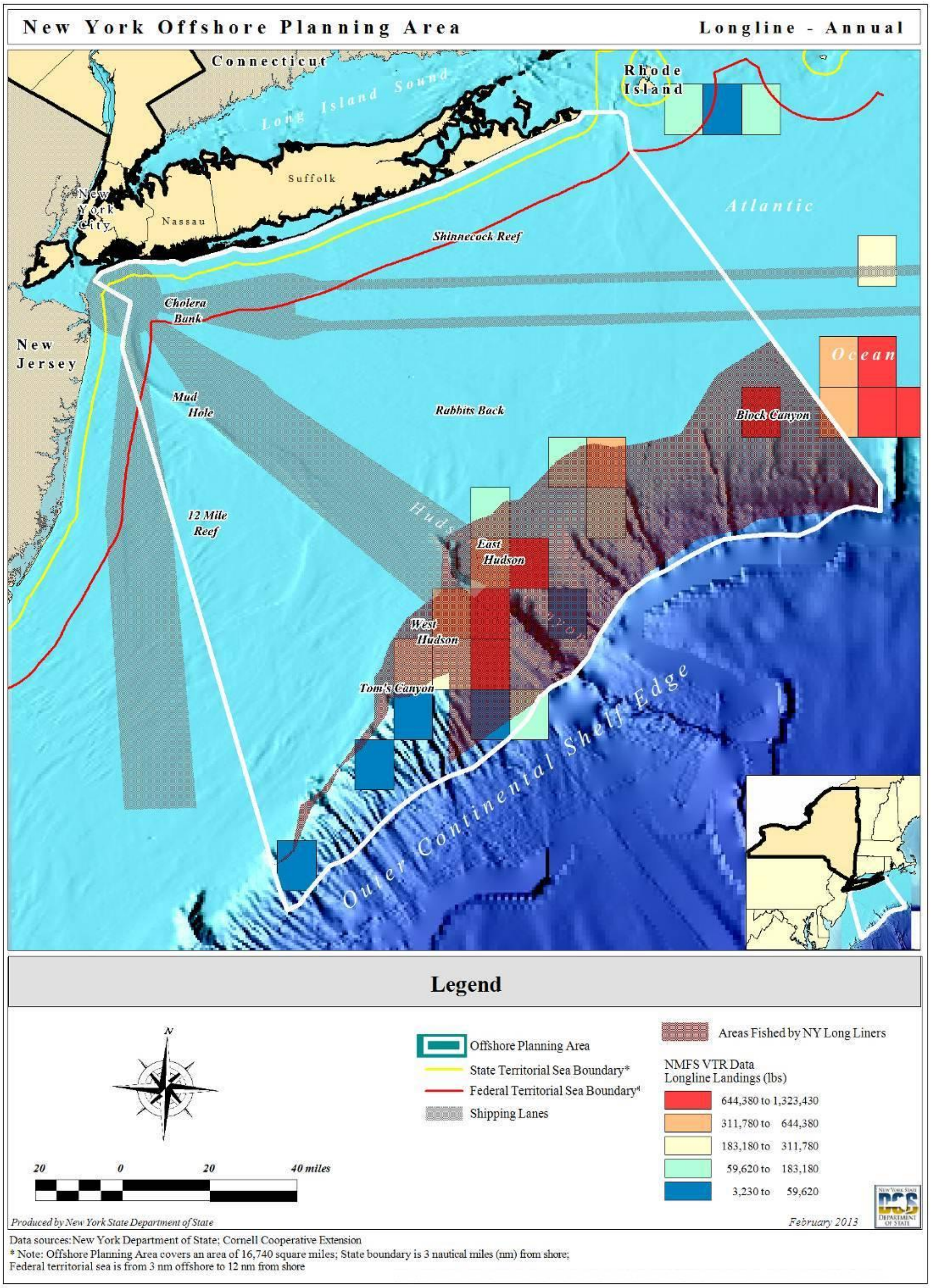

Figure 69: Commercial Fishing – Long Liner – Annual

This map aggregates information collected from New York-based commercial fishers using long line gear who participated in one-on-one information gathering sessions with CCE and combines it with NMFS NEFSC VTR data.

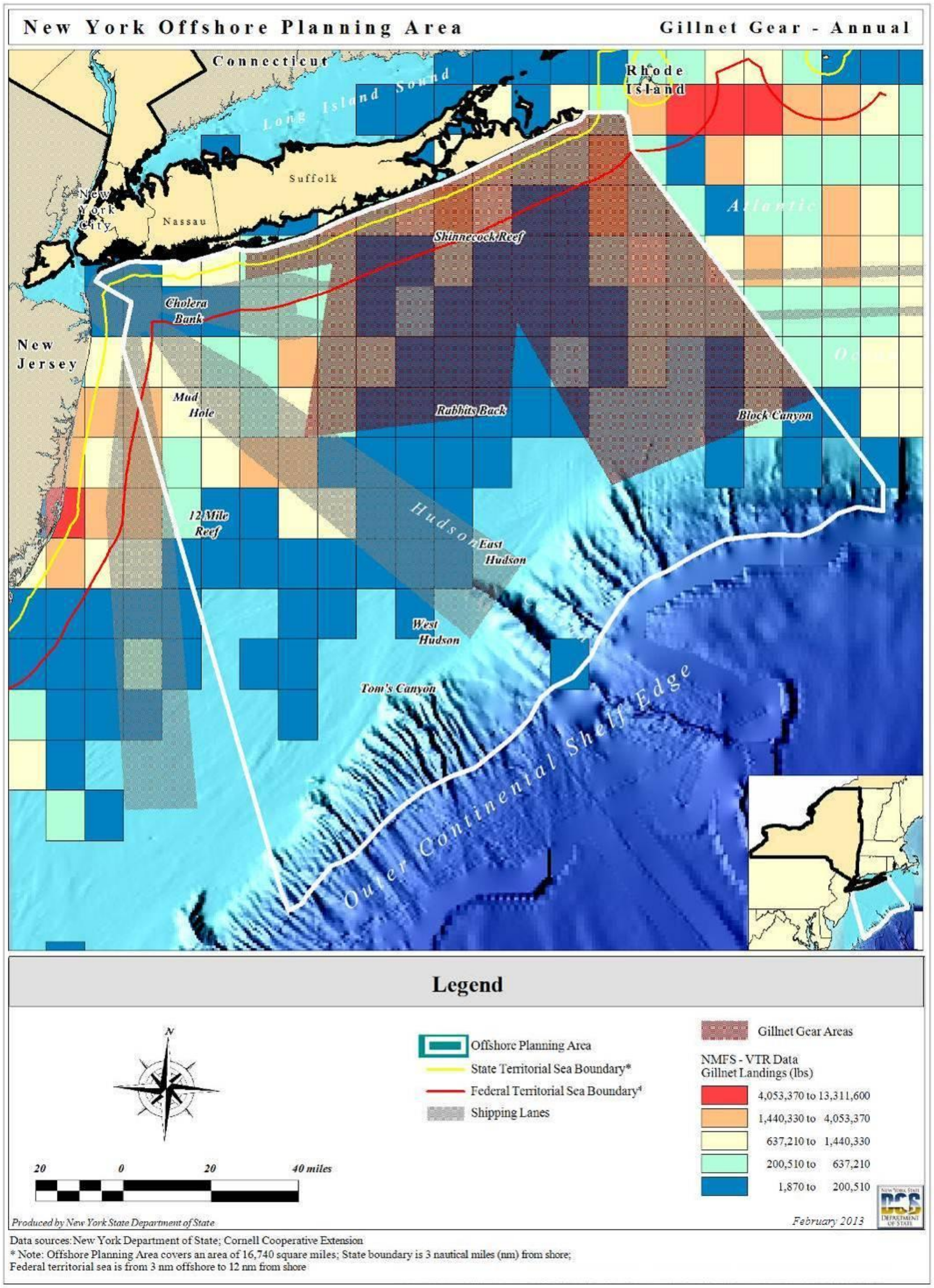

Figure 70: Commercial Fishing – Gillnet Gear – Annual

This map aggregates information collected from New York-based commercial fishers using gillnet gear who participated in one-on-one information gathering sessions with CCE and combines it with NMFS NEFSC VTR data. New York gillnet fishers use areas in the northeast quadrant of the offshore planning area, with the offshore extent limited by depth.

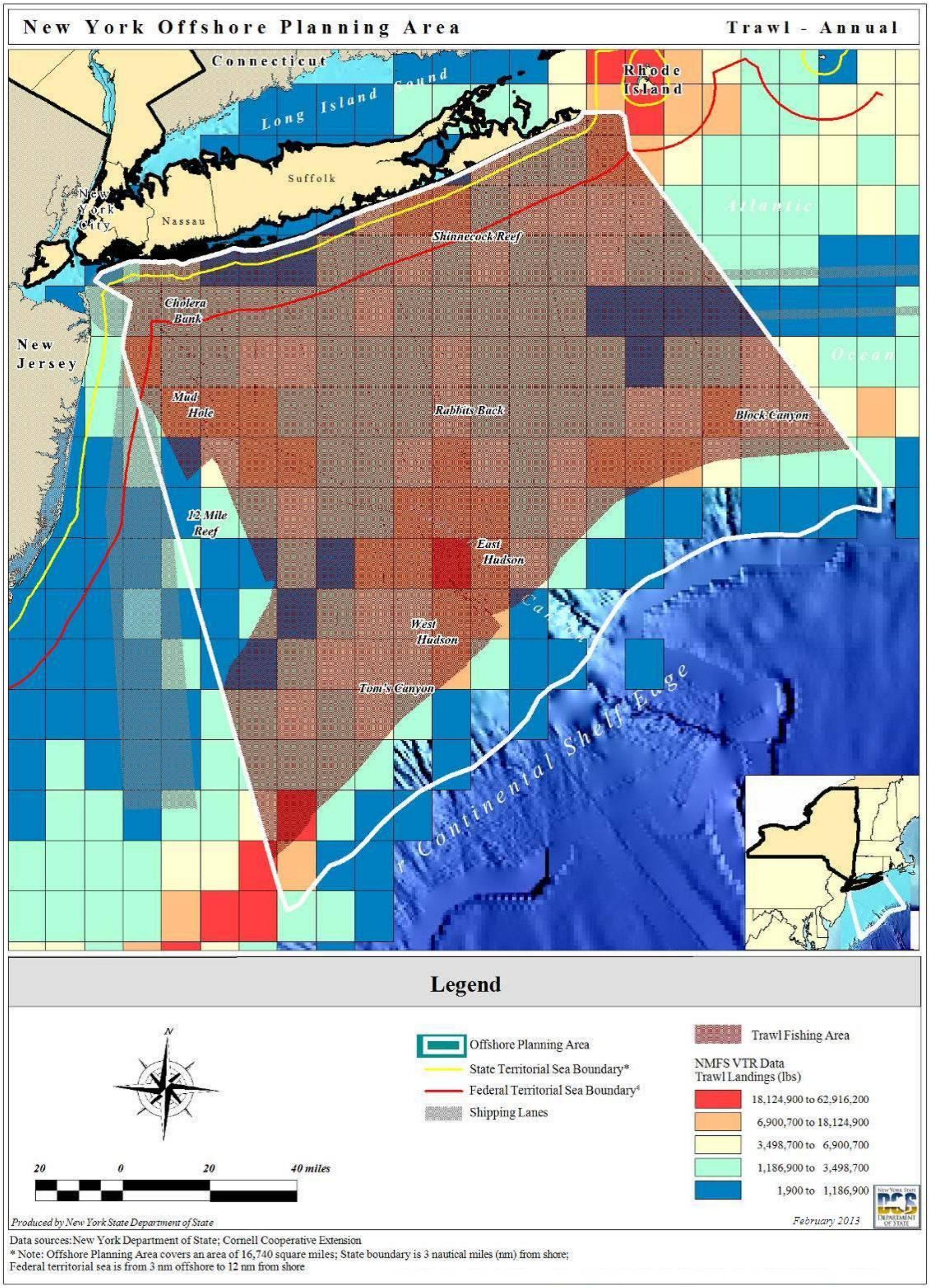

Figure 71: Commercial Fishing – Trawl – Annual

This map aggregates information collected from New York-based commercial fishers using trawl gear who participated in information gathering sessions with CCE and combines it with NMFS NEFSC VTR data.

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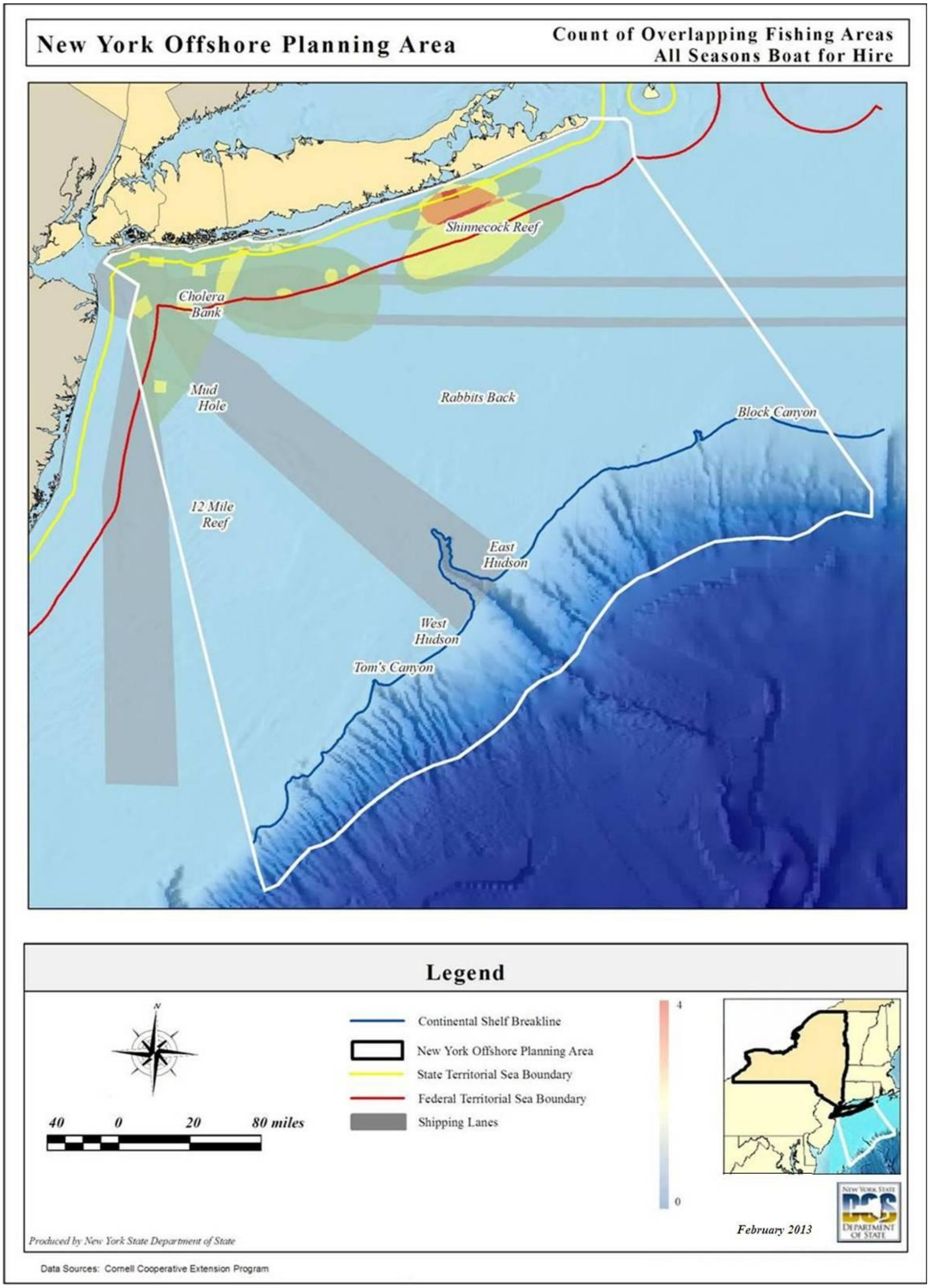

Figure 72: All Seasons Boat-for-Hire

This map shows fishing areas identified from CCE survey work with New York boat-for-hire operators. Colors indicate the locations identified, and number of overlapping areas.

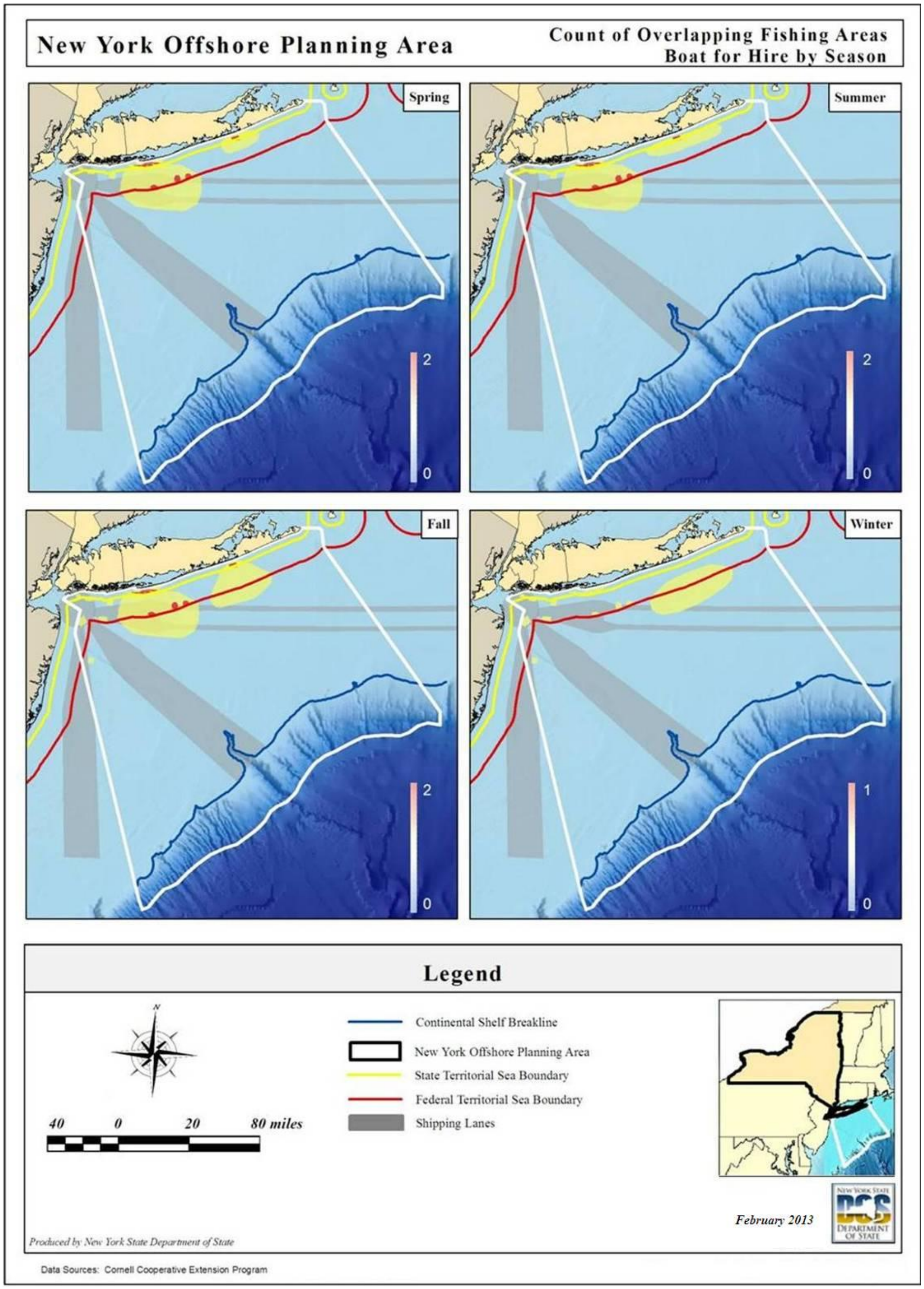

Figure 73: Boat-for-Hire by Season

This map shows those areas identified from CCE survey work with New York boat-for-hire operators. Colors indicate the locations identified, and number of overlapping areas. Red areas in the spring, summer and fall indicate two operators fishing in an area; yellow indicates one operator fishing in an area. These maps are based on 18 records, representing four individual operators and eight vessels.

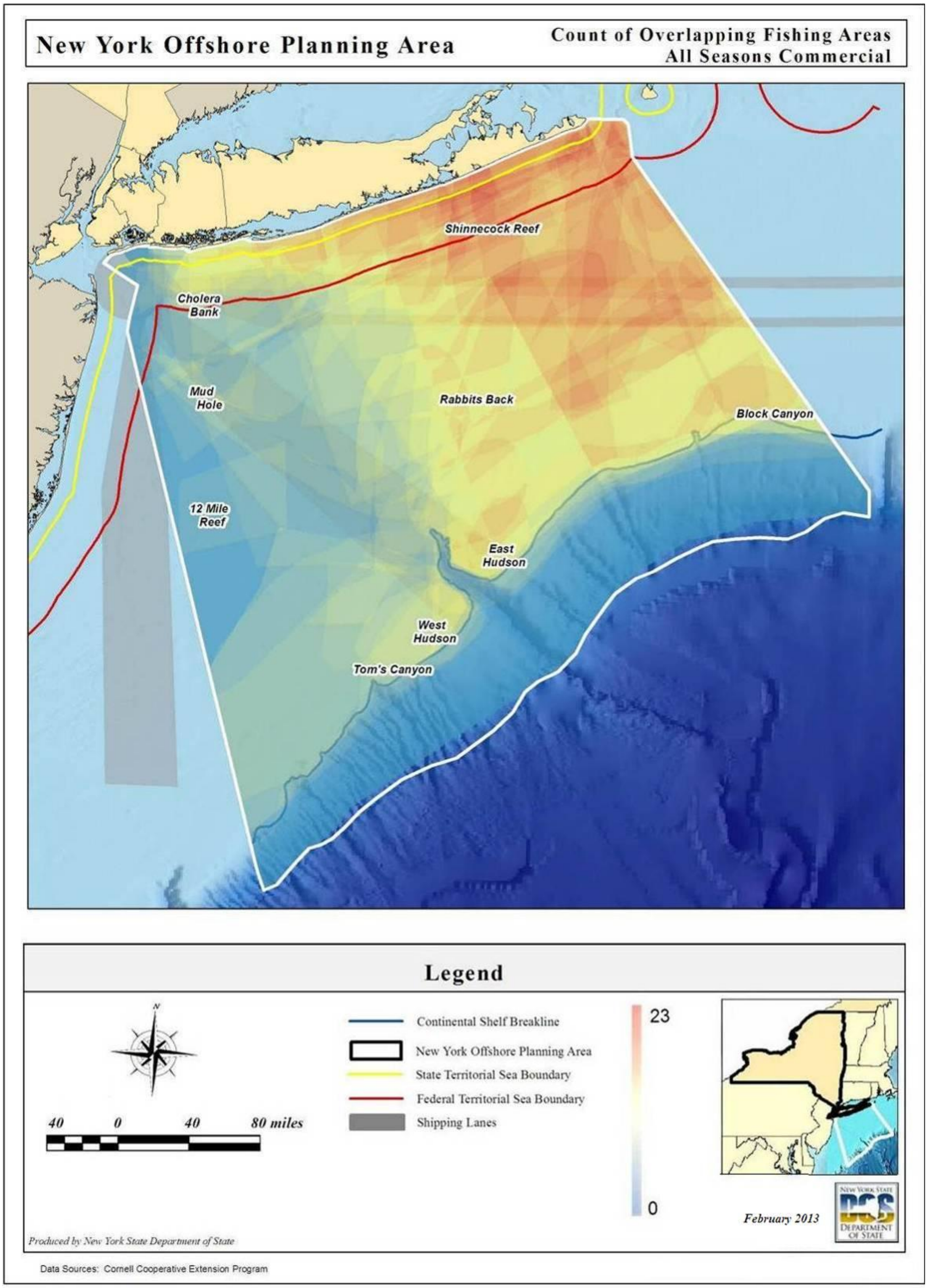

Figure 74: All Seasons Commercial

This map shows those areas identified from CCE survey work with New York commercial fishers. Colors indicate the locations identified, and number of overlapping areas. Names refer to place names used by New York commercial fishers.

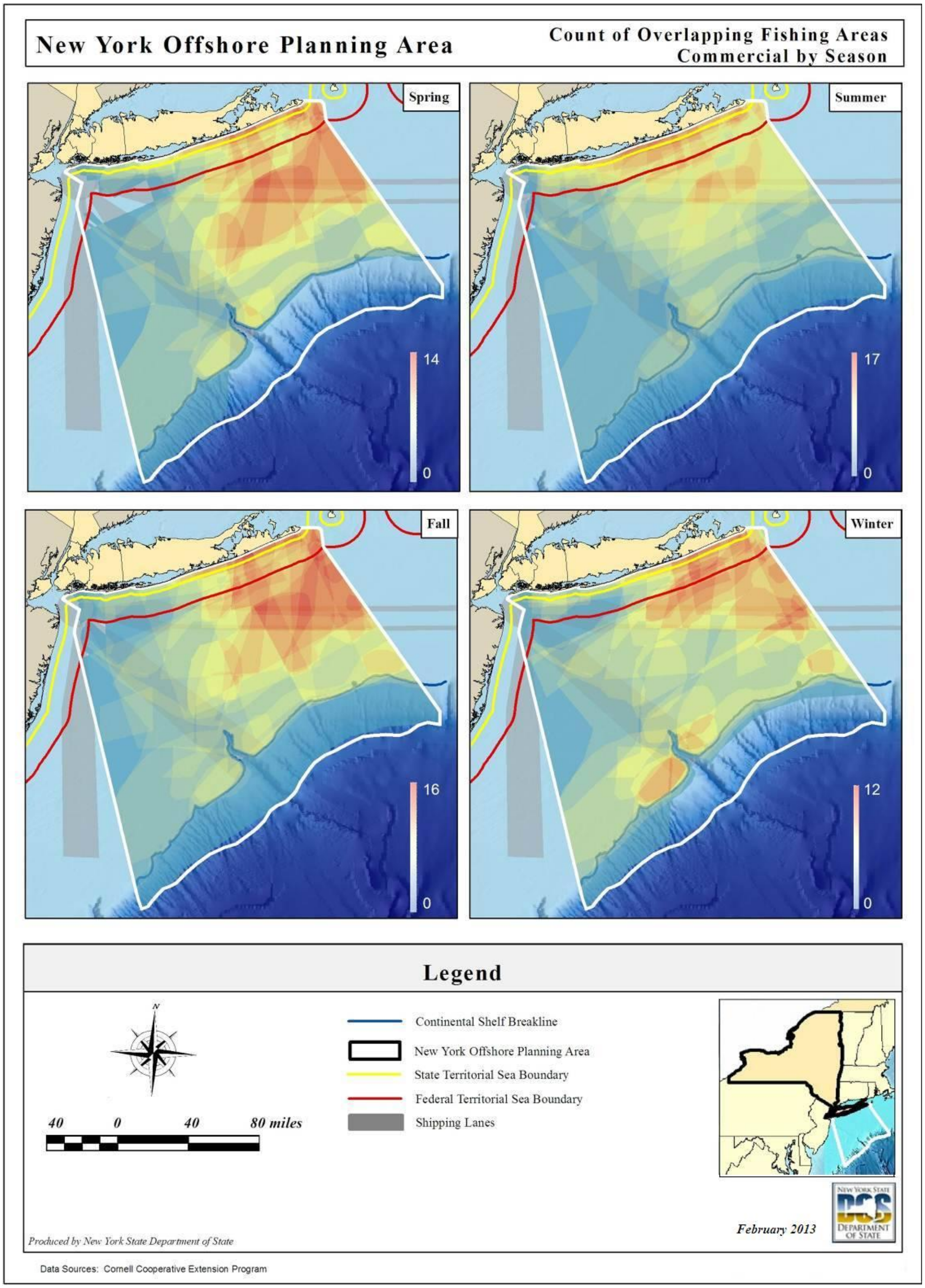

Figure 75: Commercial Fishing by Season

This map shows those areas identified from CCE survey work with New York commercial fishers. Colors indicate the locations identified, and number of overlapping areas (e.g., red areas range from a high of 12 overlapping areas fished during the winter to 17 overlapping areas in the summer).

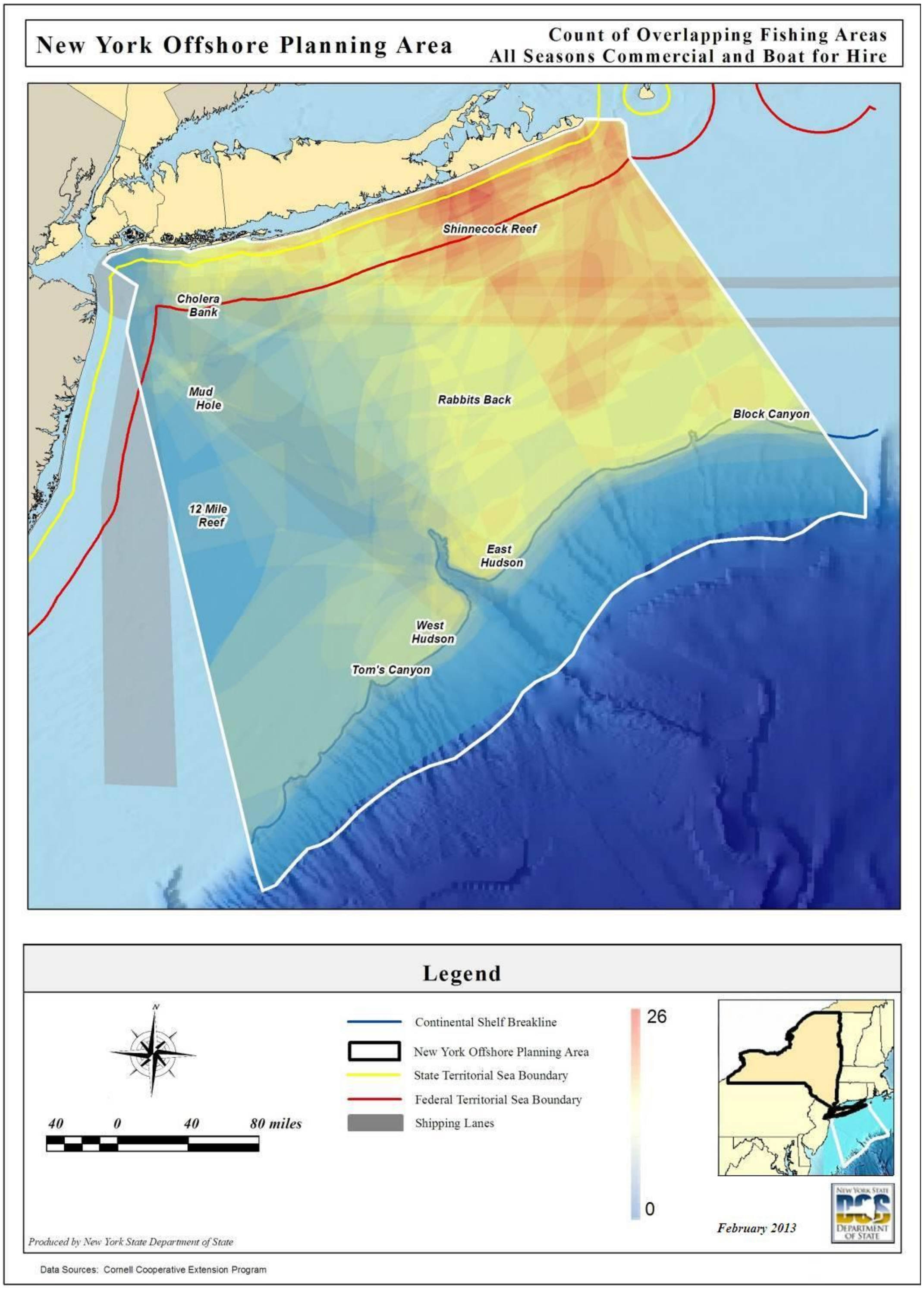

Figure 76: All Seasons Commercial and Boat-for-Hire
Data from CCE survey work with New York commercial fishers and boat-for-hire operators. This map shows those areas identified. Colors are used to indicate the locations identified, and number of overlapping areas (e.g., red areas indicate that 26 fishers identified areas that overlap in these locations). Names refer to place names used by New York commercial fishers.

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3. Commercial Vessel Traffic

(Figure 77)

The offshore planning area is heavily used by commercial shippers.[65] Large ocean-going vessels carrying bulk materials, container ships, and barge and medium-sized ships travelling along the coast transit the offshore planning area. The USCG requires all vessels with a gross tonnage of 300 tons or more and all passenger ships with a gross tonnage over 150 tons, to carry Automated Information System (AIS) equipment to identify, locate and electronically exchange information with other nearby ships.[66]

AIS information includes an identification number unique to each vessel, and data on vessel position, course and speed, all of which can be displayed on a computer screen and in a GIS dataset. AIS data are a time series of data points, each representing a vessel's location (in xy coordinates) at the time that the vessel transmitted its location. Datasets of AIS information are typically extremely large consisting of millions of point locations and associated information (e.g., Vessel ID#, course, speed) and usually require an intense level of synthesizing in order to render a map or image that is meaningful.

The USCG has initiated a significant effort to better understand existing commercial vessel traffic patterns along the Atlantic Coast. The Atlantic Coast Port Access Route Study (ACPARS) will be used, in part, to assess potential effects of new offshore wind energy facility installations on vessel movement. As part of the ACPARS-related analysis, the USCG is synthesizing AIS information and analyzing large-scale vessel traffic patterns, and making the resultant maps publicly available.[67]

Figure 77 shows ship track intensity offshore New York using ACPARS data. Designated navigation traffic lanes are quite visible as highly-used areas, but also readily apparent is significant coast-wise traffic that can be seen within the federal territorial sea limit of 12 miles from shore.

Patterns of commercial vessel usage are expected to change following the completion of the expansion of the Panama Canal. In its ACPARS effort the USCG has acknowledged these forthcoming changes, which is expected to include increased vessel traffic in and out of the Port of New York and the handful of other Atlantic Coast ports that can accommodate larger post-Panamax vessels. Expansion of port activity would likely have significant economic benefits to New York.

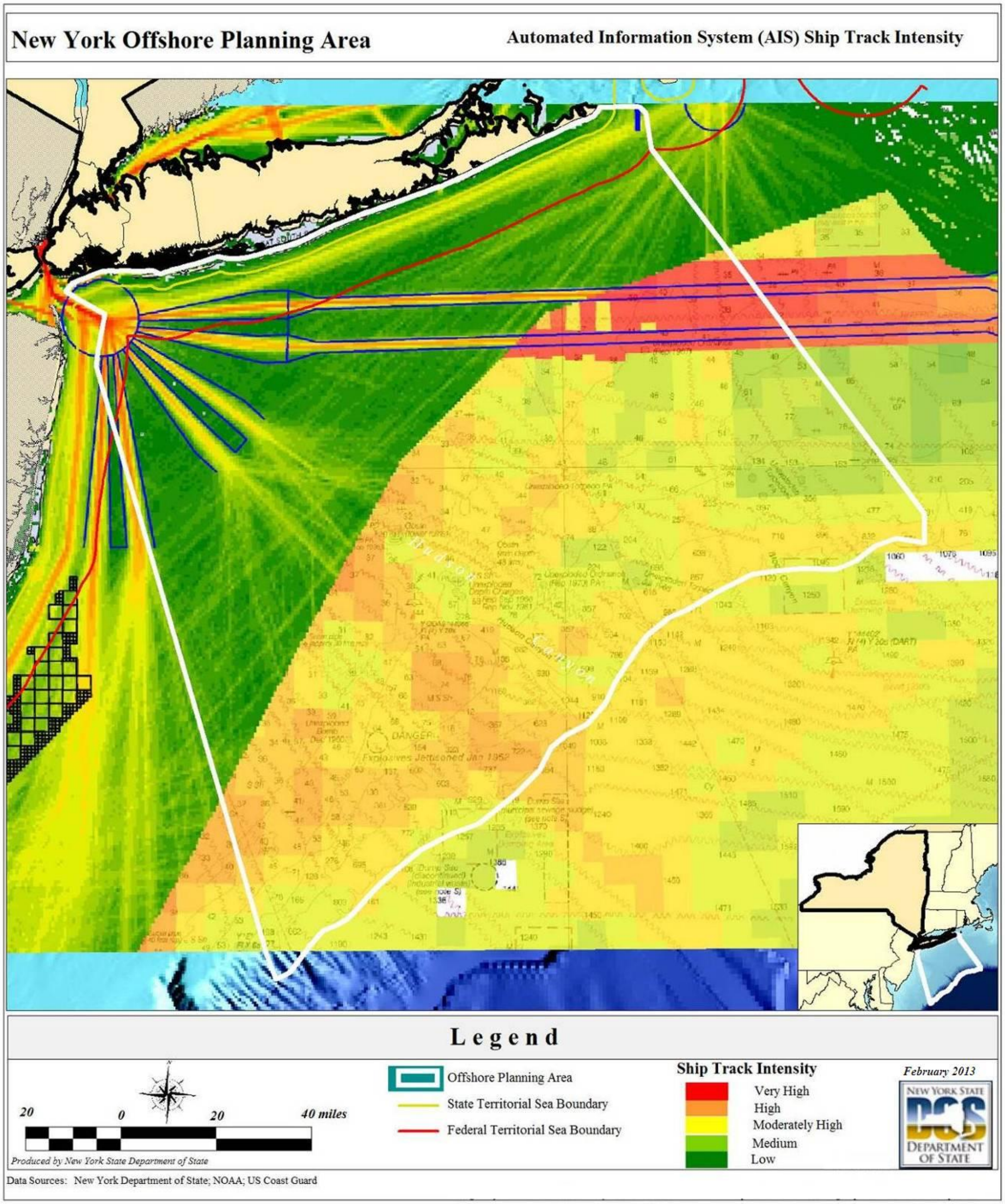

Figure 77: Coast Guard "Heat" Map

In this synthesis of AIS ship tracking information provided by the USCG through the ACPARS, increased traffic patterns can be seen within established navigation lanes. Significant coast-wise traffic can also be seen between the shore and the red federal territorial sea boundary.

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F. Selected Data Overlays

Through the Offshore Renewable Energy Work Group and Offshore Habitat Work Group, DOS is determining the most useful spatial data necessary to site new wind energy projects and identify important offshore habitats, respectively. Using the data and information in this study, DOS is developing data overlays that reflect the discussions of both Work Groups. These overlays are presented below as a launching point for future consultations with ocean users, the respective federal agencies of jurisdiction, and other potentially affected stakeholders.

1. Initial Wind Siting Data

(Figure 78)

In consultation with state and federal agencies and consistent with recent findings,[68] DOS is pre-screening the offshore planning area to identify those locations that appear most compatible with offshore wind development activities. Since the strongest and most consistent winds are farther offshore, in OCS waters, DOS's offshore wind planning effort is intended to align not only with existing State efforts but also with the federal offshore leasing and licensing process.[69]

As a first step, in consultation with the Offshore Renewable Energy Work Group, DOS identified initial uses and resources that are known or assumed to be incompatible with offshore wind energy generation or transmission. DOS staff reviewed federal, state, industry, and consultant literature[70] to identify potential uses and resource incompatibilities, based on the planning efforts of other States. The resulting list formed the basis of the "baseline criteria", the initial exclusion areas listed below and used for planning purposes to pre-screen sites (Figure 78). As the next step in this pre-screening, DOS will continue to evaluate additional siting constraints, based on the use and resource data in this study, that may also limit a site's suitability for development or make the site less desirable for commercial wind development. The identification of these constraints and their locations within the offshore planning area will help DOS better assess the "technical potential", or upper bound, of the developable offshore wind resource within the offshore planning area. As defined by the U.S. Department of Energy's classification system for renewable energy potential,[71] technical potential addresses the system/topographic and ocean use constraints, as well as system performance, but does not include market or economic considerations. Consistent with this approach, in developing baseline criteria DOS is not considering cost or the availability of equipment or components as limiting factors.

The initial exclusion areas, as defined by the baseline criteria, include the following:

Electrical Generation Turbines and Substation/Conversion Facilities are excluded within

- 12 nm of shore (turbines only)
- Established navigation lanes and within a one nautical mile buffer of those lanes
- Airport approaches (turbines only)
- Hazardous material disposal sites
- Other discrete areas to be determined

Transmission Cables are excluded within

- Hazardous material disposal sites
- Other discrete areas to be determined

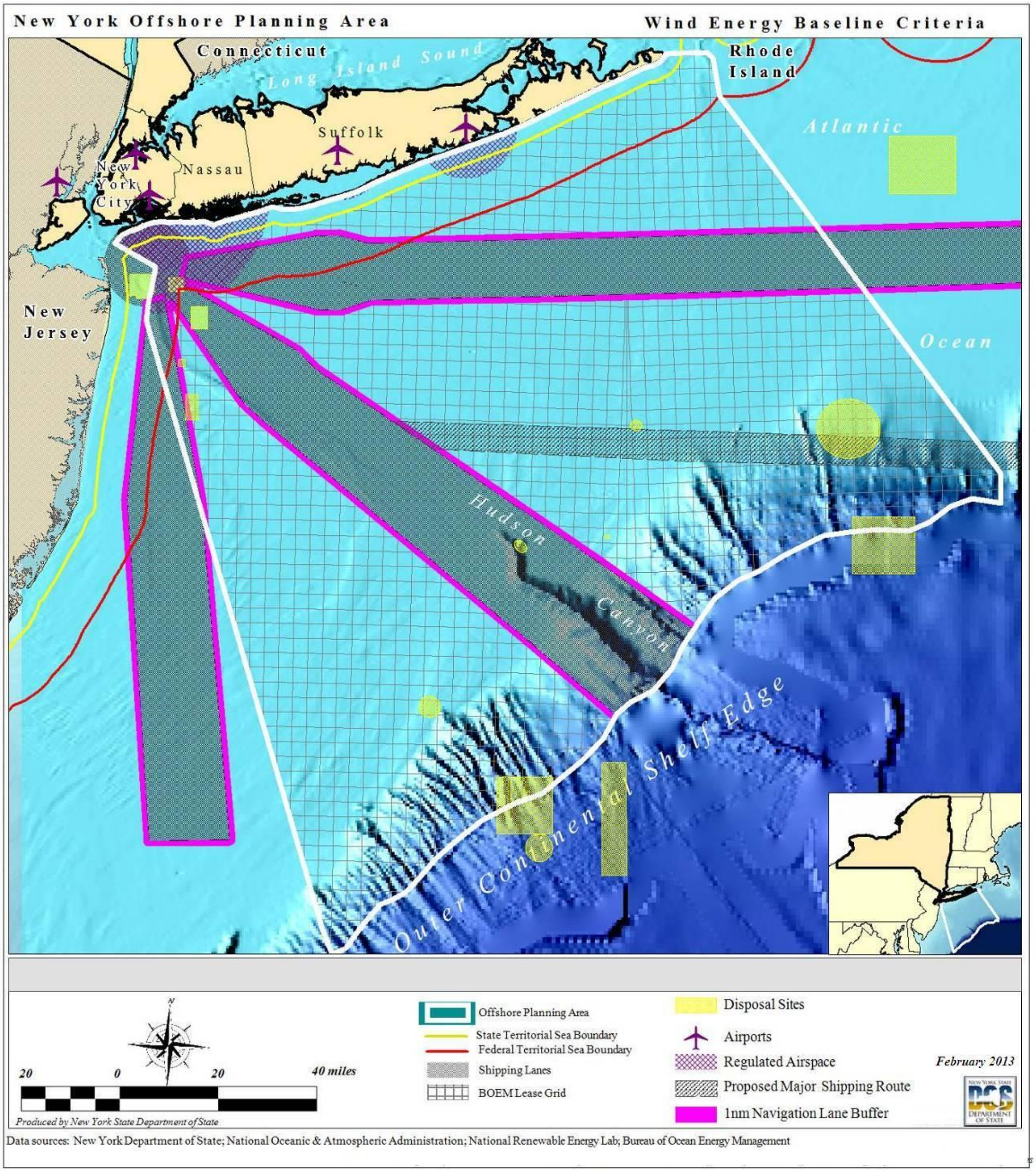

Figure 78: Wind Energy Baseline Criteria
This map displays categories of information, or criteria, considered by the Offshore Renewable Energy Work Group as areas unlikely to be favorable for offshore wind turbine development. The USCG has suggested a one nautical mile buffer around navigation lanes, represented by the pink area surrounding the navigation lanes.

2. Initial Habitat Identification Data
*(Figure 79-
Figure 81)*

In consultation with the Offshore Habitat Work Group, DOS collected and combined species' predicted relative abundance and distribution data layers to begin to identify potential habitat areas important for commercial fishing and other uses. Predictive methods differed between seabird, marine mammal/sea turtle, and groundfish taxa. To address these disparities among datasets, DOS selected the top interval for each data layer to identify areas most important to each species or group. In the case of deep sea corals and sponges, areas were drawn to capture locations with the highest observation density.

The Offshore Habitat Work Group examined a wide range of natural resource data, modeled using different statistical tools to develop (in most cases) predicted relative abundance maps for certain species. DOS chose an equal-interval classification scheme to summarize the map data for display and overlay purposes. Specifically, the range of predicted abundance values for each species was divided into five equal-sized intervals, and the top interval was retained. This method was applied to seasonal (when available) and annual datasets. DOS overlaid these top interval areas together to examine seasonal and annual patterns of predicted abundance within the offshore planning area across various groups of species. For example, Figure 79 depicts the top intervals of predicted seabird species abundance, richness, and diversity using annual data. The abundance map in Figure 79 suggests nearshore areas are home to the highest raw number of birds, and the richness map suggests the greatest number of species may be found in a band between the shore and continental slope. This likely reflects the overlap between coastal and pelagic seabird distributions. The diversity map highlights areas along the continental slope in addition to areas revealed by the abundance and richness maps. The hotspots map shows an overlay of all three maps together (abundance, richness, and diversity), revealing general seabird geographic patterns in the region. Note that while DOS received species abundance, richness, and species diversity data for seabirds, DOS only received abundance data for most other taxa.

DOS selected representative species and groupings of species relevant to New York's coastal ecosystems and economies. Data layers in Figures 80 and 81 are therefore the result of two refinements and represent relatively abundant, rich, or diverse areas. Where these data layers overlap, important ecological areas may be inferred. Seasonally important areas could have been masked by combining and modeling solely on an annual basis. Therefore, this overlay was done on both a seasonal (Figure 80) and annual basis (Figure 81). To the extent that these data layers are indicative of broader ecological trends, Figure 80 and 81 help identify areas with important habitat characteristics based on the best available information. In particular, Figure 81 may suggest that the shelf edge comprises important habitat for both a high number and high variety of species on an annual basis. Ongoing analysis of these and future expected data will help to identify resource areas important to New York.

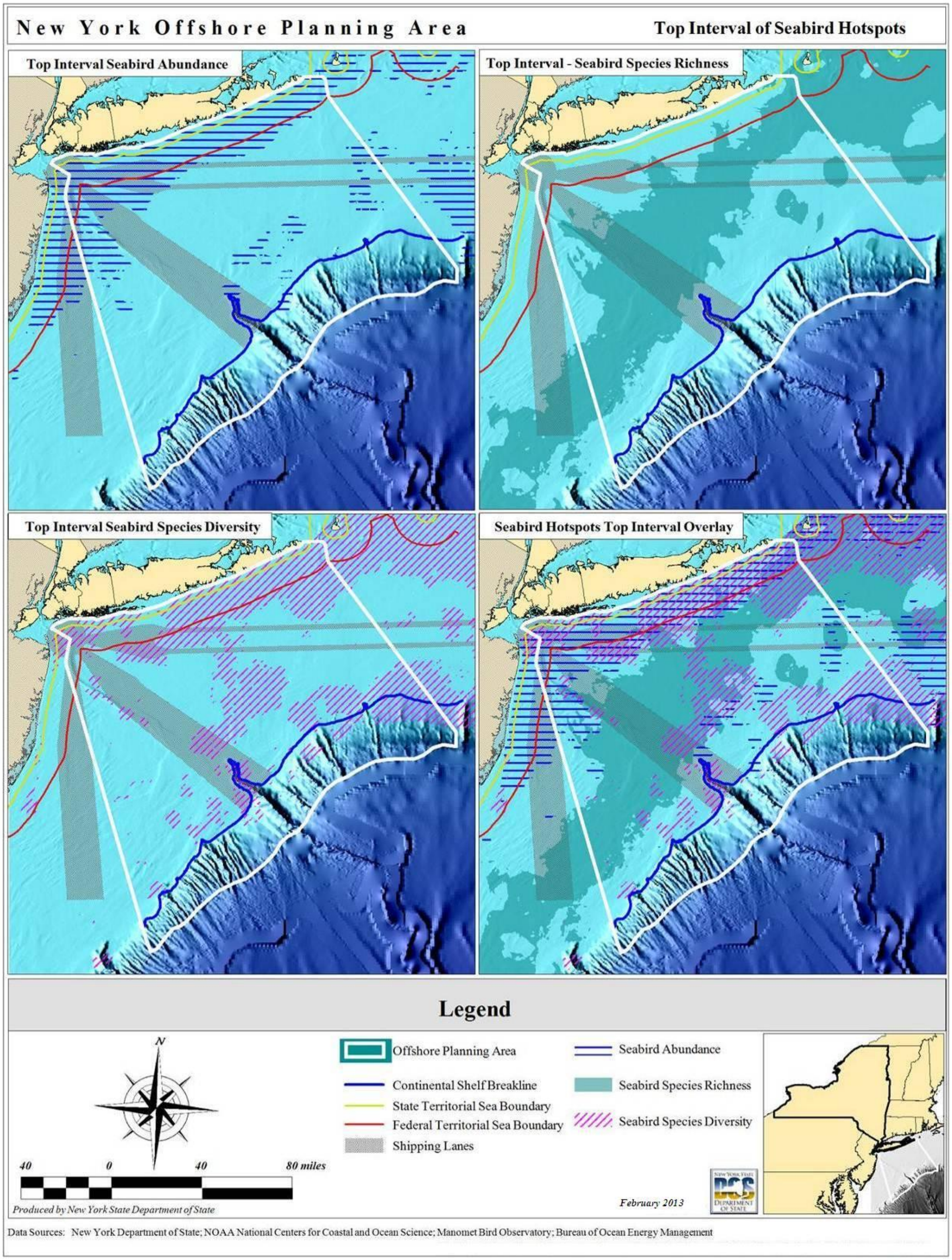

Figure 79: Seabird Annual Data Top Intervals and Overlay

This map series shows the construction of a natural resource overlay (lower right corner) through its component pieces.

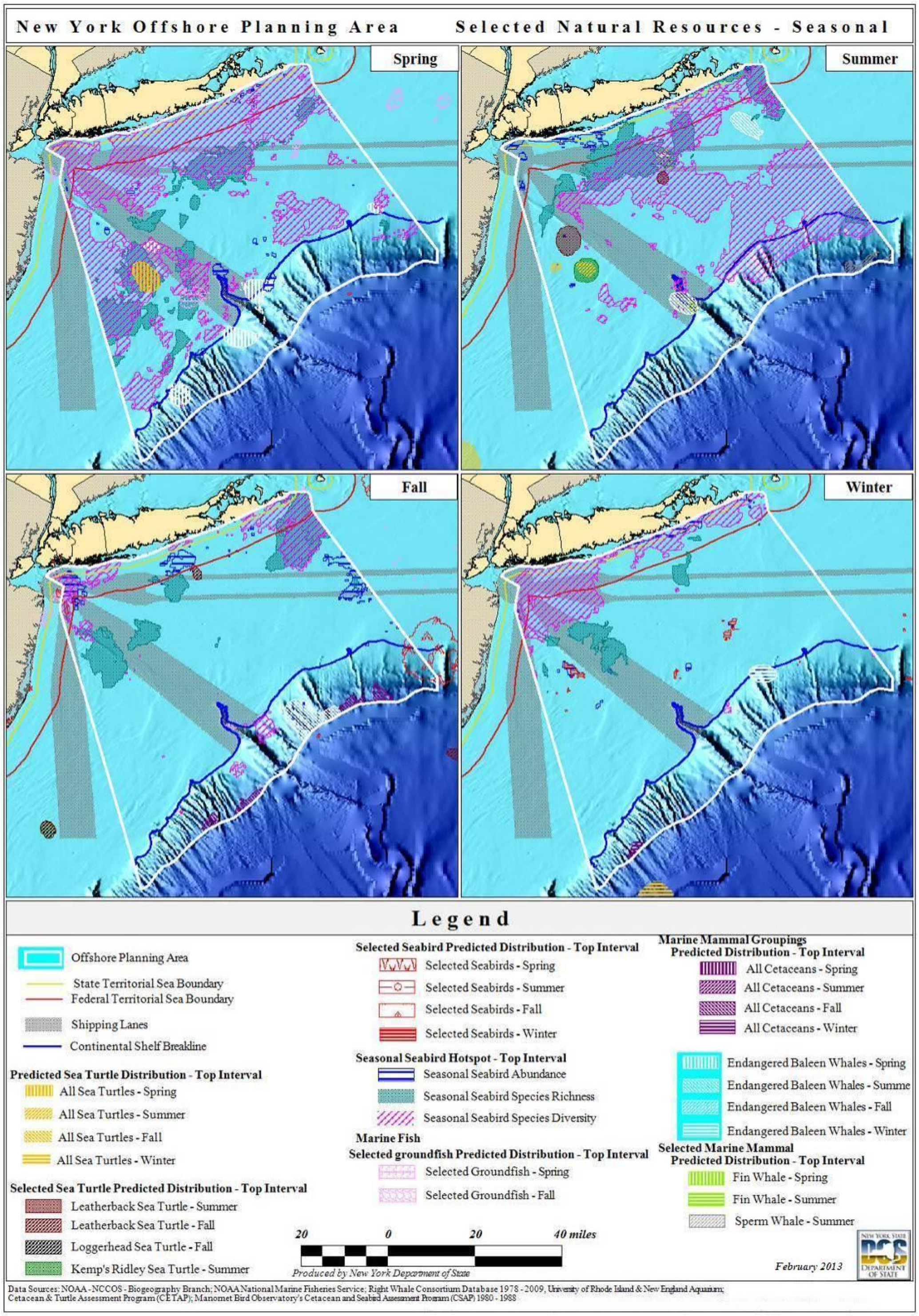

Figure 80: Natural Resources – Seasonal

This map aggregates seasonal relative abundance and distribution predictions of natural resources information, including sea turtles, seabirds, fish and marine mammals, from various sources previously mentioned.

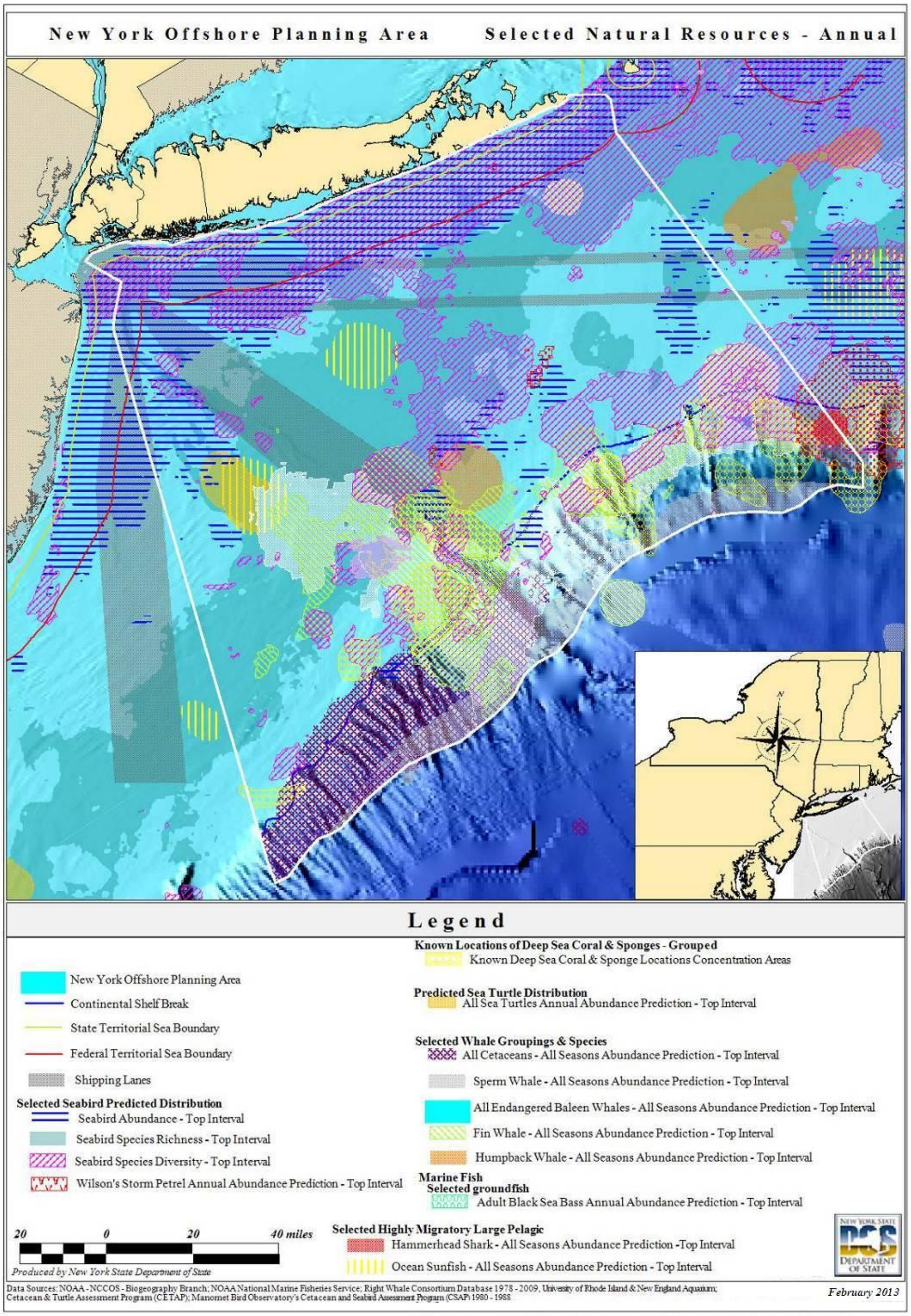

Figure 81: Natural Resources – Annual

This map aggregates annual relative abundance and distribution predictions of natural resources information, including sea turtles, seabirds, fish, and marine mammals, and deep sea coral and sponge observations, from various sources. The map shows that diverse natural resource areas occur along the continental shelf edge and mid-shelf south of the Hudson Shelf Valley.

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III. List of Acronyms

The following is a list of acronyms used throughout this document.

ACPARS	Atlantic Coast Port Access Route Study
AIS	Automated Information System
BOEM	Bureau of Ocean Energy Management
CCE	Cornell Cooperative Extension of Suffolk County
CRM	Coastal Relief Model
CSAP	Cetacean and Seabird Assessment Program
CSC	Coastal Services Center
CZMA	Coastal Zone Management Act
DOI	U.S. Department of the Interior
DOS	New York State Department of State
ENC	Electronic Navigation Chart
NARWC	North Atlantic Right Whale Consortium
NCCOS	National Centers for Coastal Ocean Science
NEA	New England Aquarium
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
OCS	Outer Continental Shelf
pGIS	participatory Geographic Information System
SPUE	Sightings Per Unit Effort

SST Sea Surface Temperature

USCG U.S Coast Guard

VTR Vessel Trip Report

IV. Detailed Methodology

A. Introduction

The material included in this Section provides a more detailed version of the methodologies used to develop the predictive models that were discussed more generally in the New York Department of State's (DOS) Offshore Atlantic Ocean Study. In particular, the below provides information on statistical analyses undertaken by DOS to better understand the certainty of models used by the National Oceanic and Atmospheric Administration (NOAA) National Center for Coastal and Ocean Science (NCCOS), the New England Aquarium, and Stone Environmental.

B. Methods

1. Substrate

NCCOS developed predictive models of mean sediment grain size and the probability of hard bottom occurrence for DOS's offshore planning area.[72] Predictions were made on a 30 arc-second geographic grid.

NCCOS obtained mean grain size data from Dr. John Goff,[73] who obtained data from the publicly available usSEABED Atlantic Coast Offshore Surficial Sediment Data Release and applied bias corrections and quality control procedures. Using the same general geostatistical modeling approach they applied to the bathymetric data, NCCOS created a continuous surface for surficial sediment mean grain size from scattered sediment survey point data. NCCOS also compiled an integrated point dataset of known hard bottom locations from the usSEABED database, the NOAA and U.S. Coast and Geodetic Survey Bottom Type Descriptions from Hydrographic Surveys database, and a database of usSEABED and National Marine Fisheries Service (NMFS) surveys compiled by The Nature Conservancy. Points in densely-surveyed nearshore areas were removed to create a dataset with more uniformly-distributed sampling effort. Because hard bottom data did not include absences, geostatistical methods similar to those used for bathymetric modelling were inappropriate. Thus, a maximum entropy (MaxEnt) model was used to predict the likelihood of hard bottom occurrence based on known locations and potential predictor variables. Eighty percent of the hard bottom presence points were used to train the model and 20% were randomly withheld for testing. A number of predictor importance metrics were calculated within the MaxEnt software, and model performance was evaluated by qualitative comparison to an independent sidescan sonar dataset and cross-validation on the 20% of data withheld for testing. DOS selected areas with a high likelihood of hardbottom occurrence and overlaid them on a map of predicted mean grain size for context.[74]

Mapping seafloor features, including sediment characteristics and distribution, provides crucial information for a number of offshore activities. Like bathymetric data, other seafloor data can be used to help identify habitat areas for benthic organisms (e.g., corals, and groundfish), select appropriate offshore wind development sites, and plan sand/gravel mining operations.

The new NCCOS models build upon existing data compilations and analytical frameworks. The mean grain size model provides a continuous prediction map and corresponding certainty estimates. The hard bottom occurrence model also provides a continuous prediction map representing the likelihood of hard bottom occurrence.

Mean grain size model certainty was poorer in areas offshore of the continental shelf break vs. nearshore areas, reflecting the paucity of surveys past the offshore shelf break. Overall cross-validation results yielded reasonable performance (root-mean-square error or RMSE of 1.4 φ) given the measurement error inherent to the grain size samples (1.0 φ). Qualitative comparison to a U.S. Geological Service (USGS) backscatter map suggested a good, albeit imperfect, matchup.[75] Note that mean grain size predictions are likely biased toward finer particles due to issues with sediment sample processing.

Hard bottom likelihood was high in nearshore areas and in the vicinity of canyon features. It is important to note that the model provides a relative likelihood of at least one hard bottom point occurring at a given location, and that these points may be in areas predominated by non-hard bottom (e.g. sandy) substrate. Model performance was good in tests of both cross-validation (test area under the curve or AUC value of 0.73) and comparison to the independent backscatter dataset.[76] Nonetheless, any model based on presence-only data should be approached with caution.

2. Marine Mammals and Sea Turtles

Marine Mammal and Sea Turtle Species Examined by DOS as Modeled by NEA: loggerhead sea turtle, Risso's dolphin, bottlenose dolphin, short-beaked common dolphin, fin whale, pilot whale, sperm whale, harbor porpoise, leatherback sea turtle, Atlantic white-sided dolphin, common minke whale, Kemp's ridley sea turtle, striped dolphin, humpback whale, spotted dolphin, harbor seal, North Atlantic right whale, beaked whale, sei whale, Cuvier's beaked whale, green sea turtle, Sowerby's beaked whale, Atlantic spotted dolphin, killer whale, white-beaked dolphin, hawksbill sea turtle, northern bottlenose whale, pygmy sperm whale, pygmy killer whale.

*Individual species may have been pooled into larger taxonomic groups for modeling (e.g. "all protected species", "all cetaceans", "endangered baleen whales", "small toothed whales", etc.)

The North Atlantic Right Whale Consortium (NARWC) database, managed by Dr. Robert Kenney at the University of Rhode Island and funded by NMFS, contains thousands of aerial and shipboard survey observations from 1978-2011 for marine mammals and sea turtles in southern New England waters. Data extend into the New York study area and represent the majority of existing survey records for the region.[77] The NEA refined this database for DOS, selecting usable records and binning them by a regular grid of cells that had an area of

Figure 82: Pooled NARWC Records

Pooled species categories	N
<u>All protected species</u>: Atlantic spotted dolphin, beaked whale, bottlenose dolphin, fin whale, Cuvier's beaked whale, Risso's dolphin, green sea turtle, harbor porpoise, harbor seal, hawksbill sea turtle, humpback whale, killer whale, leatherback sea turtle, loggerhead sea turtle, common minke whale, northern bottlenose whale, pilot whale, pygmy sperm whale, pygmy killer whale, Kemp's ridley sea turtle, North Atlantic right whale, short-beaked common dolphin, sei whale, Sowerby's beaked whale, spotted dolphin, sperm whale, striped dolphin, unidentified *Balaenoptera*, unidentified blackfish, unidentified beaked whale, common or white-sided dolphin, unidentified dolphin/porpoise, fin or sei whale, bottlenose or spotted dolphin, unidentified Kogia, unidentified large whale, unidentified medium whale, unidentified rorqual (Balaenopteridae), unidentified seal, unidentified *Stenella*, unidentified sea turtle, unidentified whale, white-beaked dolphin, Atlantic white-sided dolphin	4980
<u>All marine mammals</u>: Atlantic spotted dolphin, beaked whale, bottlenose dolphin, fin whale, Cuvier's beaked whale, Risso's dolphin, harbor porpoise, harbor seal, humpback whale, killer whale, common minke whale, northern bottlenose whale, pilot whale, pygmy sperm whale, pygmy killer whale, North Atlantic right whale, short-beaked common dolphin, sei whale, Sowerby's beaked whale, spotted dolphin, sperm whale, striped dolphin, unidentified *Balaenoptera*, unidentified blackfish, unidentified beaked whale, common or white-sided dolphin, unidentified dolphin/porpoise, fin or sei whale, bottlenose or spotted dolphin, unidentified Kogia, unidentified large whale, unidentified medium whale, unidentified rorqual (Balaenopteridae), unidentified seal, unidentified *Stenella*, unidentified whale, white-beaked dolphin, Atlantic white-sided dolphin	3340
<u>All cetaceans</u>: Atlantic spotted dolphin, beaked whale, bottlenose dolphin, fin whale, Cuvier's beaked whale, Risso's dolphin, harbor porpoise, humpback whale, killer whale, common minke whale, northern bottlenose whale, pilot whale, pygmy sperm whale, pygmy killer whale, North Atlantic right whale, short-beaked common dolphin, sei whale, Sowerby's beaked whale, spotted dolphin, sperm whale, striped dolphin, unidentified *Balaenoptera*, unidentified blackfish, unidentified beaked whale, common or white-sided dolphin, unidentified dolphin/porpoise, fin or sei whale, bottlenose or spotted dolphin, unidentified Kogia, unidentified large whale, unidentified medium whale, unidentified rorqual (Balaenopteridae), unidentified *Stenella*, unidentified whale, white-beaked dolphin, Atlantic white-sided dolphin	3141
<u>All endangered & threatened species</u>: fin whale, green sea turtle, hawksbill sea turtle, humpback whale, leatherback sea turtle, loggerhead sea turtle, Kemp's ridley sea turtle, North Atlantic right whale, sei whale, sperm whale, unidentified *Balaenoptera*, fin or sei whale, unidentified large whale, unidentified rorqual (Balaenopteridae), unidentified sea turtle	2329

<u>Small toothed whales</u>: Atlantic spotted dolphin, bottlenose dolphin, Risso's dolphin, harbor porpoise, pilot whale, pygmy sperm whale, pygmy killer whale, short-beaked common dolphin, spotted dolphin, striped dolphin, unidentified blackfish, common or white-sided dolphin, unidentified dolphin/porpoise, bottlenose or spotted dolphin, unidentified Kogia, unidentified *Stenella*, white-beaked dolphin, Atlantic white-sided dolphin	2245
<u>All sea turtles</u>: green sea turtle, hawksbill sea turtle, leatherback sea turtle, loggerhead sea turtle, Kemp's ridley sea turtle, unidentified sea turtle	1640
<u>Endangered baleen whales</u>: fin whale, humpback whale, North Atlantic right whale, sei whale, unidentified *Balaenoptera*, fin or sei whale, unidentified rorqual (Balaenopteridae)	398
<u>Large toothed whales</u>: beaked whale, Cuvier's beaked whale, killer whale, northern bottlenose whale, Sowerby's beaked whale sperm whale, unidentified beaked whale (Ziphiidae)	359
<u>All seals</u>: unidentified seal, harbor seal	199
<u>All beaked whales</u>: beaked whale, Cuvier's beaked whale, northern bottlenose whale, Sowerby's beaked whale and unidentified beaked whale (Ziphiidae)	53

Figure 83: NARWC Database Marine Mammal and Sea Turtle Records
(N = number of sightings)

Individual Species	N
Atlantic spotted dolphin (*Stenella frontalis*)	3
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	129
Beaked whale (*Mesoplodon* sp.)	8
Blue shark (*Prionace glauca*)	113
Bottlenose dolphin (*Tursiops truncatus*)	368
Bottlenose or spotted dolphin	5
Common minke whale (*Balaenoptera acutorostrata*)	94
Common or white-sided dolphin	30
Cuvier’s beaked whale (*Ziphius cavirostris*)	7
Fin or sei whale	67
Fin whale (*Balaenoptera physalus*)	238
Green sea turtle (*Chelonia mydas*)	7
Harbor porpoise (*Phocoena phocoena*)	178
Harbor seal (*Phoca vitulina*)	20
Hawksbill sea turtle (*Eretmochelys imbricata*)	1
Humpback whale (*Megaptera novaeangliae*)	47
Kemp’s ridley sea turtle (*Lepidochelys kempii*)	73
Killer whale (*Orcinus orca*)	2
Leatherback sea turtle (*Dermochelys coriacea*)	169
Loggerhead sea turtle (*Caretta caretta*)	1236
North Atlantic right whale (*Eubalaena glacialis*)	16
Northern bottlenose whale (*Hyperoodon ampullatus*)	1
Pilot whale (*Globicephala* sp.)	208
Pygmy killer whale (*Feresa attenuata*)	1
Pygmy sperm whale (*Kogia breviceps*)	1
Risso’s dolphin (*Grampus griseus*)	375
Sei whale (*Balaenoptera borealis*)	8
Short-beaked common dolphin (*Delphinus delphis*)	307
Sowerby’s beaked whale (*Mesoplodon bidens*)	5
Sperm whale (*Physeter macrocephalus*)	204
Spotted dolphin (*Stenella* sp.)	24
Striped dolphin (*Stenella coeruleoalba*)	54
Unidentified *Balaenoptera*	7
Unidentified beaked whale (Ziphiidae)	32
Unidentified blackfish	2
Unidentified dolphin/porpoise	486
Unidentified Kogia	7
Unidentified large whale	87
Unidentified medium whale	29
Unidentified rorqual (Balaenopteridae)	15
Unidentified sea turtle	154
Unidentified seal (Phocidae)	179
Unidentified *Stenella*	65
Unidentified whale	29
White-beaked dolphin (*Lagenorhynchus albirostris*)	2

approximately 25 square nautical miles each. The number of animals sighted in each cell was divided by the survey flight or cruise length in each cell, resulting in a relative index of abundance called sightings per unit effort (SPUE), represented here as sightings per mile. The majority of species, or in some cases groups of species (e.g., dolphins, endangered baleen whales; see Figure 82 – Figure 83), were interpolated by NEA staff using geostatistical modeling techniques which resulted in predictive abundance maps.[78] Pinnipeds are not included in this study due to relatively few observations in the offshore planning area.

In addition to the NEA-models, DOS developed predictive abundance models using the same data for two species (fin whale, sperm whale) and two groupings (all cetaceans, baleen whale) of species using methods that, while somewhat similar, allowed DOS to understand the certainty behind the prediction. DOS interpolated SPUE point data with separate, seasonal models for sperm whales, fin (finback) whales, baleen whales (including fin whales, North Atlantic right whales, humpback whales, sei whales, an unidentified fin or sei whale group, unidentified rorquals, and an unidentified *Balaenoptera* group), and an “all cetaceans” group (all whales, dolphins, and porpoises for which data were available).

The processes determining presence or absence may be different from the ones determining abundance, so interpolations were conducted using a two-stage approach.[79] First, the abundance observations were re-coded into presence/absence observations, and these were interpolated using Indicator Kriging (Stage I). The resulting continuous probability of presence surface (0 to 1) was then thresholded (0 or 1) at an optimal cutoff determined via Receiver Operating Characteristic (ROC) analysis (e.g.,Figure 84). Finally, this thresholded "mask" was multiplied by a surface based on an Ordinary Kriging interpolation of the non-zero abundance data (Stage II). The final map depicts estimated abundance only where the species or group is predicted to be present in the first place (e.g.,Figure 85). Modeling presence/absence separately from abundance also allows certain statistical assumptions to be met, which in turn allows for the creation of certainty (prediction error) maps.

Error estimates ("certainty") for these predictions were created via leave-one-out cross-validation, and DOS divided these error maps by the standard deviation of the input data. When the resultant value is greater than one, the prediction error is greater than the inherent variability of the input data, and therefore the prediction may be less reliable. Lower values of the index relate to higher confidence in the prediction. Note that this index only captures error associated with Stage II.

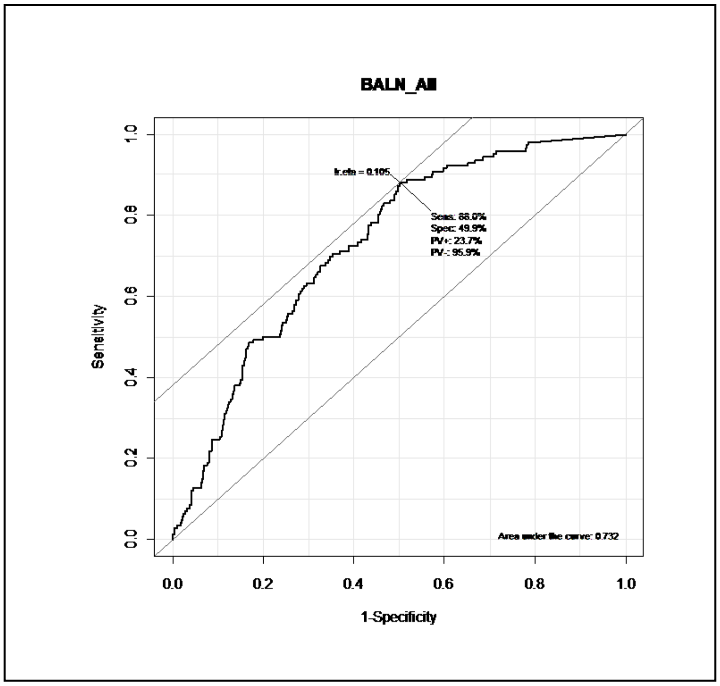

Figure 84: ROC Analysis Example
ROC curve for baleen whale presence/absence indicating the optimal cutoff probability (0.105 in this case) that maximizes the correct number of classifications. Cutoffs were determined in cross-validation but applied to the full dataset for the final models.

Sea turtle sightings are part of the NARWC database and predicted abundance distributions for the offshore planning area were carried out by NEA in the same way as marine mammal distributions. Information in the database represents sightings for five sea turtle species grouped together: green; hawksbill; Atlantic (Kemp's) ridley; leatherback; and loggerhead sea turtles.

For NEA models, there was general agreement (>70% for most taxa) between marine mammal and sea turtle interpolated values and original points withheld for cross-validation. For DOS models, measures of Stage I and Stage II error suggested that models performed fairly well overall, although this performance varied with species, season, and space. In particular, area under the curve (AUC) values (>.70 for most species/season combinations) suggested the Stage I presence/absence classifier performed much better than random in most models, and ratios of Kriging standard error to data standard deviation (<1.0) suggested errors for the Stage II abundance predictions are moderate in most cases. Note that abundance estimates for both NEA and DOS models are a relative index and should not be confused with absolute population estimates.

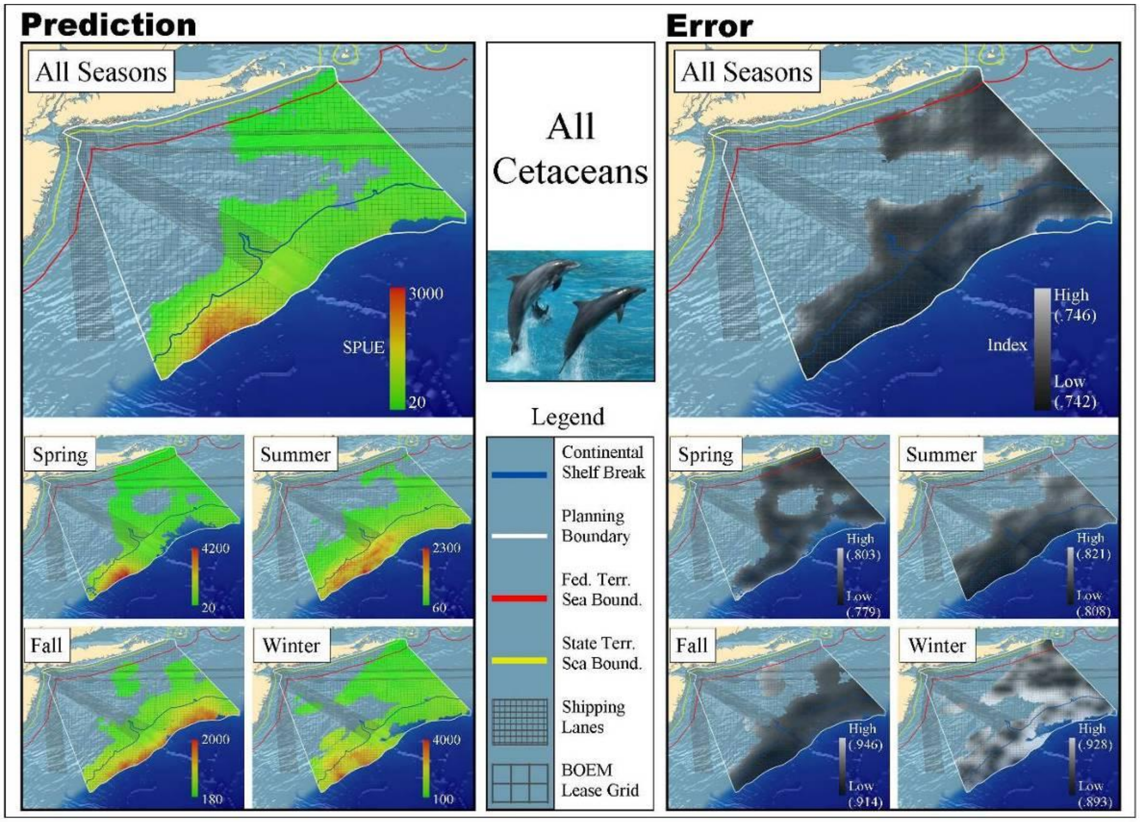

Figure 85: Two-Stage Kriging Example
Example of the two-stage Kriging model for the "all cetaceans" grouping, showing abundance prediction and associated certainty (certainty was lower in winter, corresponding to fewer observations). Lower values of the error index relate to higher confidence in the model prediction.

3. Seabirds

Seabird Species/Groups* Examined by DOS as Modeled by NCCOS: black-legged kittiwake, common tern, common loon, Cory's shearwater, dovekie, great black-backed gull, great shearwater, herring gull, laughing gull, northern fulmar, northern gannet, pomarine jaeger, sooty shearwater, Wilson's storm-petrel, less common alcids (incl. Altlantic puffin, common murre, thick-billed murre, razorbill), coastal waterfowl (incl. white-winged scoter, black scoter, surf scoter, long-tailed duck, red-throated loon, red-breasted merganser, common eider), jaegers (incl. parasitic jaeger, long-tailed jaeger), phalaropes (incl. red phalarope, red-necked phalarope), less common shearwaters (incl. manx shearwater, Audobon's shearwater), small gulls (ring-billed gull, Bonaparte's gull), less common storm-petrels (incl. Leach's storm-petrel, band-rumped storm petrel, white-faced storm petrel), less common terns (incl. royal tern, arctic tern, roseate tern, least tern, sooty tern, bridled tern, Forster's tern), and unidentified gulls.

*Some species grouped for modeling. Group members given in parentheses.

Seabird sightings data for the offshore planning region were extracted by NCCOS from the Manomet Bird Observatory's (MBO, now the Manomet Center for Conservation Sciences, or MCCS) Cetacean and Seabird Assessment Program (CSAP) database, which contains over 9,000 survey locations. During these surveys a small number of expert observers were placed on research vessels undertaking a wide variety of work, including NMFS groundfish, scallop, and plankton surveys, U.S. Coast Guard (USCG) surveys, and U.S. Environmental Protection Agency surveys. Seabirds were identified to the most specific taxonomic level possible, usually species, and counted within a fixed strip width of 300 m at one side of a ship as it traveled on a straight course, at a constant speed (generally 8-12 knots). Observations were separated by season, and for each species or group sighting record in each season, the number of individuals of that species observed during the timed survey was divided by the corresponding survey tract area to yield an index of relative abundance that was standardized by both time and area, resulting in SPUE represented as sightings per 15 minutes per sq. km of transect footprint.

Based on available high-resolution data coverage within the offshore planning area and previous studies of environmental correlates of seabird distribution and abundance, NCCOS identified 11 potential environmental predictor variables. These variables were: bottom depth; bottom slope; slope-of-slope; distance from shore; signed distance from shelf; mean sediment grain size; water-column stratification; sea surface temperature; surface turbidity measure; surface chlorophyll-a concentration; and zooplankton biomass. For each season with sufficient data within each species/group selected for predictive modeling, they modeled the transect estimates of SPUE as point samples (located at the centroid of each transect) of two spatial random processes, Stage I and Stage II. Stage I used binary (presence/absence) data from the CSAP surveys and Stage II used relative abundance (i.e., SPUE) observations for each species or group from the same surveys, but did not consider locations where SPUE=0. Within each stage of the model, they used a regression-Kriging framework to account for both seabird-environment relationships and spatial structure. Both Stage I and Stage II models included two components: a trend model that used a generalized linear model (GLM) and incorporated environmental predictors and a geostatistical model that accounted for spatial autocorrelation in the residuals. NCCOS assessed model performance and error via cross-validation, producing numerous statistics for model evaluation.[80]

Fourteen species were individually mapped and remaining species were aggregated into seven broader taxonomic groups, due to lower sightings numbers. Seasonal patterns of abundance were summed to derive an annual estimated individual species abundance for each individual species mapped and for grouped species. Abundance estimates are a relative index and should not be confused with absolute population estimates.

NCCOS combined the estimated abundance distributions of the 14 seabird species individually mapped to identify “hotspots” of abundance and species diversity. Abundance hotspots are defined as concentrations of large numbers of individual seabirds. They also developed a model of estimated Species Richness, which is synthesized from a direct count of the number of different seabird species seen at a survey location, and Species Diversity, where a large variety of seabird species are proportionally well-represented. Thus, Species Diversity is a function of Abundance and Species Richness.

The data used to develop these models do not capture many dynamic aspects of seabird ecology and were collected in the 1980s. Modeling required an assumption that the climatological patterns of ocean conditions have not undergone substantial shifts since then. Finally, survey biases (e.g., detectability) are likely to vary between species. These issues underscore the importance of treating the measures of relative abundance presented here as proxies for underlying patterns. Nonetheless, these maps represent the first high-resolution depiction of spatial patterns in the marine avifauna of New York.[81]

4. Groundfish

<u>Groundfish Species Examined by DOS as Provided by NEFSC</u>: American lobster*, American shad, Atlantic cod, Atlantic herring*, Atlantic mackerel, Atlantic menhaden, Atlantic sturgeon, barndoor skate, bay anchovy, black sea bass*, blue crab, bluefish, butterfish*, clearnose skate, goosefish*, haddock, horseshoe crab, little skate, longfin squid*, northern shortfin squid*, red hake, rosette skate, sandbar shark, scup*, sea scallop*, silver hake*, smooth dogfish*, spiny dogfish, striped bass, summer flounder*, tautog, weakfish, winter flounder*, winter skate, yellowtail flounder*.

*selected by DOS for modeling.

The NOAA Northeast Fisheries Science Center (NEFSC) has been conducting biannual fisheries-independent bottom trawl surveys since 1963. The starting locations ("station") of each tow were assigned based on a stratified random sampling design, and strata were defined in 1963 based on water depth, latitude, and historical fishing patterns. The number of stations allotted to a stratum was proportional to its area. Each tow proceeded at approximately 3.5 knots for 30 minutes, using #36 Yankee trawl (or similar trawling gear). Once onboard, fish were weighed, measured, sexed, and identified to the species level.[82]

Stone Environmental, Inc. obtained trawl stations and catch records from NEFSC from 1975-2009.[83] They calculated species abundance (number of individuals) at each station and summarized it by five-year intervals, season (spring/fall), and life stage (juvenile/adult). Life stage categories were defined based on published estimates of length at maturity.[84]

DOS received this pre-processed data from Stone Environmental and selected 14 species important to New York's coastal resources for modeling. DOS modeled abundance as a function of 11 environmental predictor variables[85] based on previous studies of environmental correlates of fish abundance. DOS implemented models as zero-inflated GLMs. The zero-inflation component was necessary as the data exhibited a preponderance of absences likely arising from both unsuitable environmental conditions and the difficulty of catching the fish when they were in fact present. Because model residuals displayed spatial autocorrelation, an additional, geostatistical model was necessary to capture this pattern. This hybrid approach is known as regression-Kriging.[86] Residual maps from the geostatistical model were added to prediction maps from the trend model to produce the final maps. To avoid extrapolation beyond the range of the data, maps were clipped to the spatial extent of the NEFSC surveys.

For each dataset, 50% of the observations were randomly allocated to a training subset and the remaining 50% were allocated to a test subset. Model selection and model fitting proceeded with the training subset, and the predictions from these models were compared to the true values from the test subset, resulting in cross-validation statistics (e.g., Figure 86). However, the final predictions were based on applying the models selected via training to the entire dataset.

DOS also developed "persistence" (that is, presence over time) maps for six selected groundfish species. Groundfish data were aggregated in five-year increments over a 35-year period (1975 – 2010). Each of those five-year increments were summed to count the number of increments a selected species age group (adult or juvenile) was found by season (fall or spring).

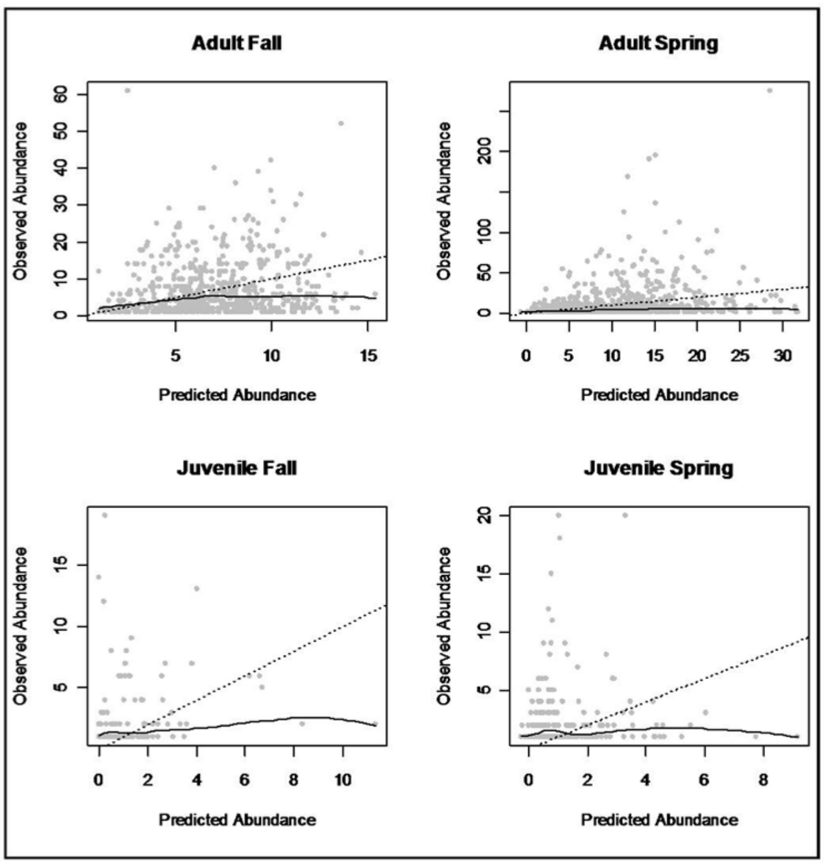

Figure 86: Observed vs. Predicted Abundance Example

Plots of observed vs. predicted abundance using cross-validation data for summer flounder. The dashed line represents perfect fit and the solid line is a Loess regression. In these graphs models tend to under-predict abundance.

Groundfish predicted abundance models were used to show distribution during different seasons and life stages. Given the inherent difficulties in modeling dynamic species from limited survey data, cross-validation statistics suggest that the models' performance was fair overall, with individual model performance varying considerably between species, season, and life stage combinations. Spearman rank correlation between predicted and observed responses in cross-validation generally ranged between 0.3 – 0.6, suggesting models were successful in describing some but not all variation in the data. Abundance displayed significant relationships with many environmental predictors in most cases.

Although long-term averages have been used to smooth out the differences, dates for certain trawl surveys and some predictor variables differ by as much as 32 years. The assumption is that predictors and the relationship between predictors and abundance has remained constant through the 1975-2009 time period. The validity of this assumption is likely to vary by species, area, and predictor. Many stocks have shifted north in response to warming ocean temperatures[87] and models predict average historical abundance, which does not necessarily represent current or future trends. Also, species which are more easily caught by bottom trawling are likely to be over-represented in the data used here. Finally, these abundance estimates are a relative index and should not be confused with absolute population estimates.

5. Human Use Workshops

DOS identified leaders and key contacts from 30 partner organizations whose members regularly use the ocean. DOS also identified a number of individuals who have worked with DOS on past coastal and ocean issues and demonstrated a reliable knowledge of how New Yorkers use the ocean. These organizational contacts and individuals were invited to participate in one of five offshore use workshops: two each in Riverhead and Baldwin, and one in Manhattan.

Prior to the workshops, DOS staff worked with NOAA's Coastal Services Center (CSC) to design and develop participatory geographic information system (pGIS) training materials that described protocols of ocean use data collection and reporting back to DOS. CSC also provided technical assistance in the pGIS workshops to prepare and equip participants to compile ocean use information.

At the workshops, DOS and CSC trained these organizational contacts and knowledgeable individuals to work with their colleagues, constituents and memberships to collect ocean use information. DOS and CSC conducted mock mapping and data collection exercises to familiarize participants with how information needed to be collected.

At the conclusion of the workshops, participants were provided with information-collecting kits containing navigation charts, information tables, guidance for meeting with their members and collecting information, sample charts and tables, and copies of several one-pagers explaining DOS's offshore study and planning process, ocean uses, offshore habitats, and offshore renewable energy development. DOS's assistance and support contacts also were distributed. At later dates, DOS conducted a refresher webinar and hosted two conference calls for participants to call in with questions, concerns, or ideas.

DOS digitized the geographic information provided by ocean users and created an aggregate dataset, including linked attribute data characterizing each mapped use area. Creating the dataset in this way allows access to details such as the use of a given area, when the use occurs, and how often it occurs.

During the winter of 2011 and through the spring of 2012, DOS staff returned to the organizations that provided ocean use information, to "ground truth" the individual and aggregate information as organized by DOS. This was an opportunity for the organizations to modify or improve the data and resulted in some additions and corrections.

Long Island currently is home to one federally recognized tribe, the Shinnecock Indian Nation, and one state recognized tribe, the Unkechaug Indian Nation. DOS provided on-site briefings to the leaderships of both tribes and received ocean use information from the Shinnecock Indian Nation. The Shinnecocks identified ocean uses within a narrow coastal band of the larger study area.

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V. Endnotes

[1] [NOAA] National Oceanic and Atmospheric Administration, Coastal Services Center [Internet]. 2012. Coastal county snapshots [cited 2012 July 24]. Available from http://www.csc.noaa.gov/snapshots/.

[2] Port Authority of New York and New Jersey [Internet]. 2012. About the port [cited 2012 July 16]. Available from http://www.panynj.gov/port/about-port.html.

[3] TechLaw, Inc. 2001. The economic contribution of the sport fishing, commercial fishing, and seafood industries to New York State. Stony Brook (NY): New York Sea Grant.

[4] [IPCC] Intergovernmental Panel on Climate Change. 2012. Chapter 4: Changes in impacts of climate extremes: human systems and ecosystems. In Field CB, Barros V, Stocker TF, Qin D, Dokken DJ, Ebi KL, Mastrandrea MD, Mach KJ, Plattner G-K, Allen SK, Tignor M, Midgley PM, editors. Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge (UK) and New York (NY): Cambridge University Press. p. 231-290.

[5] Walther G-R, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fromentin JM, Hoegh-Guldberg O Bairlein F. 2002. Ecological responses to recent climate change. Nature 416: 389-395.

[6] Nye JA, Link JS, Hare AJ, Overholtz WJ. 2009. Changing spatial distribution of fish stocks in relation to climate and population size on the northeast United States continental shelf. Marine Ecology Progress Series 393:111–129.

[7] Basic units of marine distance have historically differed from measures of land distance, being based on the circumference of the earth rather than assuming a straight line. One nautical mile is about equivalent to about 1.15 miles. One square nautical mile is about equivalent to 1.3 square miles.

[8] For more information on New York's CMP, see the DOS website http://www.dos.ny.gov/communitieswaterfronts/. Federal consistency regulations can be found at http://coastalmanagement.noaa.gov/consistency/media/15CFRPart930_2007.pdf. New York State's coastal policies can be found at http://www.dos.ny.gov/communitieswaterfronts/pdfs/CoastalPolicies.pdf. New York Law: Executive Article 42: Waterfront Revitalization of Coastal Areas and Inland Waterways can be found at: http://www.dos.ny.gov/communitieswaterfronts/pdfs/Article_42.pdf.

[9] Deep-sea exploration along the continental shelf edge has uncovered resources of particular promise for biotechnology. While not an immediate focus of this offshore planning work, DOS will continue to work in partnership with the research community to explore opportunities for improving access to these areas for New York-based researchers. For more information on the topic, see the National Academies Press publication *Marine Biotechnology in the 21st Century: Problems, Promise and Products* available at http://www.nap.edu/catalog/10340.html.

[10] Schwartz M, Heimiller D, Haymes S, Musial W. 2010. Assessment of offshore wind energy resources for the United States. Golden (CO): US Department of Energy, Office of Energy Efficiency and Renewable Energy, National Renewable Energy Laboratory. Technical Report NREL/TP-500-45889. 104 p.

[11] New York State agencies and other entities have undertaken recent efforts to better understand offshore uses and resources to support scientific understanding or project development. However, relative to the Offshore Atlantic

Ocean Study, these other efforts are more limited in their scope and scale. For examples, a more thorough review and discussion of meteorological and oceanographic trends was conducted for New York State in a smaller subset of the planning area of interest to the New York Power Authority, Consolidated Edison, and the Long Island Power Authority for a potential offshore wind site. See [NYSERDA] New York State Energy Research and Development Authority. 2010. *Pre-development assessment of geophysical qualities for the proposed Long Island – New York City offshore wind project area* and *Pre-development assessment of meteorological and oceanographic qualities for the proposed Long Island – New York City offshore wind project area*. Prepared by AWS Truepower, LLC, Geo-Marine, Inc., and Energy and Environmental Analysts. Available from http://www.nyserda.ny.gov/en/Renewables/Offshore-Wind.aspx.

[12] Several past attempts have been made to hypothetically extend state boundaries into federal waters for the purposes of delineating a state's interests beyond its territory. Most notably, the federal Bureau of Ocean Energy Management uses a set of administrative boundaries based on an equidistance principle to identify planning areas and determine revenue sharing with states. Such efforts ignore the dynamic nature of offshore uses and resources and the potential far-reaching affects of future project development in the ocean. For this reason, the offshore planning area delineated by DOS is not intended to be definitive in identifying the geographic scope of the state's interests, but rather is a practical attempt to prioritize the study's focus and related data gathering and analysis.

[13] Chapman DC, Beardsley RC. 1989. On the origin of shelf water in the Middle Atlantic Bight. J Phys Oceanogr 19(3):384–391.

[14] Navigation traffic lanes are elements of traffic separation schemes, overseen by the International Maritime Organization. Traffic separation schemes are established in busy shipping areas where a lack of traffic regulation may result in accidents. The traffic-lanes (or clearways) indicate the general direction of the ships in that zone; ships navigating within a traffic lane sail in the same direction. Within a traffic separation scheme there usually is at least one traffic-lane in each direction, turning-points, deep-water lanes and separation zones between the main traffic-lanes. Separation zones are the body of water between two opposite lanes and are no-go areas. From International Maritime Organization [Internet]. 2012. Ships' routeing. [cited 2012 July13]. Available from http://www.imo.org/ourwork/safety/navigation/pages/shipsrouteing.aspx.

[15] [NOAA] National Oceanic and Atmospheric Administration, Office of Coast Survey [Internet]. 2012. Electronic navigational charts: NOAA ENC® [cited 2012 July 13]. Available from http://www.nauticalcharts.noaa.gov/mcd/enc/index.htm.

[16] Supported by funding and technical expertise from BOEM, CSC developed the MMC, which delivers jurisdictional and authorities' boundaries, as well as other ocean data, for viewing and download.

[17] While the nine square nautical mile lease block is the standard unit, BOEM can further subdivide these lease blocks into equal units as small as 1/16th of a lease block for the purposes of determining the geographic area to be leased.

[18] NOAA's Office of Coast Survey is the entity responsible for maintaining and updating ENCs, the nautical maps used by commercial and recreational vessel operators to ensure safe navigation. Office of Coast Survey has extracted the information (e.g., shipping lanes, buoys, submarine cables, etc.) which goes into making navigation charts and provides those as individual data layers through its ENC webpage. ENCs are geo-referenced vector files of NOAA nautical chart features and their attributes, published by NOAA. These geographic data layers are freely available to the public for download and use in GIS. ENC vector files are provided in geographic coordinate system in decimal degrees using World Geodetic System (WGS) 1984. From [NOAA] National Oceanic and Atmospheric Administration, Office of Coast Survey [Internet]. 2012. Marine chart division [cited 2012 July 13]. Available from http://www.nauticalcharts.noaa.gov/mcd/mcd.htm.

[19] Johnson MR, Boelke C, Chiarella LA, Colosi PD, Greene K, Lellis-Dibble K, Ludemann H, Ludwig M, McDermott S, Ortiz J, Rusanowsky D, Scott M, Smith J. 2008. Chapter 6: Offshore dredging and disposal activities. In Johnson MR, et al. 2008. Impacts to marine fisheries habitat from nonfishing activities in the Northeastern United States. Silver Spring (MD): US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-NE-209. 339 p.

[20] Kenney RD. 2011. The North Atlantic right whale consortium database: a guide for users and contributors. Narragansett (RI): University of Rhode Island Graduate School of Oceanography, North Atlantic Right Whale Consortium. North Atlantic Right Whale Consortium Reference Document 2011-01. 141 p.

[21] The complete NCCOS report, A Biogeographic Assessment of Seabirds, Deep Sea Corals and Ocean Habitats of the New York Bight: Science to Support Offshore Spatial Planning, is available at http://ccma.nos.noaa.gov/ecosystems/coastalocean/ny_spatialplanning.aspx.

[22] In addition to the NCCOS report, these reports include: Lagueux K, Wikgren B, Kenney R. 2010. Technical report for the spatial characterization of marine turtles, mammals, and large pelagic fish to support coastal and marine spatial planning in New York. Boston (MA): New England Aquarium and Kingston (RI): University of Rhode Island. 194 p. and Stone Environmental. 2010. Spatial characterization of marine fishes to support New York coastal and marine spatial planning. Project ID 071866-G. Albany (NY): New York Ocean and Great Lakes Ecosystem Conservation Council (OGLECC) and New York State Department of State. Prepared under State of New York Contract # 000273/19000. These reports will be made available on the DOS website at http://www.dos.ny.gov/communitieswaterfronts/offshoreResources/index.html.

[23] Poti M, Kinlan B, Menza C. 2012. Chapter 2: Bathymetry. In Menza C, Kinlan BP, Dorfman DS, Poti M, Caldow C, editors. A biogeographic assessment of seabirds, deep sea corals and ocean habitats of the New York Bight: science to support offshore spatial planning. Silver Spring (MD): National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment. NOAA Technical Memorandum NOS NCCOS 141. p 9-32.

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[25] Poti, et al. 2012. Chapter 2.

[26] Poti, et al. 2012. Chapter 2.

[27] [NOAA] National Oceanic and Atmospheric Administration[Internet]. 2012. Atlantic Canyons Undersea Mapping 2012 Expeditions. [cited 2012 July 13] Available from http://oceanexplorer.noaa.gov/okeanos/explorations/acumen12/welcome.html.

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[29] Poti M, Kinlan B, Menza C. 2012. Chapter 3: Surficial sediments. In Menza C, Kinlan BP, Dorfman DS, Poti M, Caldow C, editors. A biogeographic assessment of seabirds, deep sea corals and ocean habitats of the New York Bight: science to support offshore spatial planning. Silver Spring (MD): National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment. NOAA Technical Memorandum NOS NCCOS 141. p 33-58.

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[34] Williams, et al. 2006.

[35] Williams, et al. 2006.

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[37] Butman B, Twichell DC, Rona PA, Tucholke BE, Middleton TJ, Robb JM [Inernet]. 2006. Sea floor topography and backscatter intensity of the Hudson Canyon region offshore of New York and New Jersey. [cited 2012 July 13] Reston (VA): US Geological Survey. US Geological Survey Open-File Report 2004-1441, version 2.0. Available from http://pubs.usgs.gov/of/2004/1441/.

[38] For a more detailed discussion of meteorological trends in the New York Bight, see AWS Truepower LLC and Geo-Marine, Inc. 2010. Pre-development assessment of meteorological and oceanographic conditions for the proposed Long Island – New York City offshore wind project 2area. Albany (NY): New York State Energy Research and Development Authority. 113 pp. Available from http://www.nyserda.ny.gov/Renewables/~/media/Files/EIBD/Research/10-22_linyc-collaborative-climatology.ashx.

[39] NREL's offshore wind resource assessments were modeled by AWS Truepower, a New York-based firm that maps wind resources. Updates to this information can be found at http://www.nrel.gov/gis/data_wind.html.

[40] The National Hurricane Center classifies storm strength based on characteristics, such as wind speed, that may change as the storm gains strength or weakens. See http://www.nhc.noaa.gov/aboutgloss.shtml#t.

[41] Kinlan B, Poti M, Menza C. 2012. Chapter 4: Oceanographic setting. In Menza C, Kinlan BP, Dorfman DS, Poti M, Caldow C, editors. A biogeographic assessment of seabirds, deep sea corals and ocean habitats of the New York Bight: science to support offshore spatial planning. Silver Spring (MD): National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment. NOAA Technical Memorandum NOS NCCOS 141. p 59 – 68.

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science to support offshore spatial planning. Silver Spring (MD): National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment. NOAA Technical Memorandum NOS NCCOS 141. p 69-86.

[46] According to The National Academies booklet *Oceans and Human Health: Highlights of National Academies Reports,* "An estimated 30 percent of all potential marine-derived medications currently in the pipeline—and about 75 percent of recently patented marine-derived anticancer compounds—come from marine sponges." (page 3) [2011. Washington, DC: National Academies Press. 20 p]. This booklet is available at http://dels.nas.edu/resources/static-assets/osb/miscellaneous/Oceans-Human-Health.pdf.

[47] Kenney, 2011.

[48] The standards used included the sea-state and presence of observers at all times. Data from whale watch boats dominated the raw sightings dataset, though they were not necessarily included in the calculation of SPUEs.

[49] Lagueux, et al. 2010.

[50] The value of the continental shelf edge as cetacean habitat has been established in past reviews. See Kenney RD and Winn HE. 1986. Cetacean high-use habitats of the Northeast United States Continental Shelf. National Oceanic and Atmospheric Administration National Marine Fisheries Service. Fishery Bulletin Vol 84, No. 2. p. 345-357.

[51] Cornell Lab of Ornithology Bioacoustics Research Program. 2010. Determining the seasonal occurrence of cetaceans in New York coastal waters using passive acoustic monitoring. Technical Report 09-07. Albany (NY): New York State Department of Environmental Conservation.

[52] Kinlan BP, Menza C, Huettmann F. 2012. Chapter 6: Predictive modeling of seabird distribution patterns in the New York Bight. In Menza C, Kinlan BP, Dorfman DS, Poti M, Caldow C, editors. A biogeographic assessment of seabirds, deep sea corals and ocean habitats of the New York Bight: science to support offshore spatial planning. Silver Spring (MD): National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment. NOAA Technical Memorandum NOS NCCOS 141. p 57-127.

[53] Kinlan, et al. 2012.

[54] [NOAA] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Survey Working Group. 1988. An evaluation of the bottom trawl survey program of the Northeast Fisheries Center. Gloucester (MA): National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center. NOAA Technical Memorandum NMFS-F/NEC-52. 83 p.

[55] NEFSC trawl survey methodology changed after 2009, and data collected after this date requires statistical corrections for comparison to previous data. DOS is aware of these issues and is working to incorporate more recent trawl survey data into its offshore planning effort.

[56] Stone Environmental. 2010. Available at http://www.oglecc.ny.gov/media/data%20survey%20results%20report%20final.pdf.

[57] Kinlan, et al. 2012.

[58]The recreational boater survey is being coordinated by an interstate partnership in New England, called the Northeast Regional Ocean Study. The survey details will be available online at http://northeastoceandata.org.

[59] The term used in the figures is "landings", which in fishery science is usually reported at the locations at which fish are brought to shore. For the purposes of this dataset, the word "landings" means the part of the catch that is selected and kept during the sorting procedures on board vessels.

[60] Jenks GF. 1967. The data model concept in statistical mapping. Int Yearbook of Cartogr 7: 186-190.

[61] Orphanides D, Magnusson G. 2007. Characterization of the northeast and mid-atlantic bottom and mid-water trawl fisheries based on vessel trip report (VTR) data. Woods Hole (MA): National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center. Northeast Fisheries Science Center Reference Document 07-15. 127 p.

[62] Fishing vessels with New York licenses are not included in the VTR data for the period after 2009. This is especially relevant for the seine data and the recreational charter data.

[63] These VTR data included head boats within the party boat data.

[64] Scotti J, Stent J, Gerbino K. 2012. Commercial Fishermen Ocean Use Mapping. Cornell Cooperative Extension. 64 p. This report will be made available on the DOS website at http://www.dos.ny.gov/communitieswaterfronts/offshoreResources/index.html.

[65] New York Shipping Association, Inc. [Internet] (2012). Labor, cargo, and tonnage statistics [cited 2012 July 13]. Available from http://www.nysanet.org/labor_cargo_tonnage_statistics.asp.

[66] United States Coast Guard Navigation Center [Internet]. 2012. AIS requirements [cited 2012 July 13]. Available from http://www.navcen.uscg.gov/?pageName=AISCarriageReqmts.

[67] The USCG's ACPARS process was initiated in May 2011 under federal docket number USCG–2011–0351. The USCG subsequently released an "interim report" of the ACPARS work group's findings, available at http://www.uscg.mil/lantarea/acpars/.

[68] DOS has conducted a review of existing planning and regulatory documents that were developed to support offshore wind development either generally or for a specific project. These include:

- US Department of the Interior, Bureau of Ocean Energy Management [Internet]. 2012. Outer Continental Shelf (OCS) Alternative Energy Final Programmatic Environmental Impact Statement. [cited 2012 July 13]. Available from http://ocsenergy.anl.gov/eis/guide/index.cfm.

- Atlantic Renewable Energy Corporation and AWS Scientific [Internet]. 2004. New Jersey offshore wind energy: feasibility study [cited 2012 July 13]. Trenton, NJ: New Jersey Board of Public Utilities. Available from http://www.njcleanenergy.com/files/file/FinalNewJerseyDEP.pdf.

- US Department of Energy, National Renewable Energy Laboratory [Internet]. 2010. Large-scale offshore wind power in the United States: assessment of opportunities and barriers [cited 2012 July 13]. Golden (CO): US Department of Energy, National Renewable Energy Laboratory. Available from http://www.nrel.gov/wind/pdfs/40745.pdf.

- Massachusetts Executive Office of Energy and Environmental Affairs [Internet]. 2008. Report of the work group on renewable energy[cited 2012 December 13]. Available from http://www.env.state.ma.us/eea/mop/tech_reports/120308_renewables.doc.

- Spaulding ML, Grilli A, Damon C, Fugate G [Internet]. 2010. Application of technology development index and principal component analysis and cluster methods to ocean renewable energy facility siting for the Rhode Island ocean special area management plan 2010 [cited 2012 July 13]. Wakefield (RI): Rhode Island Coastal Resources Management Council. Rhode Island Ocean Special Area Management Plan, Technical Report #16. Available from http://seagrant.gso.uri.edu/oceansamp/pdf/appendix/16-SpauldingTDI.pdf.

In addition to the two Work Groups, DOS is using the BOEM–NY Offshore Wind Task Force as a mechanism to consult with affected federal,local, and tribal government entities in the development of the offshore wind siting criteria. More information on Task Force activities can be found on the BOEM–New York Offshore Renewable Energy Task Force website, http://www.boem.gov/Renewable-Energy-Program/State-Activities/New-York.aspx.

[69] Under the ‘Smart from the Start’ initiative, BOEM is working with state partners to identify offshore locations that appear most suitable for wind energy development. Data would continue to be collected for these high priority areas to inform government and industry assessments and planning, allowing a more efficient process for permitting and siting responsible development.

[70] For example, the Outer Continental Shelf (OCS) Alternative Energy Final Programmatic Environmental Impact Statement, available at http://ocsenergy.anl.gov/eis/guide/index.cfm.

[71] As discussed in Lopez A, Roberts B, Heimiller D, Blair N, Porro G [Internet]. 2012. US renewable energy technical potentials: a GIS-based analysis [cited 2012 July 13]. Golden (CO): US Department of Energy, Office of Energy Efficiency & Renewable Energy, National Renewable Energy Laboratory. Technical Report NREL/TP-6A20-51946. Available at http://www.nrel.gov/docs/fy12osti/51946.pdf. Technical potential was originally defined in: US Department of Energy, Office of Energy Efficiency and Renewable Energy. 2006, updated 2011. Report to Congress on renewable energy resource assessment information for the United States. Golden (CO): US Department of Energy, Office of Energy Efficiency & Renewable Energy, National Renewable Energy Laboratory.

[72] Poti, et al. 2012. Chapter 3.

[73] Goff, et al. 2008.

[74] Poti, et al. 2012. Chapter 3.

[75] Poti, et al. 2012. Chapter 3.

[76] Poti, et al. 2012. Chapter 3.

[77] Kenney, 2011.

[78] Lagueux, et al. 2010.

[79] Sun X, Manton MJ, Ebert EE [Internet]. 2003. Regional rainfall estimation using double-kriging of raingauge and satellite observations [cited 2012 July 13]. Melbourne, Victoria (AU): Australian Bureau of Meteorology, Bureau of

Meteorology Research Centre. BMRC Research Report No. 94, Available at: http://www.cawcr.gov.au/publications/BMRC_archive/researchreports/RR94.pdf.

[80] Kinlan, et al. 2012.

[81] Kinlan, et al. 2012.

[82] Northeast Fisheries Science Center, Survey Working Group, 1988.

[83] NEFSC trawl survey methodology changed after 2009, and data collected after this date requires statistical corrections for comparison to previous data. DOS is aware of these issues and is working to incorporate more recent trawl survey data into its offshore planning effort.

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