3. Resources and Infrastructure

3.1. Marine and coastal natural resources

3.1.1. Ocean waters

The ocean waters of the Northeast region consist of two distinct areas, separated by the Cape Cod peninsula: the Gulf of Maine to the north and east, and Rhode Island Sound, Block Island Sound, Long Island Sound, and parts of the New York Bight to the south and west. Exact numbers depend on boundary specifications, but the total surface area of ocean waters in the Northeast planning area is approximately 1 million km^2 (400,000 square miles, or 100 million hectares). The coastline from the Canadian border to New York City is about 1,000 km (670 miles) in length, which means that the region contains about 10,000 km^2 (4,500 square miles, or 1 million hectares) of bays and nearshore waters within 10 km of the coast.

The Gulf of Maine comprises Massachusetts Bay and the Bay of Fundy, and is home to the highest tidal variations on the planet. The coastline of the Gulf of Maine is predominantly rocky and scenic; the major areas of coastal development are located in the Boston, Portsmouth, Portland, and Saint John metropolitan areas. Glaciation during the last ice age stripped sedimentary soil away from the coastline; and the Gulf of Maine consequently has fewer sandy beaches than regions south and west of Cape Cod. The seabed sculptured during the lower sea levels of the ice ages makes the Gulf a semi-enclosed sea bounded to the south and east by underwater banks. Georges Bank in particular, on its southern end, separates the Gulf of Maine waters from the Gulf Stream. Gulf of Maine waters are strongly influenced by the Labrador Current, which makes Gulf of Maine waters significantly colder and more nutrient-rich than those found to the south. Undersea valleys in the central basin can reach depths of 1,500 feet (500 m) while undersea mountains rise up 800 feet (266 m) from the sea floor, almost reaching the surface in some locations, and in others forming islands.

There are three major basins contained within the Gulf of Maine: Wilkinson Basin to the west, Jordan Basin in the northeast, and Georges Basin in the south, all isolated from each other beneath the 650 foot (200 m) isobath. Georges Basin, just north of Georges Bank, is the deepest of the three at just over 1,200 feet (370 m) and generates a pocket at the end of the Northeast Channel, a deep fissure between Georges Bank and Browns Bank, the southwestern edge of the Nova Scotian Shelf. The Northeast Channel is the major channel between the Gulf and the rest of the Northwest Atlantic. A secondary, shallower connection to the Atlantic is the Great South Channel, located between Georges Bank and the Nantucket Shoals. See Northeast Ocean Data Portal for additional detail on bathymetry.

The New York Bight is a slight indentation along the US Atlantic coast centered on the mouth of the Hudson River, and extending northeasterly from Cape May Inlet in New Jersey to Montauk Point on the eastern tip of Long Island. The sea floor of the Bight consists largely of continental shelf and includes the Hudson Canyon, an undersea Pleistocene submarine canyon formed by the Hudson River during the ice ages. The continental shelf waters of the Northeast region south and west of Cape Cod are generally shallower than the Gulf of Maine (Figure 2).

Long Island Sound is a tidal estuary located between the eastern shore of Bronx County, New York City, the southern shores of Westchester County and Connecticut, and the northern shore of Long Island. The sound stretches 110 miles (177 km) from the East River in New York City eastward along the north shore of Long Island to Block Island Sound. A mix of freshwater from tributaries and saltwater from the ocean, Long Island Sound is 21 miles (34 km) at its widest point and varies in depth from 65 to 230 feet (20 to 70 m).

Block Island Sound, Buzzards Bay, and Nantucket Sound are coastal water bodies shaped by the advance and retreat of the Pleistocene glacial ice sheet in the Late Wisconsinan period (17-18,000 years ago). The maximum advance of the ice during that time produced a discontinuous terminal moraine that extends from Nantucket across Block Island to Long Island. The sounds and bays south of Cape Cod are low bedrock regions bounded by the higher bedrock that underlies Long Island, Block Island, Martha's Vineyard, Nantucket, and Cape Cod (Davis 1994). Nantucket Shoals is an area of shifting sands and shallow water (less than 1m deep in places) that extends from Nantucket Island eastward for 23 miles (37 km) and southeastward for 40 miles (64 km). The Great South Channel is an area of deeper water that runs north-south between Nantucket Shoals and Georges Bank. It is a major shipping channel connecting the Port of New York and New Jersey, and other US east coast ports to the south, with Boston and other ports in the Gulf of Maine.

The watershed of the Gulf of Maine encompasses an area of 69,115 square miles (179,008 km^2), including all of Maine, 70% of New Hampshire, 56% of New Brunswick, 41% of Massachusetts, and 36% of Nova Scotia. The watershed also includes a small southern portion (less than 1%) of the Canadian province of Quebec. Significant rivers that drain into the Gulf include, from east to west, the Annapolis, Shubenacadie, Salmon, Petitcodiac, Saint John, Magaguadavic, St. Croix, Penobscot, Kennebec, Saco, Piscataqua, Merrimack and Charles rivers; the Saint John and Penobscot provide the largest freshwater inflows to the region's coastal waters.

The Atlantic Ocean/Long Island Sound Watershed drains most of the New York City Metropolitan Area and all of Long Island, as well as much of Connecticut and Rhode Island. The watershed encompasses all marine waters in New York Harbor, Long Island Sound, Block Island Sound, and along the South Shore of Long Island, and the fresh waters that drain into them.

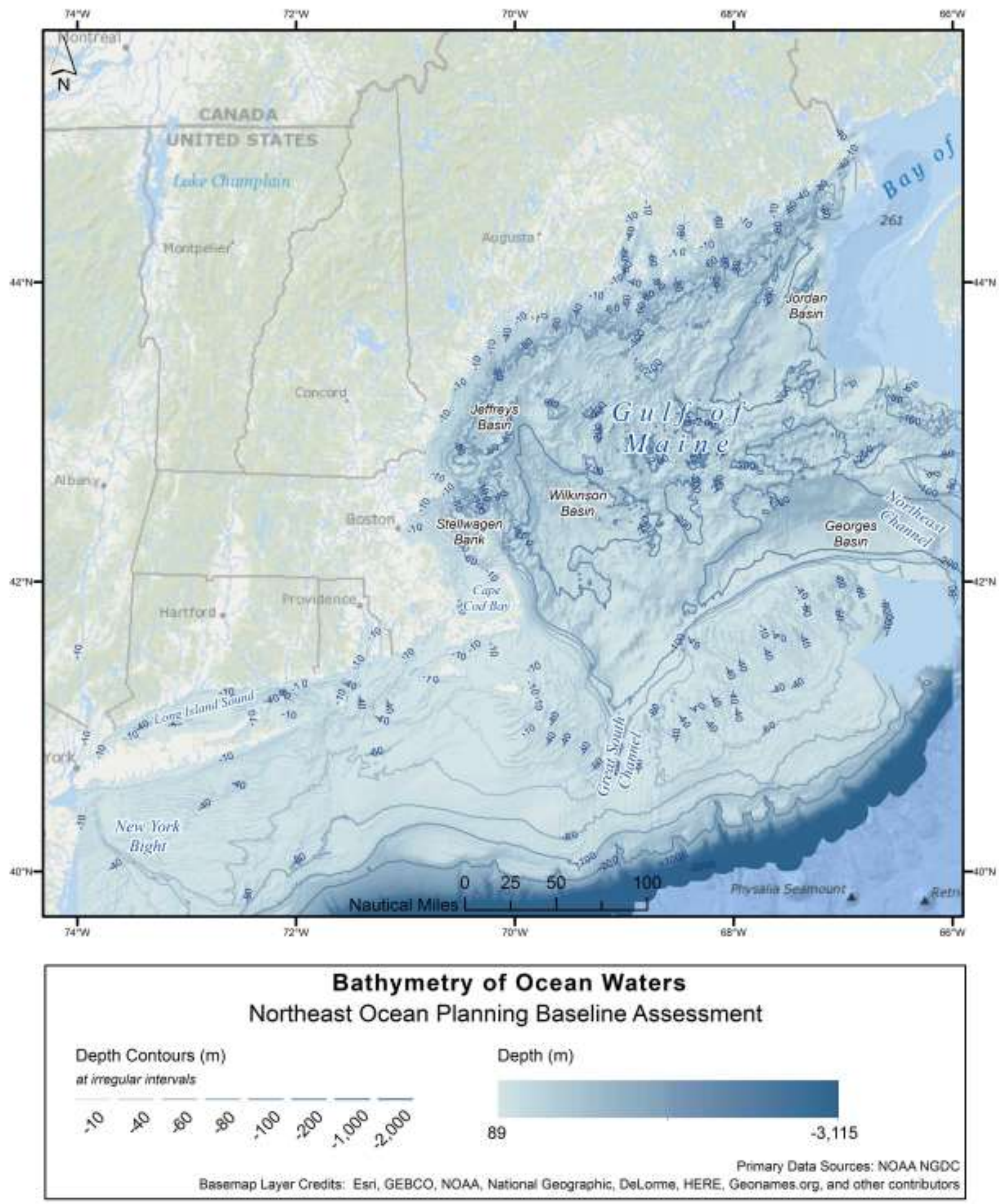

Figure 2 Ocean bathymetry

3.1.2. Coastal water quality

The open ocean waters of the Northeast region are, for the most part, clean and free from pollution that is likely to cause direct harm to marine organisms or people. Some coastal water bodies and sediments around the Region, however, are compromised by anthropogenic pollution.

Information about degraded coastal waters can be found in each state's Impaired Waters List, which is assembled by states pursuant to the federal Clean Water Act. Links to these lists can be found at: https://www.epa.gov/tmdl/impaired-waters-and-tmdls-new-england (Figure 3). States are required to update their list every two years, and include every water body (including coastal waters and estuaries) that is impaired or threatened by one or more pollutants. The most common pollution problems in Northeast coastal waters are the introduction of bacteria and other pathogens to coastal waters from runoff during rain events, and the overloading of coastal waters with nutrients (nitrogen, phosphorus) via groundwater, surface runoff, and atmospheric deposition. States establish Total Maximum Daily Loads (TMDLs) for pollutants for specific water bodies to mitigate impaired water quality. Information about TMDLs can be found at: https://www.epa.gov/tmdl. Many Northeast beaches and shellfish beds are monitored regularly for bacteria concentrations in water, to safeguard human health. When bacteria levels in water samples exceed the EPA's threshold level, this leads to beach closures. Information about beach water quality and closures can be found at: https://www2.epa.gov/beaches/find-information-about-your-beach

Sediments polluted with heavy metals, hydrocarbons, and other hazardous materials have been identified in a number of locations throughout the Northeast, including parts of the Lower Connecticut, Charles, Quinnipiac, Housatonic, Saugatouk, and Hudson Rivers, and Massachusetts Bay and Long Island Sound. Specific National Priorities List sites judged to be heavily impaired and in need of remediation include the New London Naval Submarine Base on the Thames River in Connecticut, New Bedford Harbor in Massachusetts, and the Portsmouth Naval Shipyard in Kittery, Maine. Information about designated hazardous waste contaminated sites in the region can be found at: https://www.epa.gov/cleanups/cleanups-my-community

Additional information related to water quality can be found on the Northeast Ocean Data Portal. More details on sub-regions is also available, see for example the Long Island Sound Report Card – Grading the water quality and ecosystem health of the Urban Sea. Information about current and past marine conditions in the Gulf of Maine can be obtained from the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS).

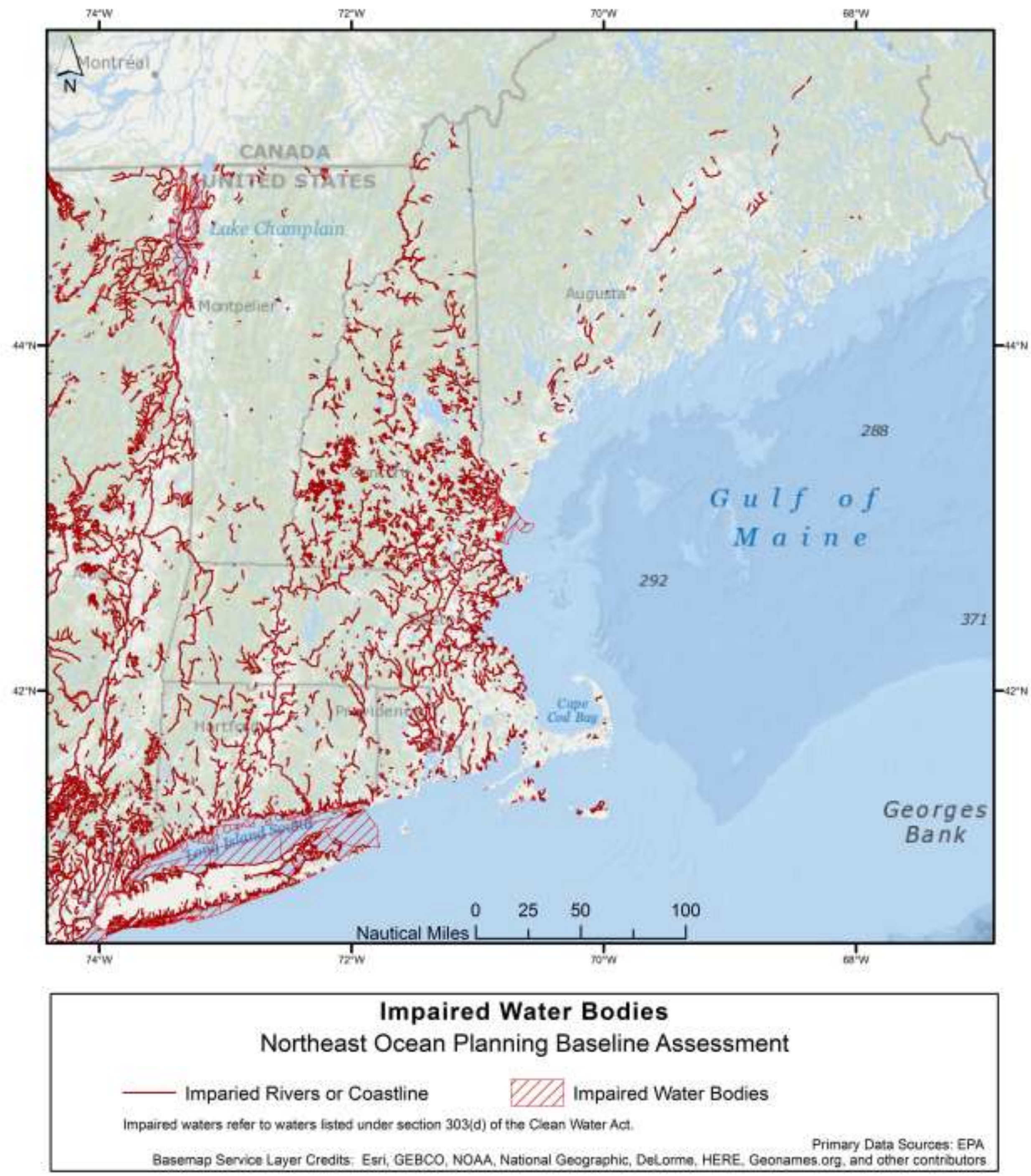

Figure 3 Impaired water bodies

3.1.3. Seabed and habitat

The Gulf of Maine was formed by glaciers pushing debris down from the Appalachian Mountains. When the glaciers retreated some 11,500 years ago, they left behind scoured bedrock and large moraines. These are now the basins and banks that give the Gulf of Maine its distinctive shape.

Because of its relative youth, the Gulf of Maine has a tremendous variety of bottom habitats, from the soft, flocculent muds that are beginning to accumulate in the deep basins, to the unsorted coarse gravel of the banks to areas of scoured bedrock. Combined with nutrient-rich waters, this range of habitats supports a large variety of benthic organisms and provides living space and protection to the developing stages of numerous pelagic and demersal species, making the Region one of the most productive marine ecosystems on the planet. South and west of Cape Cod, the seafloor is more commonly covered in some combination of sand and gravel (pebbles). Figure 4 illustrates the variety and distribution of different seabed and habitat types in the region, and highlights the difference between the deeper waters of the Gulf of Maine and the relatively shallower shelf waters south and west of Cape Cod.

The Gulf of Maine Habitat Primer (Tyrrell 2005) recognizes twenty different habitat types differentiated by the nature the substrate, the water depth, and the biogenic structure. Substrate types include sand dunes, tidal and subtidal mud flats, sand beaches, subtidal sand, intertidal and subtidal gravel and cobble, intertidal and subtidal boulders, and intertidal and subtidal rock outcroppings. Biogenic habitat types include salt marshes and *Phragmites*, shellfish beds, *Codium* beds, seagrass beds, kelp beds, and cold-water coral assemblages.

Seagrass is a general term for flowering plants that live in low intertidal and subtidal marine environments (Tyrrell 2005). Roots anchor seagrass to the sediment, but unlike terrestrial plants, seagrass also absorbs nutrients from the water along the entire length of its blades, which can reach ten feet. Similar to horizontal stems, rhizomes connect the upright shoots. Two species of seagrass are found along the coast of the Northeast. Eelgrass (*Zostera marina*) is the dominant seagrass throughout the region, while widgeon grass (*Ruppia maritima*) is limited to low-salinity waters. Eelgrass tolerates a wide range of temperature (0–30°C) and salinity regimes (10–30 parts per thousand) and takes root on substrates from coarse sand to mud. It even thrives among cobbles and boulders, in small patches of soft sediment. Eelgrass can live everywhere from tide pools along the shoreline to subtidal areas of up to 12 meters depth, as long as the water is relatively clear and allows sufficient light for growth. The most important factor in eelgrass survival and growth is light limitation. Eelgrass beds are a critical habitat in the Gulf of Maine. Their connection to fisheries is especially valuable. Eelgrass also provides vital services to improve water quality by filtering suspended sediment and excess nutrients. Additional information on habitats can be found on the Northeast Ocean Data Portal.

The Northeast Regional Ocean Council (NROC) recently sponsored a project to review marine habitat classification, characterization, and modeling activities in the Northeast region. This project resulted in an overview and comparison of existing marine habitat efforts in the Region being conducted by state and federal agencies, nongovernmental organizations, and academia. This report has been prepared to support NE ocean planning-related efforts and includes the results of a marine habitat classification and modeling workshop that the NE RPB and the Northeast Sea Grant Consortium convened in September 2013. More information is available in Review of Marine Habitat Classification, Characterization, and Modeling Activities in the Northeast United States and in Shumchenia *et al.* (2014).

Supplemental information is available from:

- Gulf of Maine Mapping Initiative
- Long Island Sound Mapping Initiative
- USGS seafloor mapping
    - CZM Cooperative Seafloor-Mapping Project (Massachusetts) provides high-resolution geologic data and products in support of the Massachusetts Ocean Management Plan
- HabCam survey work done in SBNMS (2007-2010) as component of the Northeastern Bentho-pelagic Observatory (NEBO). HabCam is an optical habitat mapping system for characterizing benthic community structure, sediment characteristics and water column properties

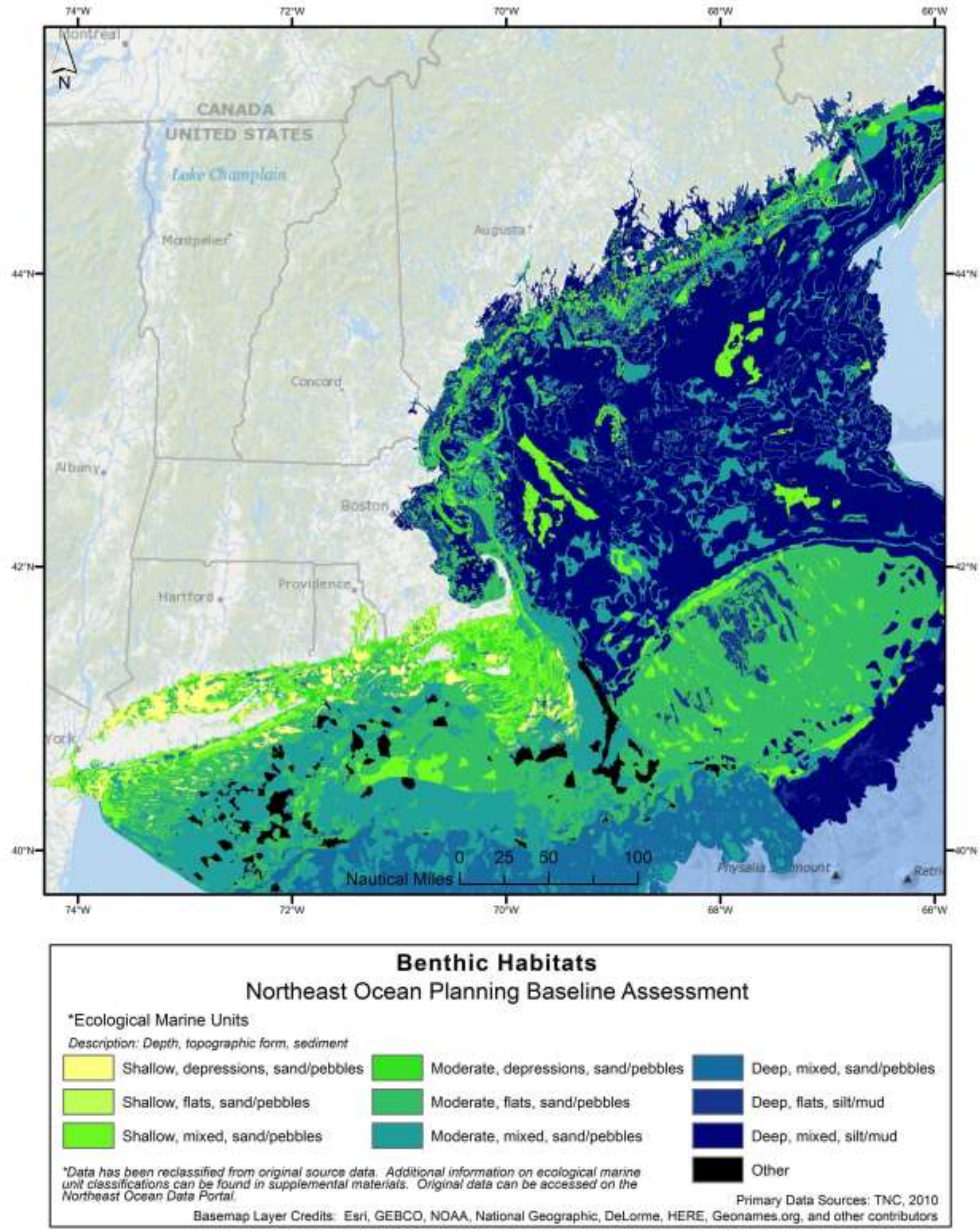

Figure 4 Benthic habitats

The information in Figure 4 is based on benthic habitat classifications from the 'Seafloor Habitats' layer downloaded from the Northeast Ocean Data Portal. Those data were assembled by The Nature Conservancy (TNC) in 2010 as part of the Northwest Atlantic Marine Ecoregional Assessment (NAM ERA). The benthic classifications were created using information on benthic fauna, bathymetry, sediment, and seabed forms. TNC's NAM ERA spatial data page provides updates and describes the synthesis of this diverse spatial data, which can also be downloaded. A complete discussion of the methodology is described in Chapter 3 of NAM ERA.

To simplify the map presentation of habitat types for purposes of this report, we have aggregated the 65 different benthic classifications NAM ERA uses for the Gulf of Maine and Southern New England Regions into 10 habitat categories (Figure 4). These are based on three depth designations (shallow, moderate, deep), three substrate designations (sand and pebbles, silt and mud, any), and four seabed forms classifications (depressions, flats, sloped, mixed). For details on the aggregation procedure, please refer to Appendix A.

3.1.4. Sand and gravel; beaches

For beach water quality monitoring purposes, the EPA recognizes more than 6,000 beaches nationally and about 900 distinct ocean beaches along the shorelines of the Northeast region (Figure 5). Sandy beaches are more prevalent in Massachusetts Bay and south and west of Cape Cod than along the coast of the Gulf of Maine. Massachusetts (374 EPA-listed beaches) and Rhode Island (74), and Connecticut (75) account for about half of the regional total. The Bronx, Nassau, Queens, Suffolk, and Westchester counties of New York have about 300 EPA-listed beaches. New Hampshire has 16, and Maine has 62. These beaches form protective barriers along some sections of the coast, are a major attraction for visitors from within and outside the Northeast region, especially in the Cape Cod area, and help generate significant market and non-market value associated with beach recreation (see section 4.4.3 below). Information is available at: http://www2.epa.gov/beaches

Sandy environments tend to have comparatively low biological productivity and species diversity, but they have unique species assemblages (Tyrrell 2005). Few species of algae grow in sandy areas because of a lack of solid substrates for attachment. Some filter- and deposit-feeding invertebrates thrive in sandy habitats, and fish hide among the ripples and ridges of subtidal sandy bottoms. Moon snails consume their bivalve prey while buried beneath the sand surface. Dunes provide nesting habitat for some imperiled birds, such as the roseate tern, northern harrier, piping plover, and least tern, and for the threatened diamondback terrapin. Some commercially valuable species such as the surf clam, quahog, winter flounder, summer flounder, and Atlantic halibut associate closely with sandy habitats. Dunes can protect inland areas from storm waves and wind, but human alterations of the shoreline frequently compromise this natural service. Sand beaches and dunes are prized for human recreation. The price of real estate along sandy shores reflects this value. The Gulf of Maine Habitat Primer provides additional information about physical habitat types.

Extensive sand and gravel deposits lie beneath the waters of the Northeast region (Figure 5), and support a modest minerals mining industry (see section 4.8.2 below). "Gravel" as used in the context of Figure 5 generally refers to sediments with grain size above 2 millimeters.

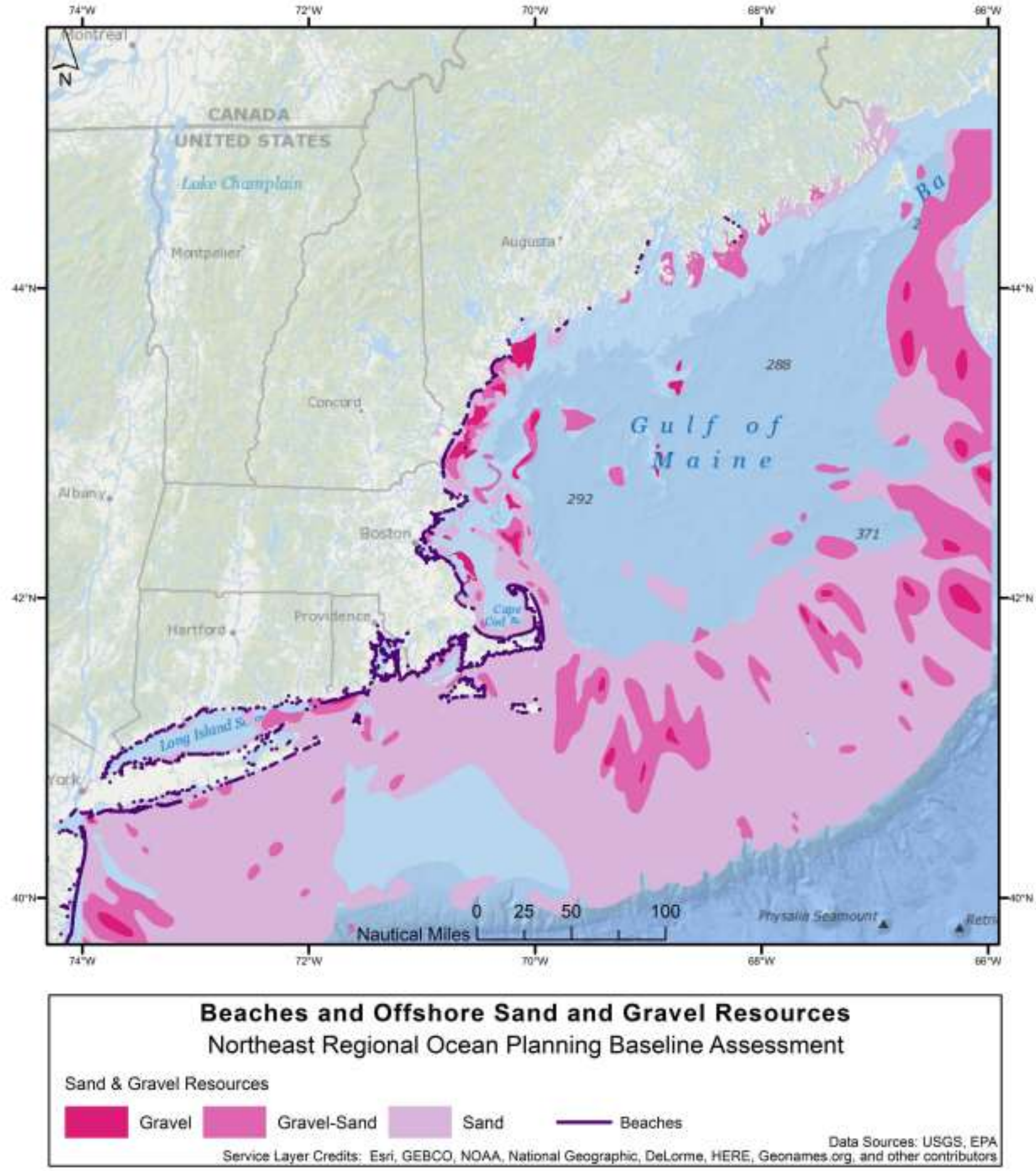

Figure 5 Beaches and offshore sand and gravel resources

3.1.5. Wetlands

Coastal marine wetlands extend along much of the shore of the Northeast region and form important habitats for marine life and birds, provide filtration functions for watershed drainage and coastal runoff, and buffer adjacent near-shore areas against coastal flooding. The Northeast as whole has some 300,000 acres of marine and estuarine wetlands (Table 1; Figure 6), and about 4.5 million acres of fresh water and inland wetlands (palustrine, lacustrine, and riverine). Because wetlands were long seen as "unhealthy" breeding grounds for noxious insects, and unsuitable for construction of residential or commercial buildings, many wetlands were filled or drained in the centuries after European settlement of the Region. It is estimated that the nation's wetland acreage today is about half of what it was before European colonization (Tiner 2005).

Acres of wetlands:	Marine	Estuarine	Fresh water/inland
Maine	69,816	83,175	2,022,141
New Hampshire	886	9,297	282,387
Massachusetts	21,269	61,854	453,356
Rhode Island	930	7,288	62,460
Connecticut	--	18,788	183,091
New York*	4,983	36,161	1,531,609

Table 1 Wetland acreage of the Northeast region states
Source: Tiner (2010). *Figures for New York are based on partial coverage of the entire state, not only the coastal counties included in the Northeast region. See Tiner (2010).

The state of Maine is considered to have the greatest total acreage of wetlands of all the contiguous US states; but most of these are inland freshwater wetlands. Using a measure of coastline length that is based on NOAA's 1975 estimates (CRS 2006), the wetland density along the Northeast's coast ranges from about 200 acres/mile of coast (Connecticut and Rhode Island) to about 700 acres/mile (New Hampshire and Maine). More information is available in Dahl and Stedman (2013), Tiner (2010), and on the Environmental Protection Agency's wetlands pages.

The Gulf of Maine Council on the Marine Environment has provided funding and technical assistance to 120 habitat restoration projects restoring more than 5,000 acres of important habitat in the region since 2002. These projects seek to reverse impacts to impaired coastal wetlands ands streams, and to restore their ecological functions and economic contributions to their full potential. The NE RPB also established a subcommittee to consider how best to recognize and support existing non-regulatory opportunities to work toward conserving, restoring, and maintaining healthy ocean and coastal ecosystems throughout the New England region. The subcommittee includes restoration experts at the non-governmental, tribal, state, and federal level who came together to look at restoration and conservation needs across the region, and strategically prioritize those projects most likely to produce substantial, sustainable benefits. A restoration theme on the NE Data Portal displays the location of priority Northeast US regional ecosystem restoration and conservation projects (including wetlands restoration) that, when implemented, will improve ocean health in the Northeast.

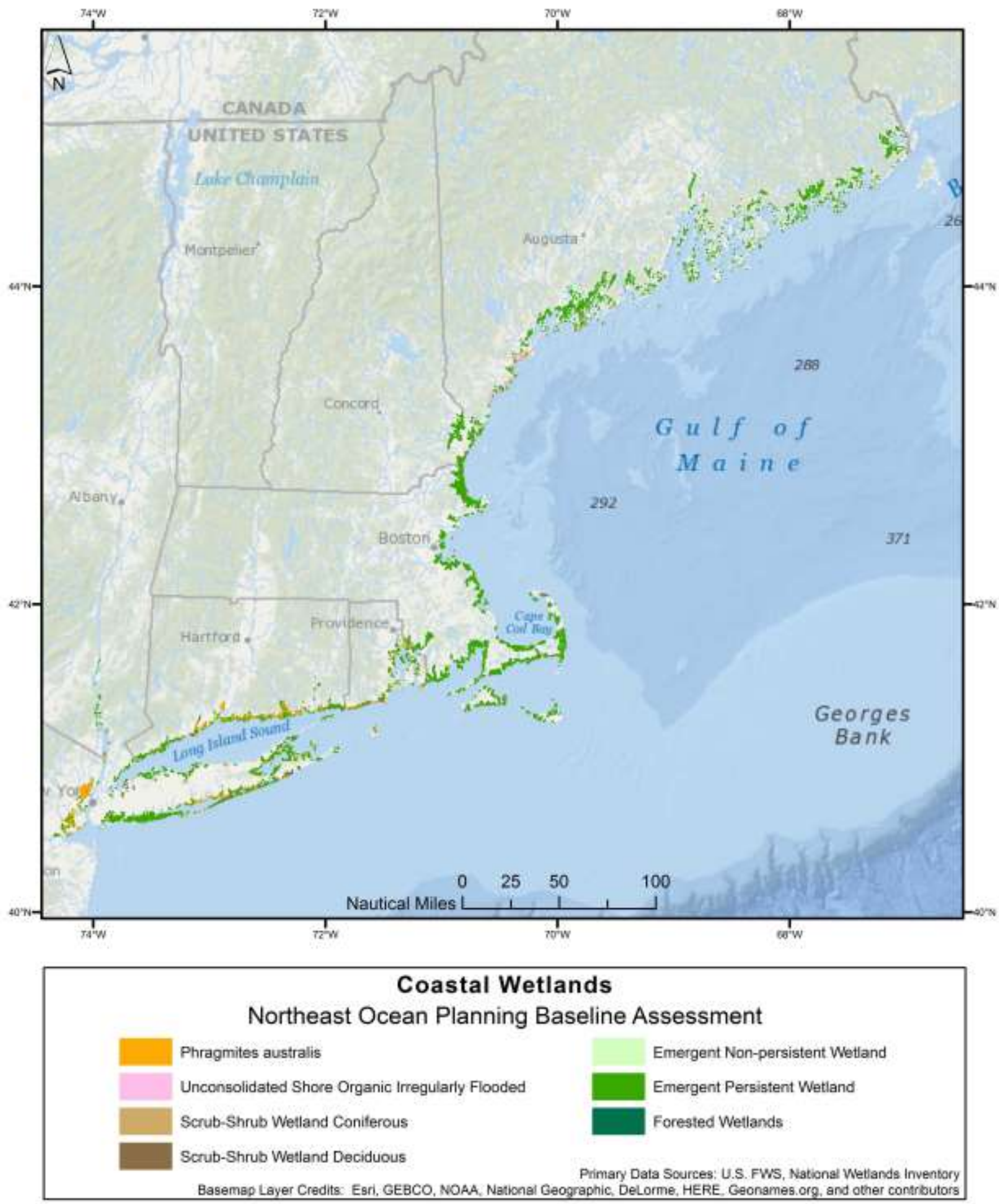

Figure 6 Coastal wetlands

3.1.6. Marine management areas

An extensive patchwork of federal and state marine management areas covers much of the Northeast region's ocean waters. Typically, each management area has a particular conservation focus to protect natural heritage, cultural heritage, or sustainable use of and/or production from marine resources.

Figure 7 illustrates some important federal management areas in the marine and coastal zone including: National Wildlife Refuges, National Park Service management areas, National Marine Sanctuaries, and National Estuarine Research Reserves. More information is available on the NOAA marine protected areas web pages and on the web sites of specific marine management areas (see Appendix B). In addition, the National Marine Fisheries Service has management areas where fishing activity is restricted for conservation or stock protection, areas protecting critical habitat for certain marine species, and areas restricting vessel and other operations to safeguard endangered species.

The Northeast also has six EPA National Estuary Programs (NEPs) established by Section 320 of the federal Clean Water Act. These include: Casco Bay Estuary Partnership, Piscataqua Region Estuaries Partnership, Massachusetts Bays National Estuary Program Buzzards Bay National Estuary Program Narragansett Bay Estuary Program, and Long Island Sound Study. In cooperation with state and local agencies and stakeholders, their work is guided by "comprehensive conservation and management plans" that provide blueprints for the protection and restoration of water quality and living resources in these waters. For more information on NEP study sites see the list of individual NEP homepages.

Examples of state management areas include the Massachusetts Ocean Plan's special, sensitive, or unique habitat designations and the Rhode Island Ocean Special Area Management Plan management areas.

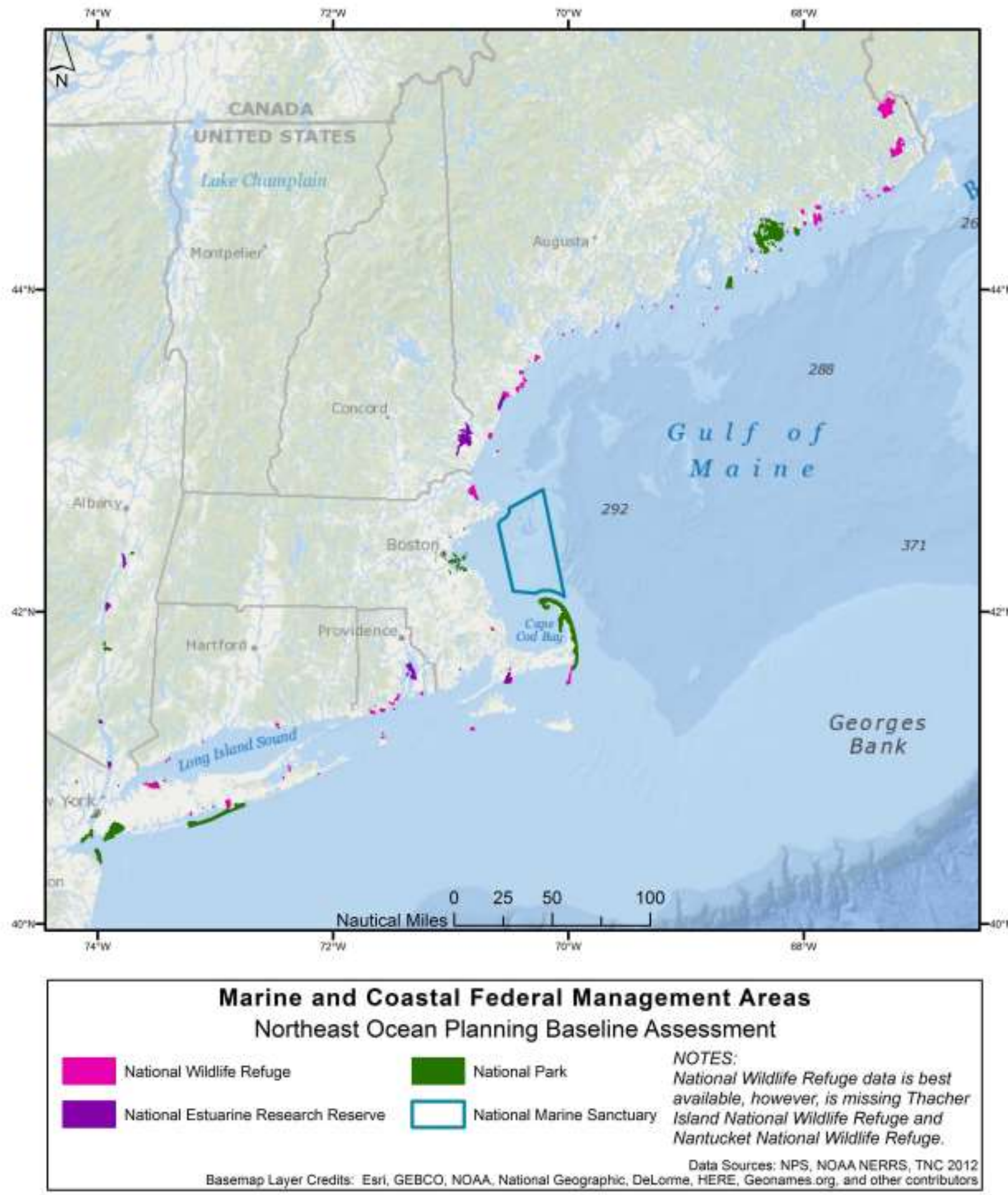

Figure 7 Federal marine management areas

3.1.7. Marine life characterization

The diverse coastal and marine habitat types in the Northeast are home to a variety of marine mammals, birds, fish, invertebrates and other species. The waters of the Gulf of Maine system, particularly at the boundary with the Bay of Fundy, are also home to the summering grounds for many different whale species, most notably the highly endangered North Atlantic right whale (*Eubalaena glacialis*).

Quantitative information about the spatial distribution and abundance of marine life is limited by the extent of human observations, which are concentrated on the coast or at the water surface, during daytime hours, and during good weather. Fish trawls and underwater imagery provide important sources of subsurface information, but are still limited by the types of environments in which they can be employed. Technologies such as satellite sensors, and environmental modeling efforts, supplement direct human observations with additional information. Still, there are geographic areas and a whole host of species—some that play important roles in the ecosystem—for which we have very little quantitative data. Scientific-quality survey data, collected by state and federal agencies, research institutions and other groups, provide information on three major taxonomic groups: marine mammals, birds, and fish. Important gaps for these three taxa remain, and relative to these, there are fewer data available for species such as sea turtles, large-bodied fishes, seals, benthic infauna/epifauna, coastal birds, bats, kelp and macroalage, and others.

Recently, new marine life data products (marine mammals, birds, and fish) were developed through a partnership with the Marine-life Data and Analysis Team (MDAT), which is a collaboration between Duke University, NOAA Northeast Fisheries Science Center, NOAA Centers for Coastal and Ocean Science, and Loyola University. The MDAT team collaborated with the RPB and expert work groups to produce individual species maps characterizing the distribution and abundance or biomass of 150 marine mammal, bird, and fish species, including several measures of uncertainty to supplement each map. Due to agency, work group, and public feedback, the RPB further aggregated these base products into summary maps (e.g., species richness) for whole taxa and certain species groups to provide a very broad snapshot of average annual marine life distribution and abundance. To better understand marine life movement, migration, and other behaviors, other datasets and/or analyses are needed. Some examples of this information are included in the descriptions below.

It is important to note that the MDAT project was conducted concurrent with the development of the Baseline Assessment. Therefore, the MDAT maps and project documentation on the Portal, combined with the Northeast Ocean Plan's Marine Life section of Chapter 3, provide a more complete source of information for marine mammals, birds, and fish. The Portal houses maps for 28 marine mammal species or guilds, 40 bird species, and 82 fish species from four separate trawl datasets. Additionally, these individual species maps have been aggregated into summary products, which represent patterns in groups of species based on existing regulatory frameworks (e.g., Endangered Species Act), species' ecology (e.g., feeding guild), and species' vulnerability to stressors (e.g., sensitivity to sound).

Marine mammals

The MDAT project developed models for 28 marine mammal species or guilds, including seals (all seal species were modeled together as a guild) and the North Atlantic right whale (Figure 8). Marine mammals were modeled at monthly, seasonal, and/or annual scales depending on the number of observations available. The MDAT map of average annual marine mammal species richness for the Atlantic coast (excluding seals; Figure 9) shows the highest number of species near the continental shelf break and slope. At the time of completion of the Phase 1 MDAT marine mammal models, there are plans in Phase 2 to supplement and/or complement the MDAT results with other marine mammals data sources such as observations from the North Atlantic Right Whale Consortium database, the Atlantic Marine Assessment Program for Protected Species database, and the Massachusetts Clean Energy Center monitoring data.

Monthly model outputs for marine mammals can be particularly important for understanding patterns in species that use the Northeast region for breeding and feeding during phases of their annual migrations. Other data sources that provide data and information about the timing and types of marine mammal life histories and behaviors include the passive acoustic monitoring work by the NOAA Protected Species Branch, and the delineation of Biologically Important Areas by the NOAA CetMap project.

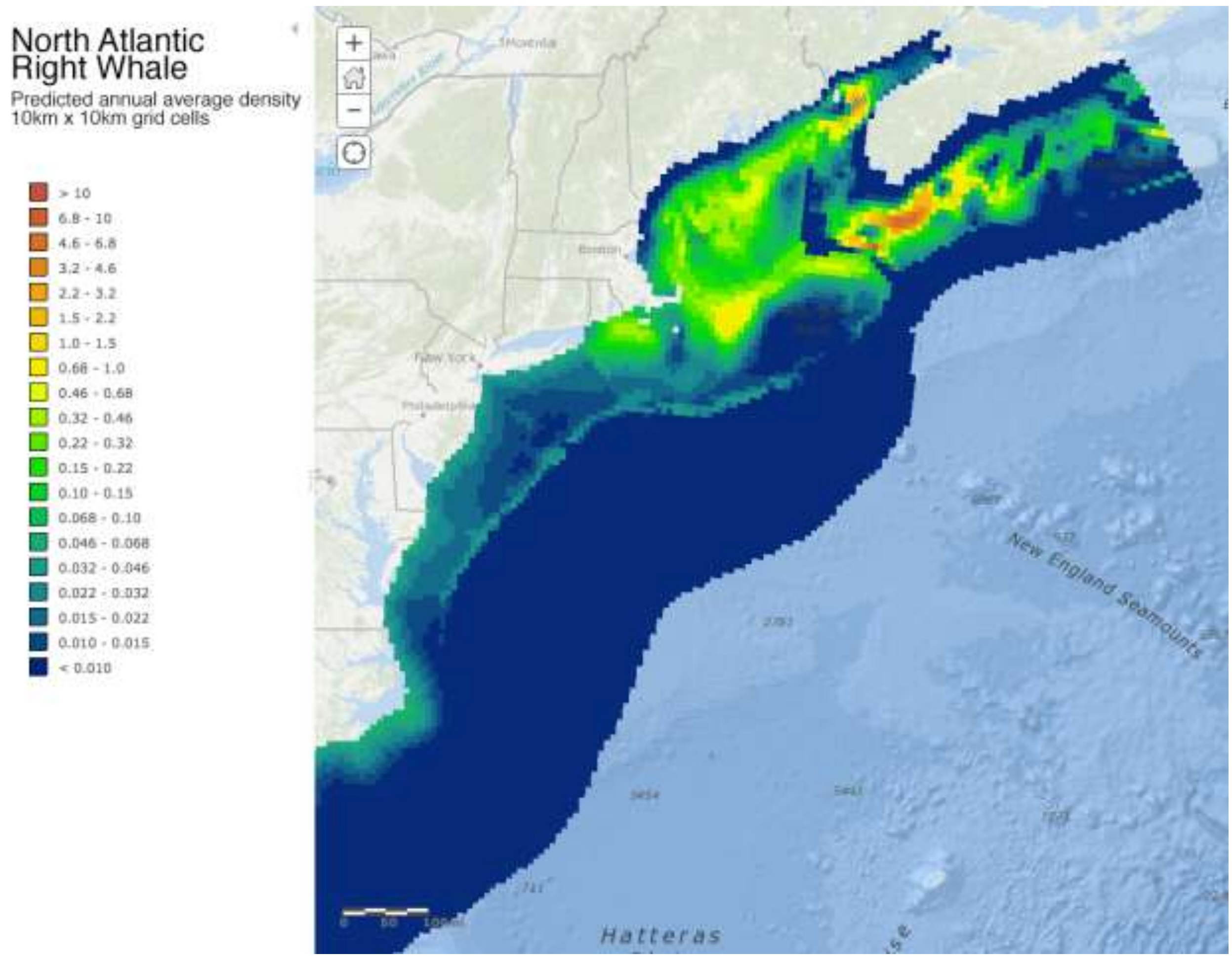

Figure 8 Modeled annual North Atlantic right whale abundance (predicted number of animals per 10km x 10km grid cell) from the Marine-life Data and Analysis team.

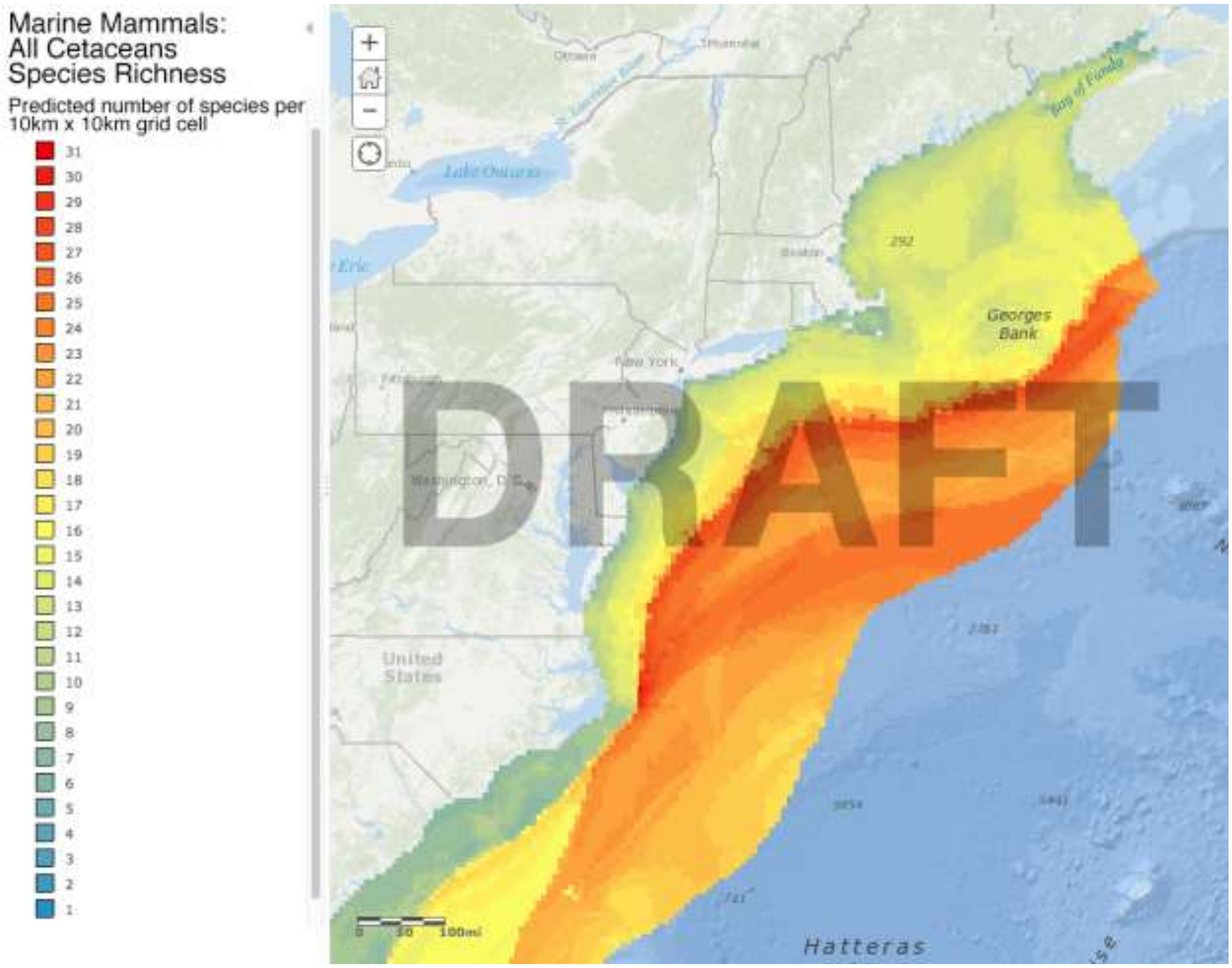

Figure 9 Marine mammals species richness (count of the total number of species present in each 10km x 10km grid cell using the annual individual species model results), excluding seals, from the Marine-life Data and Analysis Team. (Note: the marine life species group products initially were reviewed by the expert work groups and will continue to be reviewed by experts and stakeholders during the review of the draft NE Ocean Plan. Therefore, the species group products are labeled "Draft". The RPB will revise these products accordingly).

Birds

Birds are a diverse taxonomic group for which movement and migration data are also important. Seabirds, shorebirds, ducks, and even some songbirds utilize the Northeast marine environment. The MDAT project modeled the relative abundance and occurrence of 40 species—mostly "seabirds"—at seasonal and annual scales using at-sea observation data. For example, the MDAT avian model shows the relative abundance of long-tailed ducks in the region (Figure 10). The MDAT average annual species richness map for birds shows generally high richness offshore, in areas near Georges Bank, and near the continent shelf break and slope (Figure 11).

The Compendium of Avian Occurrence, from which the MDAT models were developed, is also an important source of information for nearshore and coastal bird observations.

These nearshore and coastal observations weren't included in the MDAT products because the modeling framework relied on oceanographic variables that were only available 1-2km offshore to the EEZ. Other data sources that supplement MDAT products include the US Fish & Wildlife Service Mid-winter Waterfowl Survey, the Atlantic and Great Lakes Seaduck Migration Study, and the Saltmarsh Habitat and Avian Research Program's database. Environmental Sensitivity Index maps also provide valuable supplementary information. There are other numerous ongoing avian tracking and telemetry studies in the region that can be consulted for information about avian movement patterns:

- Northeast Regional Migration Monitoring Network: http://rkozlo51-25.umesci.maine.edu/SBE/avian/MigrationMonitoring.html
- MOTUS Wildlife Tracking System: http://sandbox.motus-wts.org/data/viewtracks.jsp
- Mid-Atlantic Diving Bird Study: http://www.briloon.org/mabs/reports
- Common Eider Wellfleet Bay Virus Tracking Study: http://www.briloon.org/boston-harbor-common-eider-satellite-tracking-study
- Tracking Offshore Occurrence of Terns and Shorebirds in the Northwest Atlantic: http://www.boem.gov/AT-13-01/
- University of Rhode Island avian tracking studies: for example, see http://seagrant.gso.uri.edu/oceansamp/pdf/appendix/11a-PatonAvianRept.pdf

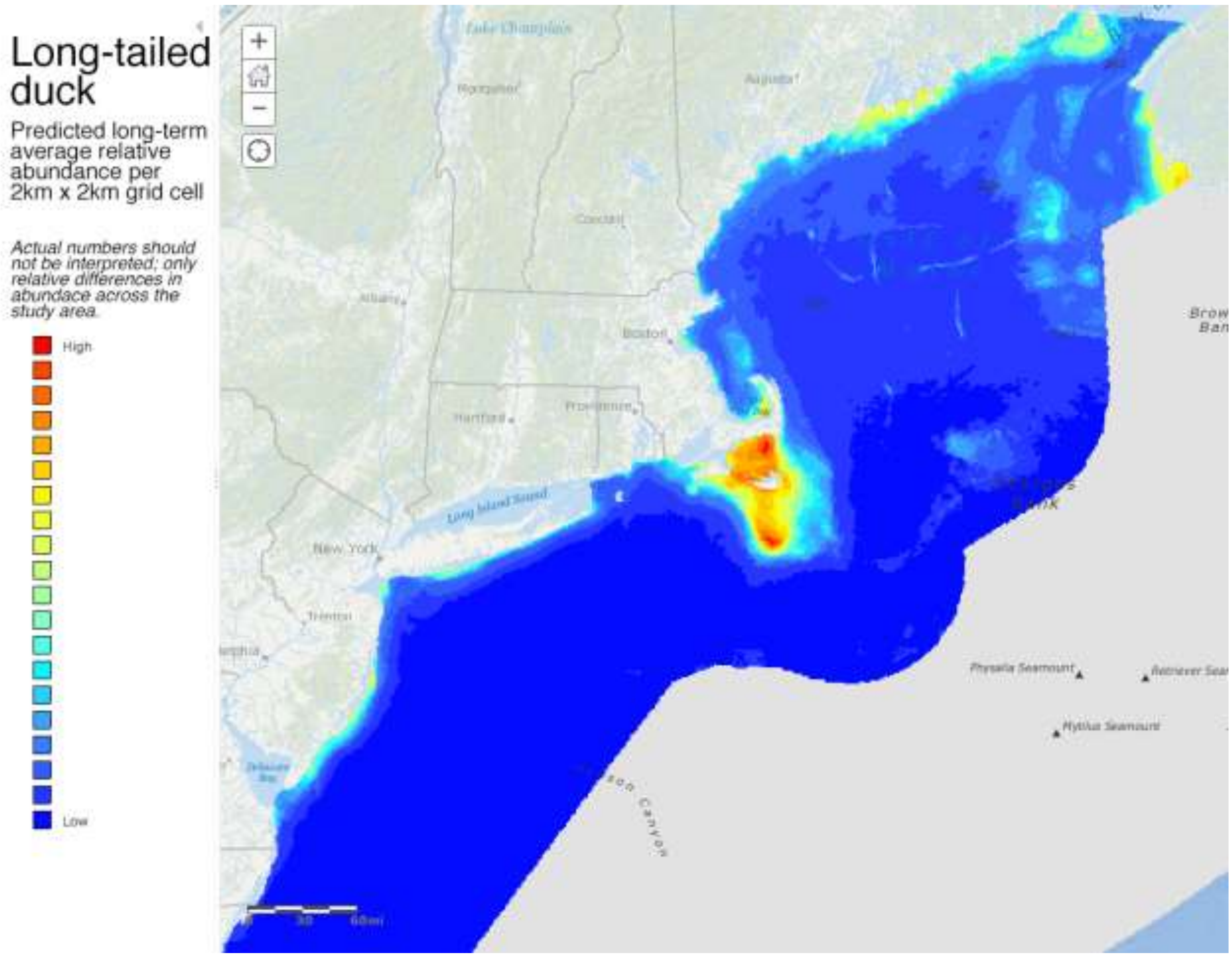

Figure 10 Long-term average annual relative abundance for long-tailed duck from the Marine-life Data and Analysis Team. The grey area masks model results further than 100km from a minimum distance path connecting the raw sighting location data.

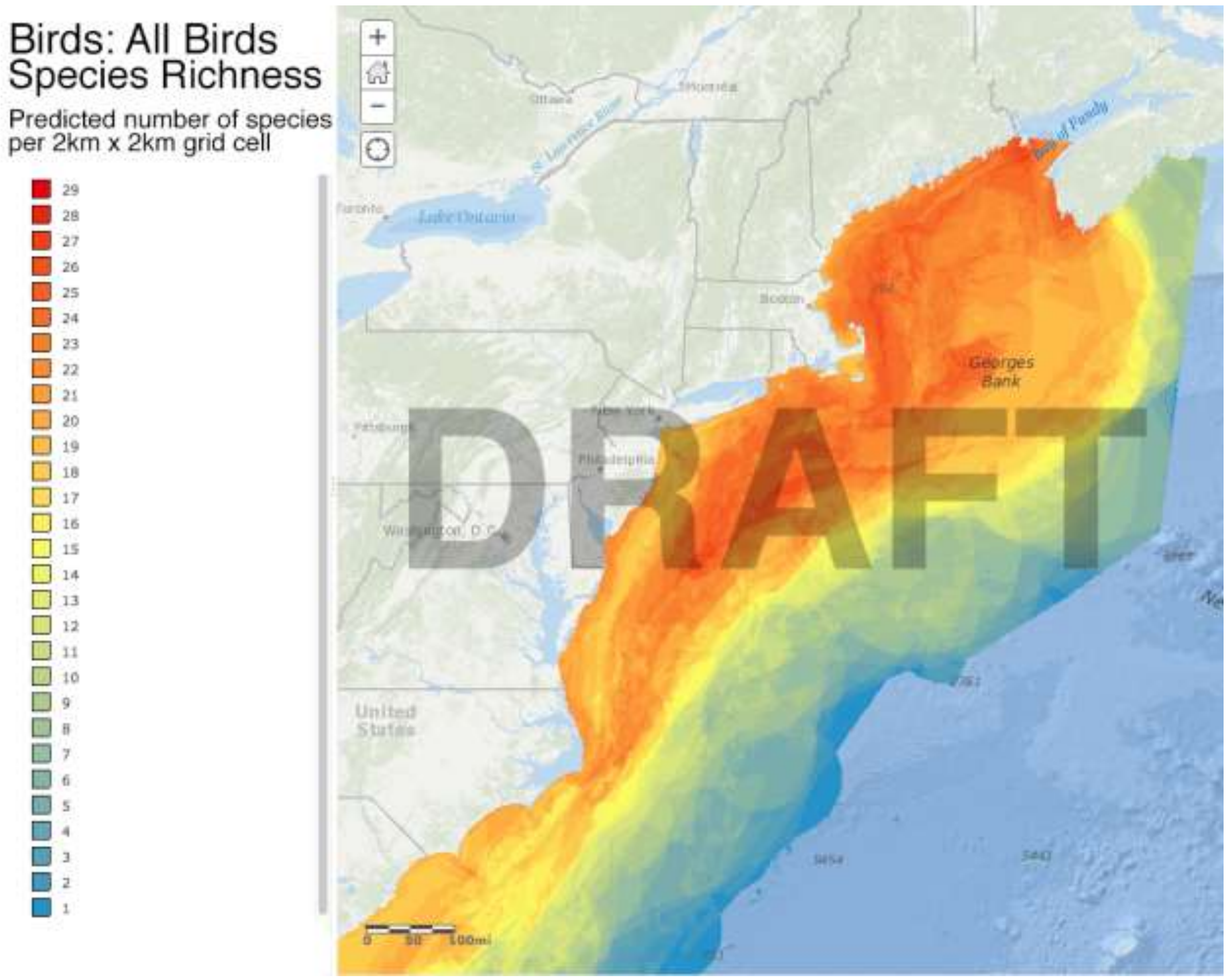

Figure 11 Avian species richness (count of the total number of species present in each 2km x 2km grid cell using the annual individual species model results) from the Marine-life Data and Analysis Team. (Note: the marine life species group products initially were reviewed by the expert work groups and will continue to be reviewed by experts and stakeholders during the review of the draft NE Ocean Plan. Therefore, the species group products are labeled "Draft". The RPB will revise these products accordingly).

Fish

MDAT map products for fish species relied on trawl survey data from several principal sources in the region: the NOAA Northeast Fisheries Science Center (NEFSC) (1970-2014), the North East Area Monitoring and Assessment Program (2007-2014), the Massachusetts Division of Marine Fisheries (1978-2014), and the Maine-New Hampshire state datasets (2000-2014). The states of Rhode Island and Connecticut also conduct nearshore fish trawls that were not part of the MDAT project (these data are planned to be integrated into the Portal separately). Unlike marine mammals and birds, fish distribution data are mapped as total fall season biomass for 82 individual species. Maps were produced for two time periods: the full time series for each trawl survey and the most recent decade, as available. An example MDAT fish map product using NEFSC data shows the interpolated log biomass of red hake in the region for all tows between 1970-2014, mapped onto 10km x 10km grid cells (Figure 12). The MDAT map of fish species richness (considering only the NEFSC trawl data) shows generally high richness near Massachusetts Bay, Cape Cod Bay, and the northern edge of Georges Bank (Figure 13).

The distribution, abundance, and biomass of sea scallops are characterized by three regular surveys on the Atlantic coast – a NOAA NEFSC scallop dredge survey, the University of Massachusetts School of Marine Science and Technology (SMAST) camera surveys, and the Virginia Institute of Marine Science dredge survey. Scallop maps were not developed as part of the MDAT project, but map products from the NEFSC and SMAST surveys are displayed on the Portal (Figure 14).

Commercial fishing effort maps, fishery observer data, anadromous species monitoring, and scientific ship-board or aerial surveys also represent important sources of information for characterizing fish distribution and abundance, especially for species that may not be well represented in the principal trawl surveys. For example, occurrences of large fish such as basking shark, blue shark and ocean sunfish were mapped from aerial photos by the Massachusetts Clean Energy Center (Taylor et al. 2014).

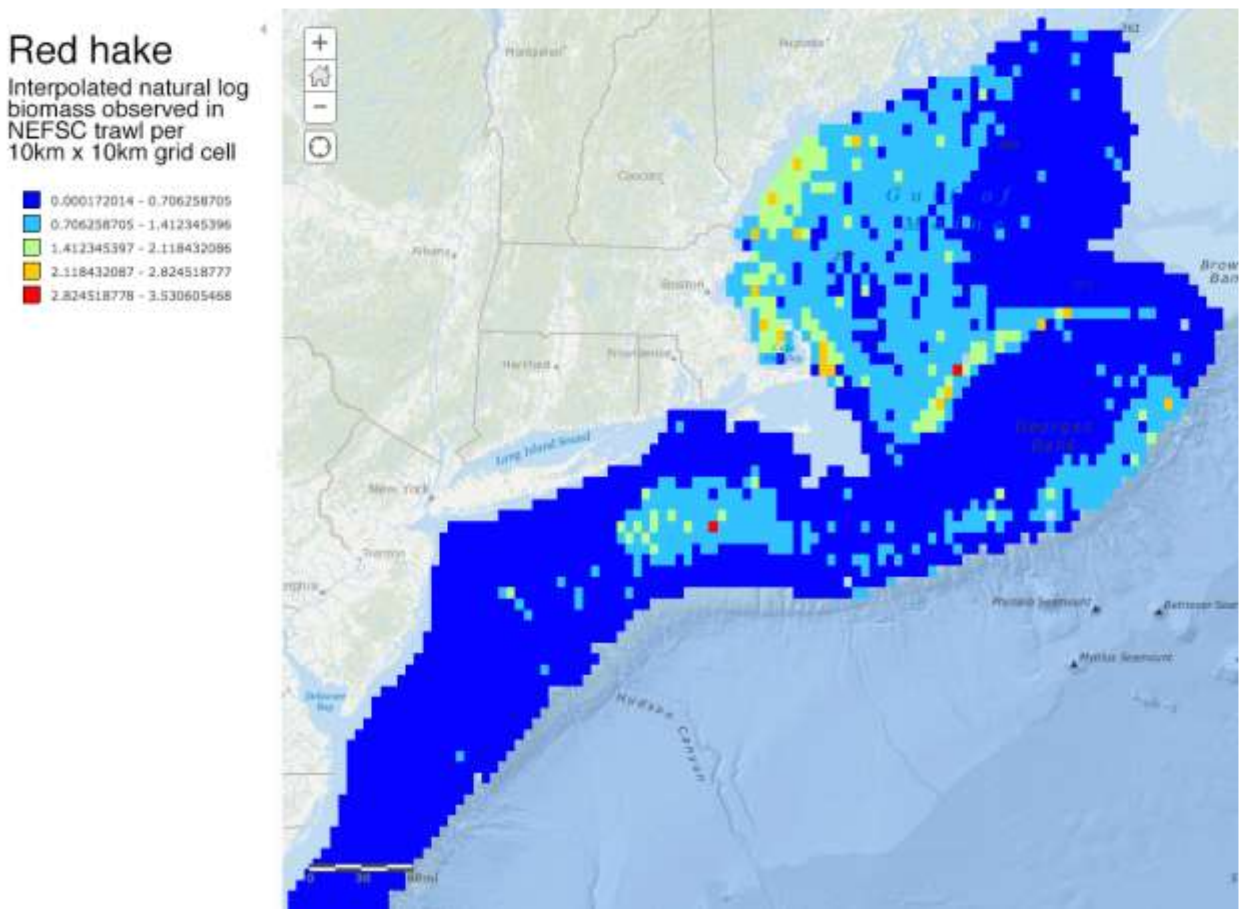

Figure 12 Interpolated natural log biomass of red hake for all NEFSC tows between 1970-2014. Grid cells are 10km by 10km.

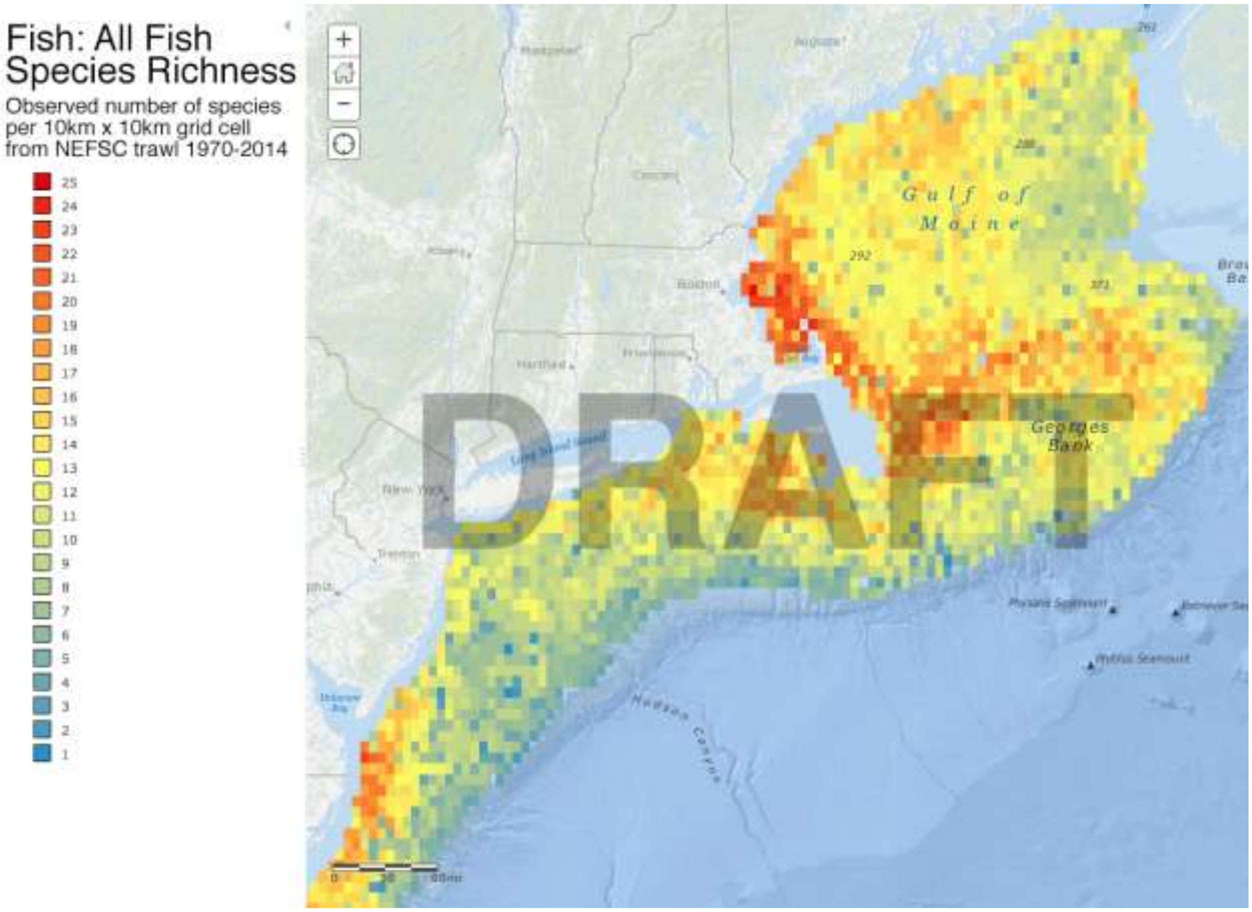

Figure 13 Fish species richness (count of the total number of species present in each 10km x 10km grid cell using interpolated biomass for each species in the NEFSC trawl data), from the Marine-life Data and Analysis Team. (Note: the marine life species group products initially were reviewed by the expert work groups and will continue to be reviewed by experts and stakeholders during the review of the draft NE Ocean Plan. Therefore, the species group products are labeled "Draft". The RPB will revise these products accordingly).

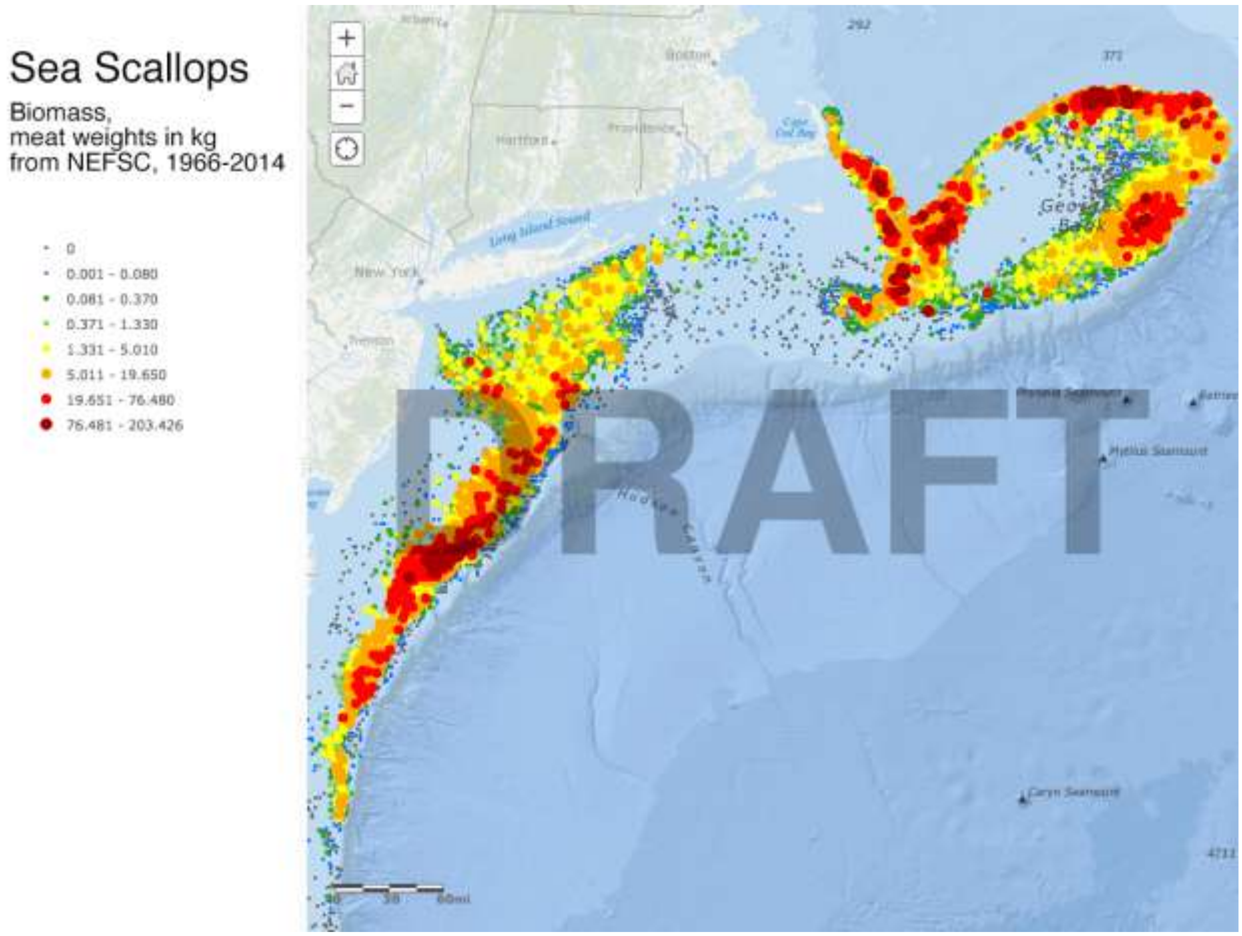

Figure 14 Scallop biomass (meat weights in kilograms) from the NEFSC Scallop trawl database, showing all trawl data from 1966-2014. (Note: these products will continue to be reviewed by experts and stakeholders during the review of the draft NE Ocean Plan. Therefore, these products are labeled "Draft". The RPB will revise these products accordingly).

Through the end of 2016, MDAT will conduct Phase 2 of their mapping efforts, which will include updating models, model outputs, and uncertainty products with additional data (e.g., developing a sea turtle model, adding new observations for marine mammals, adding Long Island Sound fish trawl and RI coastal trawl data), and updating the total abundance, richness, diversity and other summary products as necessary. This work will increase the usefulness of MDAT products for ocean planning purposes by incorporating the newest available marine life data.

3.2. Marine and coastal cultural resources

3.2.1. Tribal culture

Tribes of indigenous (native) people have lived along the coasts of the Northeast region for at least 12,000 years before the arrival of European settlers. Dozens of historical tribes have been identified; and ten have been federally recognized as of 2015 (Figure 15).

Native tribes' traditional culture included close connections with the land and coastal waters, which supported a variety of hunting, gathering, farming, harvesting, fishing, and foraging activities to obtain resources for sustenance, medicinal, spiritual, material or technological purposes, as well as travel, trade, recreation, and ceremonial activities (pers. comm., David Weeden, Mashpee Wampanoag Tribe and Elizabeth J. Perry, Wampanoag Tribe of Gay Head-Aquinnah, 2015; see also Appendix C). In their traditions, the tribes see themselves as caretakers of the land, which they regard as their spiritual mother, and the waters of the region; if the land and waters are kept healthy, they will provide for the people (pers. comm., David Weeden, Mashpee Wampanoag Tribe, July 2015).

Spring and fall anadromous and catadromous fish runs were important parts of tribes' annual harvest from the sea and rivers, including Atlantic eel, Atlantic salmon, shad, herring, Atlantic sturgeon, and whitefish. According to Mohegan Tribe archives, the Thames River (previously known as the Pequot Mohegan River) was widely known for its abundance of fish, including shad, alewives, bass, mackerel, eels, oysters, and lobster (pers. comm., Melissa Zobel and Faith Davidson, Mohegan Indian Tribe of Connecticut). Fish roe was an important part of some tribes' diet, and whales and dolphins were harvested on beaches where they would commonly strand, particularly on the Cape and Islands. Sharks were also caught and cooked. The Wampanoag Tribe of Gay Head-Aquinnah historically fished for swordfish and flatfish, hunted for whales, spearfished lobster, set crab traps in shallow water, and gathered edible seaweed (pers. comm., Elizabeth J. Perry, Aquinnah Wampanoag Tribe, 2015; see also Appendix C). The Wampanoag tribe continue to make their living off the sea in commercial fishing and shellfishing, in charter boat fishing, as tug boat Captains and in related industries such as hatchery work, ownership of seafood restaurants, as marine scientists, scientific illustrators, and marine mammal rehabilitators (pers. comm., Elizabeth J. Perry, Aquinnah Wampanoag Tribe, 2015; see also Appendix C).

Certain locations along the Northeast coast and in fresh and brackish rivers are known (or have been rediscovered through archaeology) to have been places where Native people built and maintained elaborate fish weirs for concentrating and trapping fish; Boston Common is one such place, now covered in fill. Mohegan tribal archives document weirs being used to catch eels, bass, shad, smelt and other fish, with some remains of weirs dating back beyond 2500 B.C. (pers. comm., Melissa Zobel and Faith Davidson, Mohegan Indian Tribe of Connecticut). As another important part of tribal sustenance, men and women also gathered shellfish of various species including razor clams, soft shell clams, quahogs and mussels; some of this harvest was also dried for winter use, while the shells of quahog, whelk and oyster were used to manufacture white and purple shell beads for ornament, trade and diplomacy termed wampum in the native language (pers. comm., Elizabeth J. Perry, Wampanoag Tribe of Gay Head-Aquinnah). Archeological records from the Mohegan Tribe indicate shellfish sites containing whelk, bay scallop, blue mussel, moon shell, boat shell, oyster, and soft shell clam – shell middens were the byproduct of large-scale preservation of shellfish for winter consumption (pers. comm., Melissa Zobel and Faith Davidson, Mohegan Indian Tribe of Connecticut).

Rapid development of the region since the arrival of European settlers has diminished or compromised some coastal lands and waters and the once abundant resources they support. Development and privatization of coastal property has also compromised access to waterways, intertidal areas, historic paths and ways, and woodland areas traditionally used for hunting, gathering, and harvesting. Tribes advocate for the restoration of these lands, waters, and resources, and for restoration of access, wherever possible. For example, Wampanoag tribes have been involved with seeding shellfish, growing oyster spat and eelgrass restoration, as well as piping-plover monitoring (pers. comm., Elizabeth J. Perry, Wampanoag Tribe of Gay Head-Aquinnah and Chuckie Green, Mashpee Wampanoag Tribe). Tribes are also concerned about the restoration of anadromous fish populations and prioritize the restoration of water quality and fish habitat for Atlantic Salmon and other species including American shad, river herring, and eel (pers. comm., Sharri Venno, Environmental Planner, Houlton Band of Maliseet Indians). In 2009, five federally recognized Tribal Nations in Maine and the US EPA worked cooperatively to produce the Wabanaki Traditional Cultural Lifeways Exposure Scenario (Harper and Ranco 2009), which documents past environmental contact, diet, and exposure pathways for tribal cultural traditions in Maine and is used to better understand potential impacts to tribal resources (pers. comm., Sharri Venno).

In some locations, sea level changes over thousands of years have led to submergence of settlement and ceremonial sites identified in tribal traditions. For example, Mashpee Wampanoag tribal activities are said to have occurred 200 miles off the present coast of Massachusetts, making some of these offshore areas archaeologically sensitive (pers. comm., David Weeden, Mashpee Wampanoag Tribe, July 2015). Nantucket Sound and Narragansett Bay are examples of areas where submerged sites remain important to tribal culture, history, and way of life. Data collected by USGS from Buzzards Bay, Vineyard Sound, and along the southern coast of Martha's Vineyard indicate that it is possible to detect and re-create now submerged and buried ancient postglacial landscapes. Creating a paleo-landscape map would require additional sediment cores and data mining and analyses to supplement existing USGS data. An accurate paleo-landscape model and map would require specific data analyses performed by experts in the field; and development of a reliable model will require active collaboration with Native American peoples (see p. SF-24 of the Massachusetts Ocean Management Plan (COM 2015).

Some detailed history of the Narragansett Tribe's traditions and pre- and post-colonial activities in southern New England is provided in Section 410.2, Chapter 4 of the Rhode Island Ocean Special Area Management Plan (RICRMC 2010). In Section 420.4, Chapter 4, the Rhode Island Special Area Management Plan also addresses paleocultural landscape reconstruction. Efforts are underway on the part of the Bureau of Ocean Energy Management, the Narragansett Tribe, and University of Rhode Island to develop science-based "best practices" for identifying submerged Native American archaeological sites in the region. These new methods will assist resource planners, managers, and tribal communities in evaluating proposed offshore and continental shelf development projects (pers. comm., Doug Harris, Narragansett Indian Tribe of Rhode Island)

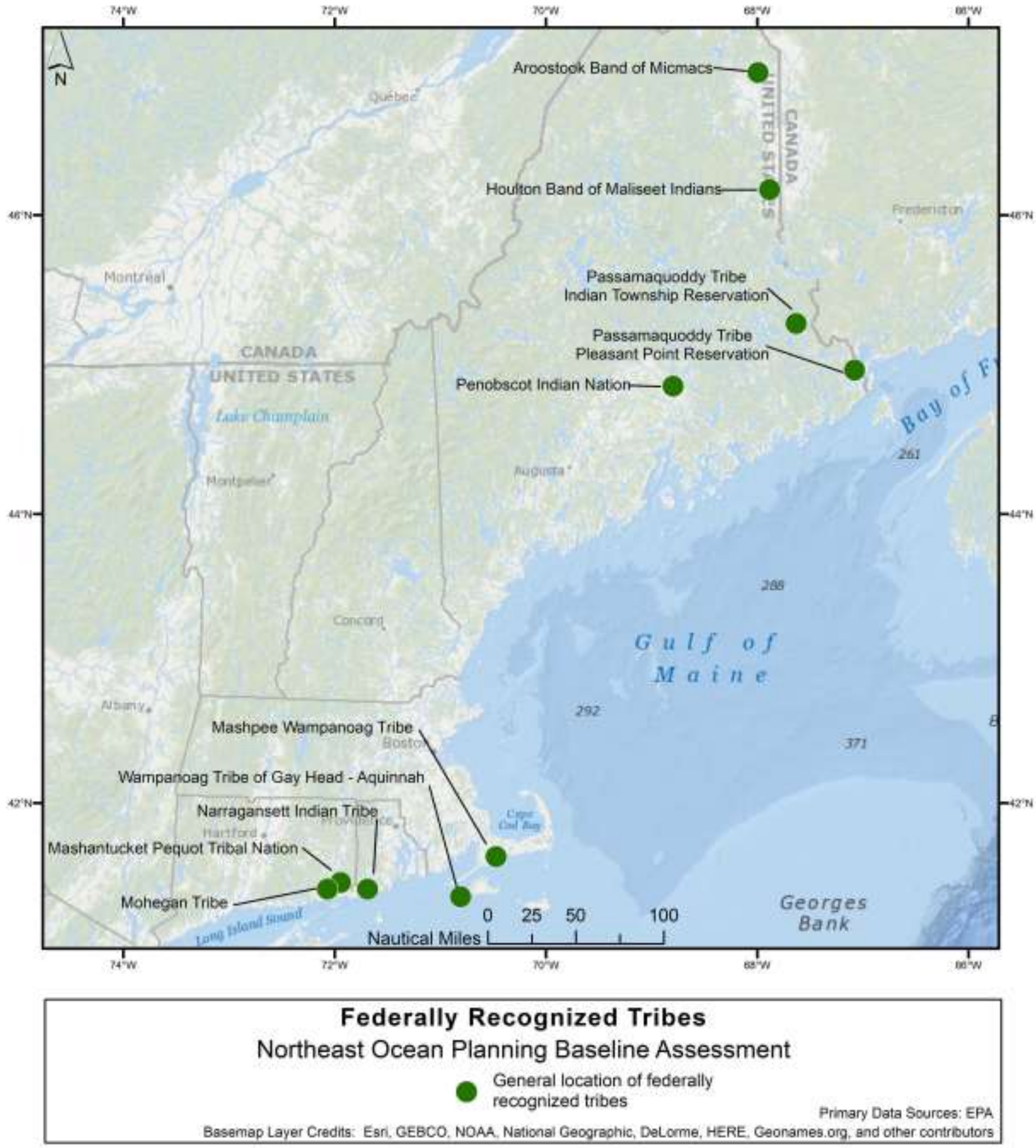

Figure 15 Federally recognized tribes

3.2.2. Coastal Communities

Reflecting the region's maritime tradition, working waterfronts and island communities rely on a healthy ecosystem and continue to have strong economic and cultural ties to the ocean. The existence of many fishing communities is tied to their ability to fish in a particular area - determined in part by the size of their boats, the species being sought, fishing pressure from other communities, and government regulations. The loss of the ability to fish can mean the decline or disappearance of an entire community (Battista 2015).

For example, Maine's coastal economy is reported to be heavily dependent on fisheries – particularly lobster. According to the Island Indicators 2015 report and Maine Department of Marine Resources, in 2014 lobster accounted for 78.1% ($457 million) of the total value of Maine's fisheries ($585 million). While the state of Maine's economy as a whole depends heavily on the lobster industry, for some small island and coastal communities, lobster is the only economy. Even in other communities with significant income from recreation, tourism, and construction, lobstering provides a significant percentage of family income that would not be easily replaced.

There are many working waterfront programs in the Northeast that seek to enhance the capacity of coastal communities and stakeholders to make informed decisions, balance diverse uses, ensure access, and plan for the future of working waterfronts and waterways. In some cases, there are state-level resources such as funding and technical assistance available to help ensure that communities consider long- and short-term needs for working waterfronts. Many of these efforts are intended to help communities maintain access for traditional, economically and culturally important uses, including commercial fishing and recreation.

3.2.3. Historic and Archeological Resources

The National Register of Historic Places is maintained by the US National Park Service as the official list of the nation's historic places worthy of preservation. Authorized by the National Historic Preservation Act of 1966, the National Register of Historic Places is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect America's historic and archeological resources. The Register includes about 1,300 historic places in Maine, 800 in New Hampshire, 4,300 in Massachusetts, 800 in Rhode Island, and 1,600 in Connecticut. Data on these are available on the National Register of Historic Places research pages. The National Park Service is in the process of digitizing the National Register information, and online records are not yet complete.

At least 150 shipwrecks have been located and identified in the waters of the Northeast. Some of these are of historical and archaeological interest; and some are an attraction for recreational divers (see section 4.4.5).

During the past 300 years, there have been at least 1,200 maritime accidents and disasters in the waters of Rhode Island and Rhode Island Sound, many of them in the vicinity of Block Island, Point Judith, Watch Hill, and Beavertail. The Rhode Island Ocean Special Area Management Plan (Section 420.2, Chapter 4, RICRMC 2010) identifies likely locations of about 50 shipwrecks in Rhode Island waters.

The Massachusetts Ocean Management Plan (p. BA-27, COM 2015) describes a list of about 40 shipwreck sites in Massachusetts waters designated for preservation and for activities such as recreational diving, and a "sensitivity map" that captures the approximate location of thousands of other potential wreck sites.

More information is available on the Wreckhunter.net web pages and from NOAA's Automated Wreck and Obstruction Information System (AWOIS). While the locations of some shipwrecks are well know to the navigation community as obstructions to vessel traffic, or to the archaeological and recreational diving communities, the locations of other historic shipwrecks are not known precisely, or not published to protect the site from damage caused by recreational divers or treasure seekers. As a result, there is no single comprehensive list or map of shipwreck locations. For ocean planning purposes, "sensitivity maps" such as that described above can be used to identify areas with potential wreck site that may warrant detailed surveys before carrying out activities that could damage historical resources.

3.3. Marine and coastal infrastructure

3.3.1. Commercial ports

Commercial ports and harbors provide dockage for cargo and passenger vessels, transfer facilities for petroleum, dry bulk, and containerized cargo, vehicles, and ferry and cruise ship passengers, landing facilities and support for commercial fishing vessels, and dockage and anchorages for recreational boats. Major commercial ports of the Northeast are shown in Figure 16, and include:

- Eastport, ME: http://me.usharbors.com/harbor-guide/eastport
- Searsport, ME: http://me.usharbors.com/harbor-guide/searsport
- Portland, ME: http://www.portlandharbor.org/
- Portsmouth, NH: http://nh.usharbors.com/harbor-guide/portsmouth-harbor
- Gloucester, MA: http://www.gloucesterma.com/Boating.cfm?c=84
- Salem, MA: http://ma.usharbors.com/harbor-guide/salem
- Boston, MA: https://www.massport.com/port-of-boston
- New Bedford and Fairhaven, MA: http://www.portofnewbedford.org/
- Fall River, MA: http://ri.usharbors.com/harbor-guide/fall-river-ma
- Providence, RI: http://www.provport.com/
- Quonset/Davisville, RI: http://www.quonset.com/sea/
- New London, CT: http://ct.usharbors.com/harbor-guide/new-london
- New Haven, CT: http://www.cityofnewhaven.com/PortAuthority/Terminal/
- Bridgeport, CT: http://ct.usharbors.com/harbor-guide/bridgeport
- Stamford, CT: http://www.stamfordct.gov/harbor-management

Many of these ports are connected by regional maritime transit routes to the Port of New York and New Jersey: http://www.panynj.gov/port/ .

See section 4.5.1 and Figure 45 below for more details.

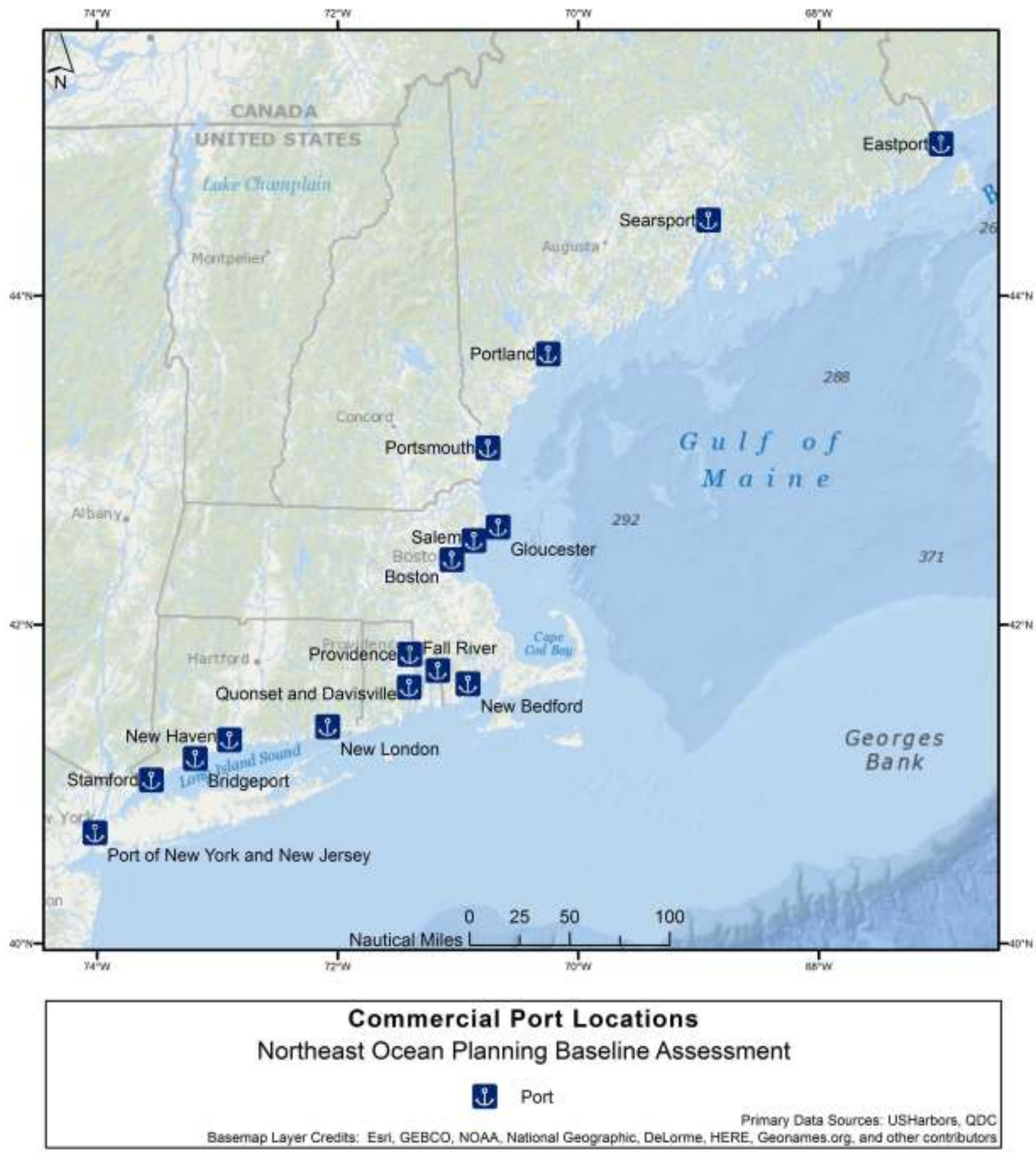

Figure 16 Commercial port locations

3.3.2. Naval/military/national security facilities

Three major naval military facilities are located in the Northeast region:

- Portsmouth Naval Shipyard, New Hampshire: focused on overhaul, repair and modernization of the US Navy's Los Angeles-class submarines; http://www.navsea.navy.mil/Home/Shipyards/Portsmouth.aspx

- Naval Station Newport, Rhode Island: a US Navy research, development, training, and education center; http://www.cnic.navy.mil/regions/cnrma/installations/ns_newport.html
- Naval Submarine Base, New London, Connecticut: the US Navy's primary submarine base on the east coast; http://www.cnic.navy.mil/regions/cnrma/installations/navsubbase_new_london.html

In addition, several commercial shipyards in the Northeast support naval ship procurement:

- Bath Iron Works (General Dynamics), Bath, Maine: focused on design, construction, and support of surface combatant ships; https://www.gdbiw.com/
- Electric Boat (General Dynamics), Groton, Connecticut: design, construction, and support of submarines for the US Navy; http://www.gdeb.com/
- Electric Boat (General Dynamics), Quonset Point, North Kingston, RI; http://www.gdeb.com/about/locations/quonset/

There is also a Naval Computer and Telecommunications Master Station in Cutler, ME, that provides communications services to naval surface ships and submarines.

In the Northeast, the US Coast Guard is represented by the First District staff and operates a number of facilities, including 55 onshore units (among them Air Station Cape Cod and International Ice Patrol), 28 "afloat" units, and seven cutters (http://www.uscg.mil/d1/units.asp). More information on USCG resources can be found at: http://www.uscg.mil/datasheet/.

The First District area of responsibility includes Northern New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, and Maine. The district is divested into five sectors: Sector Northern New England (Maine, New Hampshire), Boston (NH border south to Manomet Point, MA), Sector Southeastern New England (Manomet Point, MA to Watch Hill Point, RI), Long Island Sound (South shore of Long Island and along coastal CT), and New York (Long Branch New Jersey to New York City (all boroughs), and up the Hudson River). More information about the First District can be found at: http://www.uscg.mil/d1/units.asp and http://www.uscg.mil/top/missions/

3.3.3. Marinas

Some 600 marinas serve the recreational power boating and sailing community (see sections 4.4.1 and 4.4.2) in the Northeast. From ENOW data, the highest concentration of marinas is in New York, Massachusetts, and Connecticut (Figure 17).

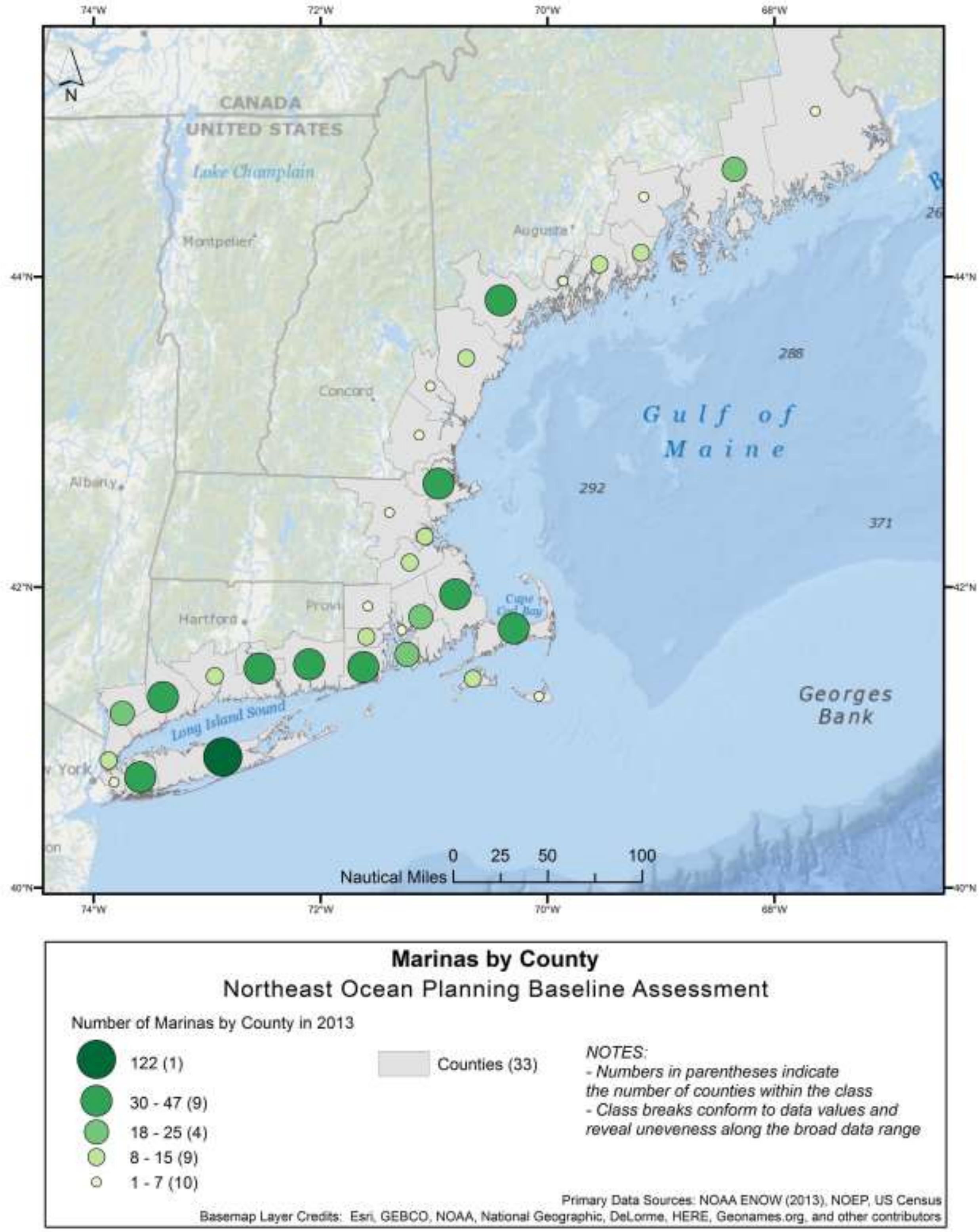

Figure 17 Marinas by county, 2013

3.3.4. Shoreline structures

Much of the shoreline of the Northeast region is extensively developed or settled, even outside urban centers. Where this shoreline is vulnerable to flooding or erosion (e.g. sandy cliffs or beaches), due to exposure to tides and waves, property owners and municipalities or states have taken steps to "armor" the shore to prevent erosion and/or flooding. For example, according to data assembled by the Massachusetts Office of Coastal Zone Management, some 27% of the Massachusetts coastline is armored in some fashion by means of public or private seawalls, bulkheads, revetments, groins, and jetties; and 5% of Maine's shoreline is similarly armored.

3.3.5. Pipelines and cables

Submarine pipelines are used to transport fuel oil and natural gas along short stretches of the Northeast region's coast; and submarine cables are used to transmit power or provide data and communications links. Submarine cables either transmit energy or telecommunication signals across stretches of water. Importantly, this includes 95 percent of the intercontinental internet traffic and essential electricity service to island communities. In New England, transatlantic telecommunication cables run through Long Island Sound and out of Charlestown, RI and Lynn, MA. A number of transatlantic cables are also just to the south of New England, originating in Long Island, New York City, and New Jersey. Electricity cables can be found along the shoreline, making critical grid connections from the mainland to islands offshore each state, and occasionally transiting longer distances with higher transmission capacity, such as in Long Island Sound.

The North American Submarine Cable Association (NASCA) serves as a forum for the exchange of information on submarine cables. Three NASCA cables are known to not have accessible spatial data, and as a result are not shown in Figure 18. These are:

- GlobeNet Segment 5 from GlobeNet
- MAC 1 and MAC 3 from Level 3
- PTAT Segment E2 from Sprint (out of service)

Locations of pipeline and cable areas are shown in Figure 18. Trans-Atlantic cable routing reflects a preference for keeping cables off the shallow shelf and banks as much as possible, since cables must be buried in those regions to protect them from damage by bottom trawling and fishing gear.

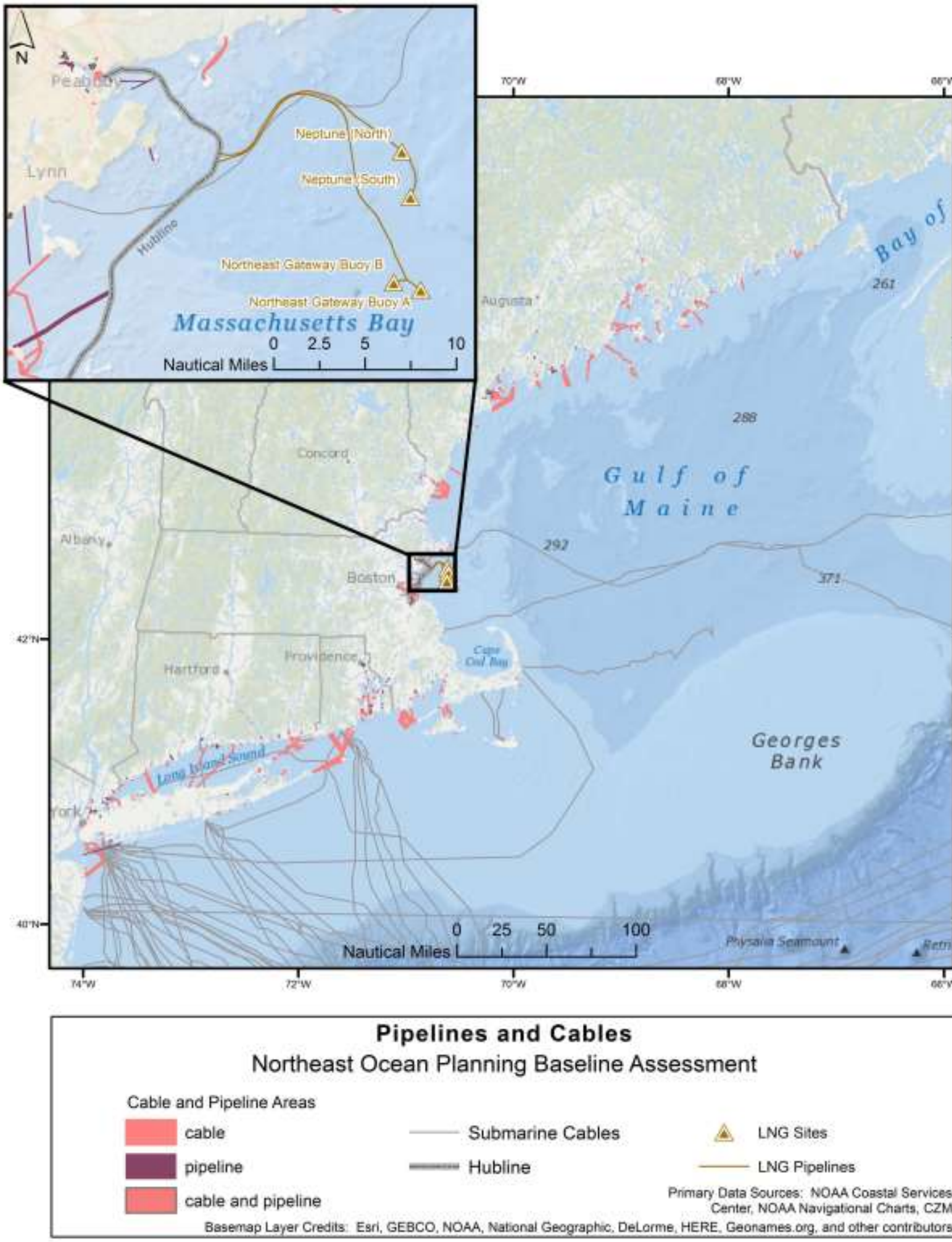

Figure 18 Pipelines and cables

3.4. Human population and residential real estate

All data used in Section 3.4 of this document are based on information from the US Bureau of the Census and on work carried out at the Center for Blue Economy, unless otherwise cited.

The coastal population of the Northeast (Figure 19) is concentrated in major urban centers and adjacent heavily populated coastal suburbs, with less densely populated coastal communities along much of the remainder of the shore. The major urban centers are the New York City area (including Nassau County) and Boston with populations over 600,000. Heavily populated suburbs are located in Suffolk County (New York), Connecticut, Rhode Island, and the South Shore of Massachusetts (the area between Boston and Cape Cod). Slightly lower population density extends up the North Shore of Massachusetts (north of Boston) through coastal New Hampshire and into Cumberland County, Maine. Smaller communities with populations generally less than 10,000 make up much of Maine east of Cumberland County, Martha's Vineyard, and the outer reaches of Cape Cod (but note that these areas have particularly strong seasonal growth in the summer months).

Recent population growth trends vary greatly across the Northeast region (Figure 20). After decades of steady growth in coastal population, some coastal areas of the Northeast saw significant population decline in the past decade. At least one town in each state of the Northeast region, and more than 80 coastal towns in total, have experienced a recent decline in population. Population losses have been particularly pronounced in Downeast Maine (locations east of Acadia National Park), and some Cape Cod towns. In other parts of the region, population growth over the past decade has been generally positive but modest, in most towns well below 2%/year. Strongest growth has been concentrated in eastern Long Island and in a stretch from Connecticut through Rhode Island, the non-Cape communities of Massachusetts, and coastal New Hampshire/Southern Maine.

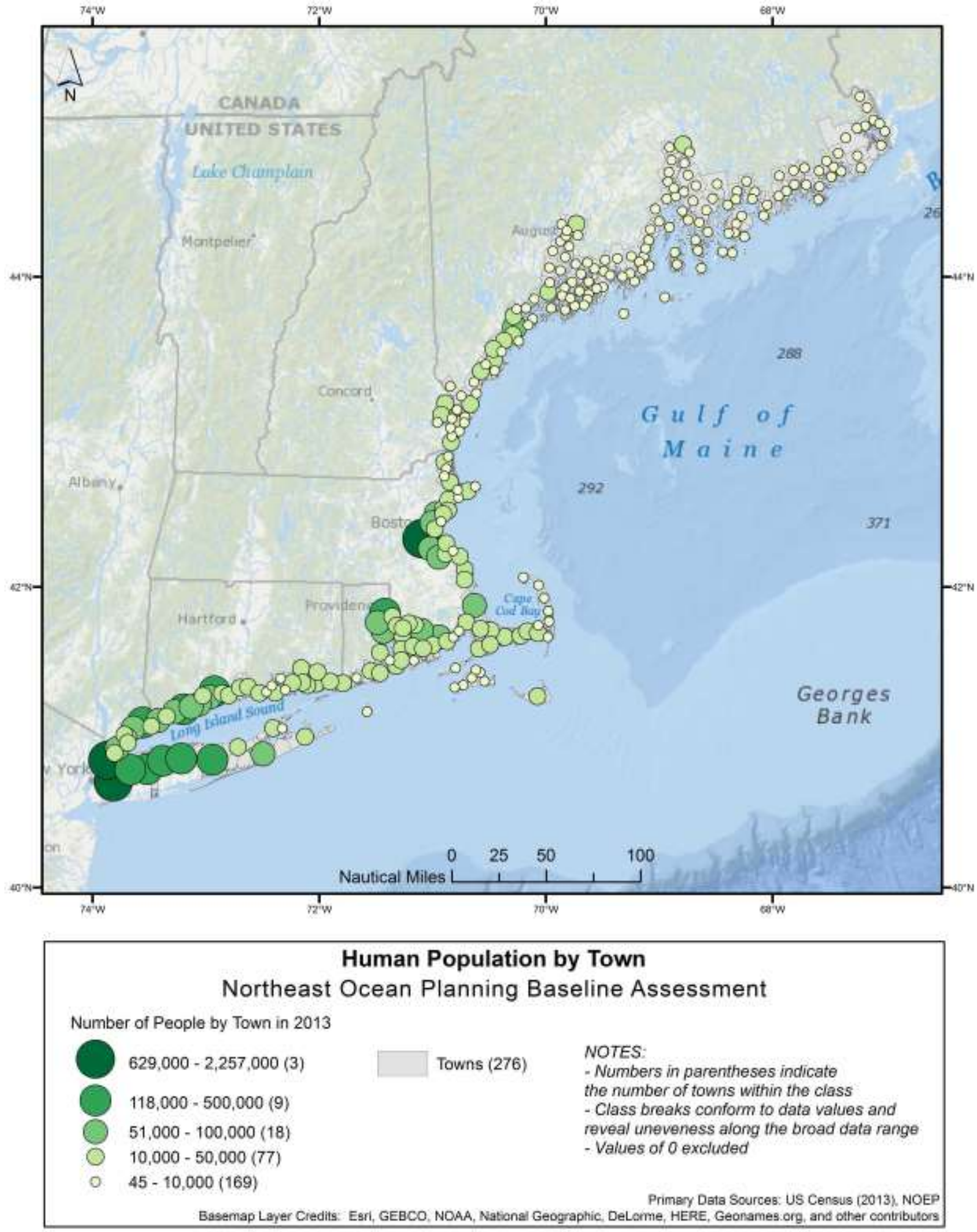

Figure 19 Human population by town, 2013

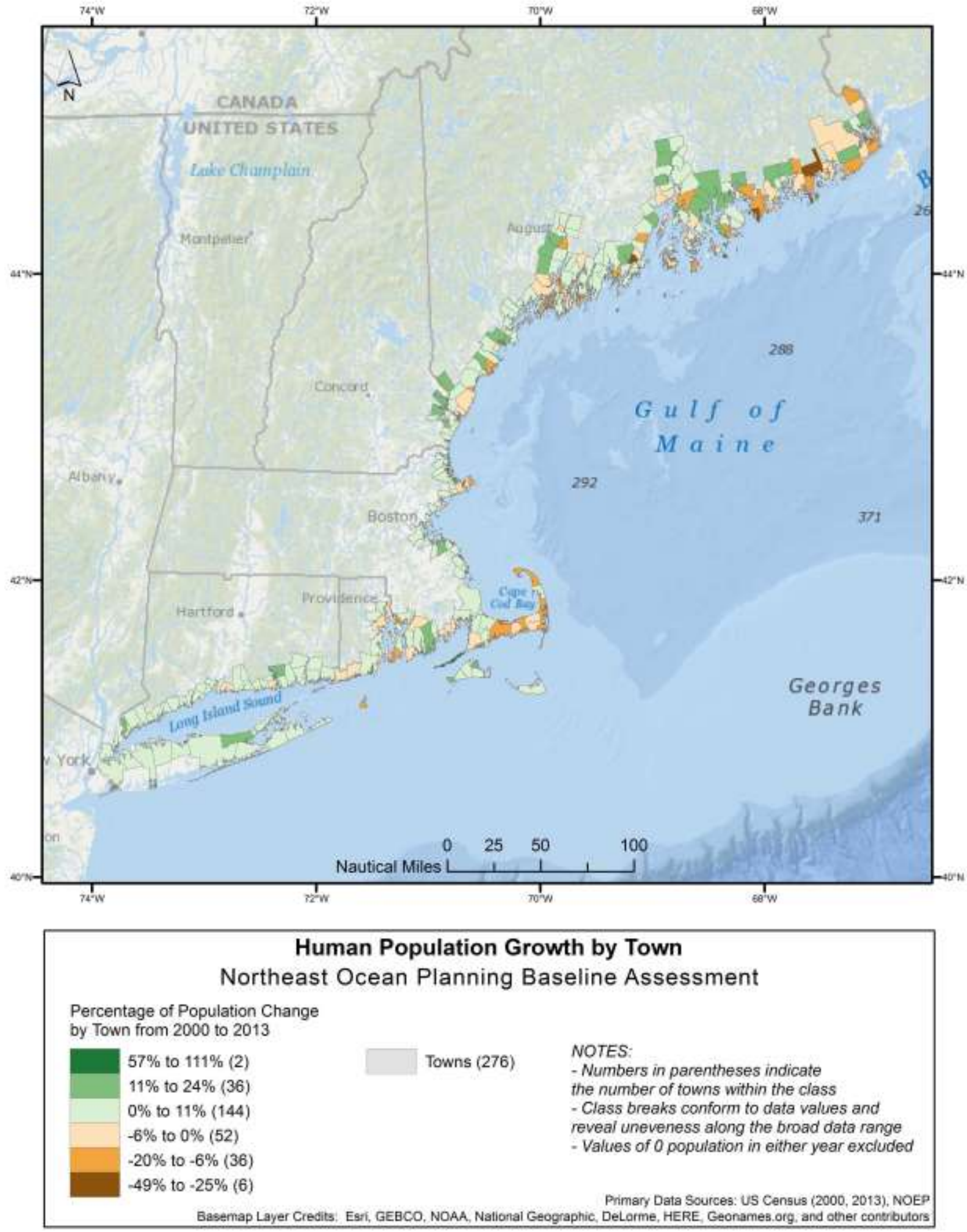

Figure 20 Human population growth by town, 2000 to 2013

The urban concentration of the regional population is mirrored in the distribution of residential housing (Figure 21) in the Northeast region's coastal counties. Housing data also illustrate the strong seasonal changes in coastal population during the summer in the Northeast, when visitors from within the Region and tourists from other parts of the US and the world swell the population of some coastal communities by a factor of five or more. Seasonal housing is concentrated on the eastern end of Long Island, on Cape Cod and the Islands, and in York County and New Hampshire coastal towns (Figure 22).
As a proportion of the total housing stock, seasonal housing is particularly important in eastern Long Island, the Cape and Islands, Southern Maine, Midcoast Maine (Waldo, Knox, Lincoln, Sagadahoc counties), and Hancock and Washington counties of Maine.

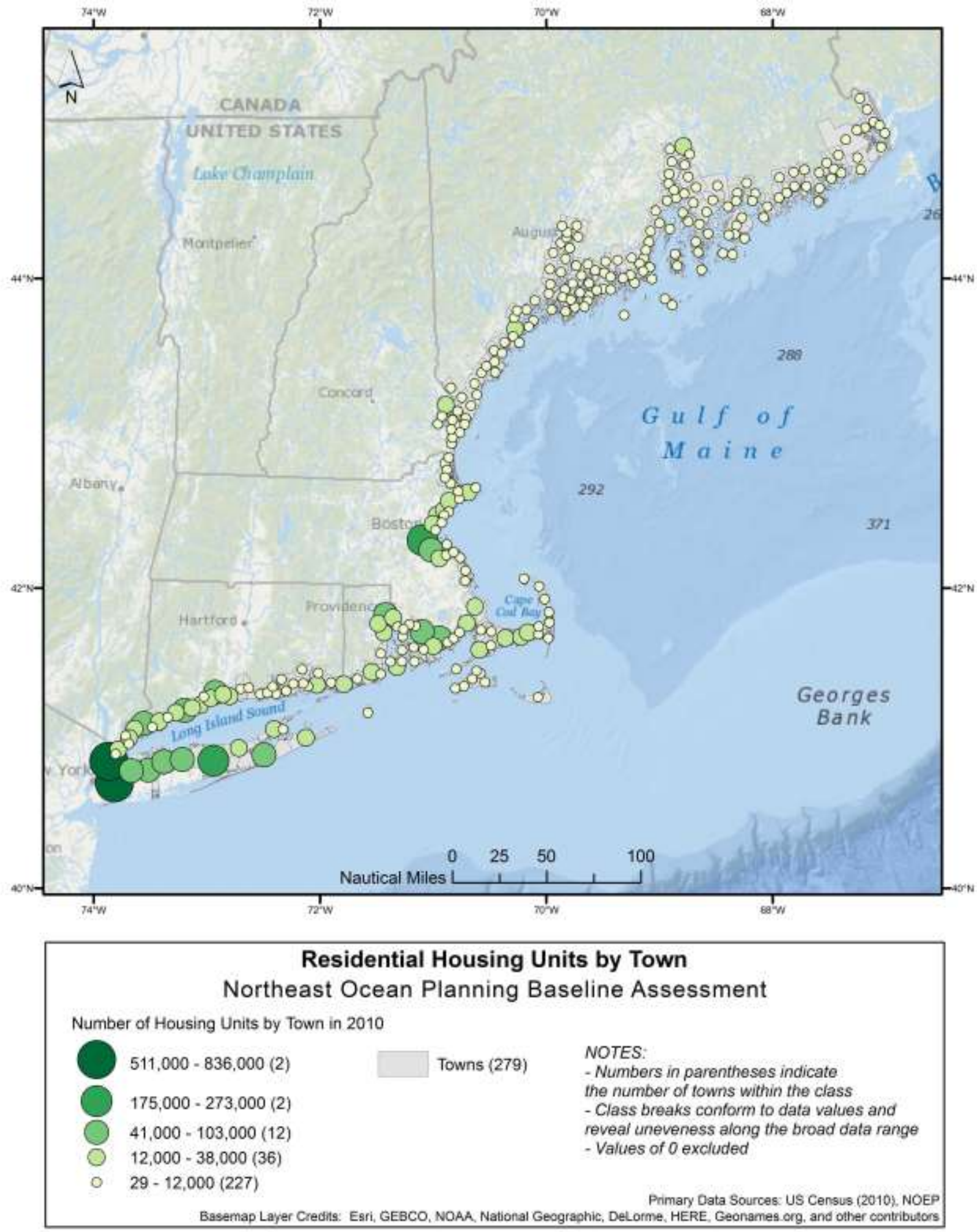

Figure 21 Residential housing units by town, 2010

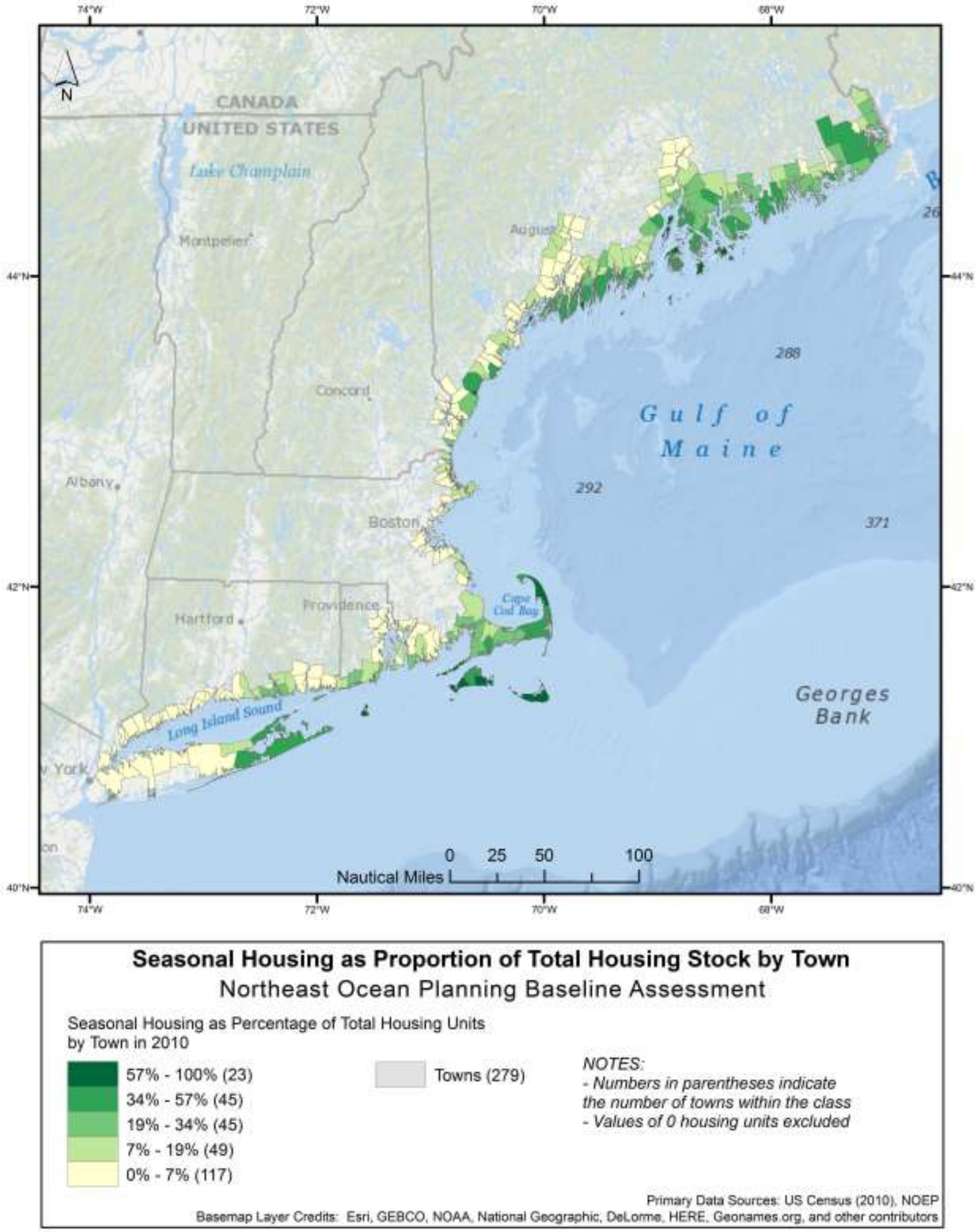

Figure 22 Seasonal housing as proportion of total housing stock by town, 2010