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Northwest Atlantic Marine Ecoregional Assessment: species, habitats and ecosystems

Phase One


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Acknowledgements

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CHAPTER 1

Introduction

Mark Anderson, Jay Odell, and Caroly Shumway

Introduction to Ecoregional Assessments

The ocean provides the largest living environment on Earth and is home to millions of species, some as yet undiscovered. All of Earth's biodiversity depends on the ocean's life-support services. The ocean regulates climate, mediates global nutrient and sediment cycles, and powers food-webs that span the poles. Humans depend on the ocean for transportation, recreation, energy, and food. Human survival and well-being is tightly linked to the condition of coastal and ocean ecosystems. For example, more than three billion people derive at least one-fifth of their needed protein from fresh and saltwater fish. The United States commercial fishing industry is valued at $28 billion and the recreational saltwater fishing industry at about $20 billion (USCOP 2004).

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Recognizing the vital role of marine ecosystems to the health of the planet and the increasingly strong human dependency on ocean resources, The Nature Conservancy (TNC) has endeavored to synthesize data on species distributions, geology, oceanography, chemistry, biology and social science to create maps and other tools that reveal conservation priorities and inform management decisions to help sustain coastal and marine ecosystems and the people that depend on them. This process, known as an **ecoregional assessment,** is part of a TNC wide effort supported by its Global Marine Initiative to protect and restore ocean and coastal ecosystems. Since the early 1990s, TNC has focused on expanding expertise in the marine realm, and now has about 130 staff members working on marine conservation around the world. To date, TNC has completed 10 marine ecoregional assessments, and many more are pending.

The Ecoregional Assessment Process

Ecoregional assessments provide a vision of success for conserving the biodiversity of an ecoregion, a large, relatively distinct area that shares similar climate, topography or assemblages of species. TNC is working with partners to develop ecoregional assessments for every ecoregion in North America, from the Central California Coast to the Northern Appalachians of New England and Maritime Canada.

Important steps in the ecoregional planning process, whether applied to terrestrial or marine and coastal ecosystems, include (Groves et al. 2002):

1. Identification of the species, habitats and ecological processes (conservation targets) that best represent the biodiversity of the ecoregion.
2. Collection of data and information on the targets' ecology, distribution, current condition and vulnerability to human uses and/or environmental changes (threats).
3. Determination of conservation goals for the targets (e.g. population size, areal coverage, distribution).
4. Identification of a set of sites and strategies for meeting conservation goals for the targets.

Introduction to this Assessment

The Northwest Atlantic region is known for its cold, nutrient-rich, and highly productive waters that have sustained regional economies for centuries. With its strong tidal flows, complex circulation patterns, and varied seafloor topography the region supports large diverse populations of bottom dwelling fish and an array of benthic communities. The deep basins and shallow banks of the Gulf of Maine, with seasonal concentrations of plankton and forage fish, attract an impressive number of marine mammals. Farther south, the broad continental margin, large estuaries, and deep submarine canyons function as nursery areas for estuary dependent fishes, critical stopover sites for millions of seabirds, migratory pathways for large pelagic species, and key habitat for coldwater corals.

While the accumulated pressures of population growth and human use of the coasts and oceans have resulted in widespread damage and loss to marine and coastal habitats and species, there is nonetheless, significant evidence of resilience and opportunity for actions to conserve and restore the Northwest Atlantic's marine biodiversity and ecosystem services. This assessment highlights the areas in this region where significant species, natural communities and ecological processes hold the greatest promise for conservation success. This information, in turn, will provide the basis for developing a suite of strategies, from resource management to marine spatial planning, for achieving that success.

This assessment is intended to support regional ecosystem-based management (EBM), an approach previously endorsed by several blue-ribbon panels and recently by the United States Ocean Policy Task Force. Ecosystem based management approaches acknowledge the interconnections between air, land, sea, marine organisms and people, and the dynamic interactions between living resources and their environments. Such approaches are most effective when management of multiple human activities is integrated rather than conducted in sector specific isolation (see Pew Oceans Commission 2003; USCOP 2004; JOCI 2006; OPTF 2009). Around the world, marine resource managers are now seeking to implement EBM to improve conservation of coastal and marine environments. In recognition that political boundaries are essentially irrelevant to marine ecosystem function, EBM planning areas are defined by biogeographic rather than political boundaries.

In order to advance these overarching goals, this assessment integrates information about multiple species and their habitats. The results summarized in this report include maps and data on concentrations of high biodiversity and critical species specific areas for refuge, forage and spawning, and also some of the limited available spatial data for human uses such as shipping lanes, port facilities, energy development, fishing effort, dredge sites and locations of shoreline armoring. The Northwest Atlantic Marine Ecoregional Assessment is designed to be used by diverse stakeholders to inform diverse decisions, to be freely available online for public use. For direct access to assessment data, please visit www.nature.org/namera/.

The Nature Conservancy's goals in conducting the Northwest Atlantic Marine Ecoregional Assessment were to produce a baseline of scientific information on the distribution and status of key habitats and species (Phase One), and a map and report of priority conservation areas for the region's marine biodiversity (Phase Two). The latter used information collected in the first phase to identify areas important to myriad species including seagrass, oysters, diverse migratory and resident fishes, sea turtles, marine mammals, and coldwater corals.

The products of the two phases include:

Phase One:

- A database of information on marine ecosystems, habitats and target species at the Northwest Atlantic regional scale.
- Maps that synthesize diverse spatial data, designed to meet multiple objectives for a variety of users, including support of decisions about conservation and resource use.
- A narrative report of the approach and methods used to build the decision support database, as well as a description of current conditions and trends in all the marine, habitats, species and human uses that were included in the analysis.

Phase Two:

- A narrative report that describes the priority places and strategies that TNC recommends for conservation action within the Northwest Atlantic region, based on analysis by teams of experts, of information gathered in Phase One.

Developing ecoregional assessments for the ocean is inherently more difficult than on land because ocean ecosystems are dominated by three dimensional and highly dynamic processes, and because precise data on the location of key habitats and species are often not available.

However, the authors of this assessment were fortunate to be working within one of the world's most well studied regions and grateful for the opportunity to integrate millions of records of data collected over several decades and graciously contributed by expert researchers from the National Oceanic and Atmospheric Administration (NOAA), the United States Geological Survey (USGS), and several other agencies and institutions listed elsewhere in this report. This rests on the foundation of data created by many scientists whose careers have been devoted to advancing knowledge of Northwest Atlantic marine ecosystems, and on the methodology from previous Conservancy assessment projects.

Over 1200 data files, from over 100 sources, were compiled for this assessment. Every effort was made to understand, and account for, the idiosyncrasies of each dataset, and to respect the value of each source. For each dataset, we contacted the source, met with the people responsible for the data to learn from their experience in collecting and processing the information, and shared our maps and analysis with them through written materials, meetings and phone calls. Any mistakes or oversights in the use of data are solely the responsibility of the authors. Moreover, the willingness of an organization or individual to contribute data to this assessment does not imply an endorsement of the final products.

Despite the availability of considerably more relevant data than is typically available for marine assessments, the challenges noted above persist, resulting in map products that contain more uncertainty, or are at coarser scales, than would be ideal. However, a balance must be struck between delaying actions because of imperfect data, and taking actions based on what we do know in the face of significant threats to marine biodiversity and associated ecosystem services. The results of this assessment are provided with caveats noted, and with the expectation that data gaps will help to inform and prioritize future survey efforts.

There is, and will continue to be, a healthy debate on many aspects of marine conservation. We hope however that we used each dataset appropriately, transparently, and in an unbiased manner. And that this work will aid others in coming to their own conclusions with respect to the conservation of marine biodiversity.

This assessment is envisioned as a mechanism to empower partners, resource users and governments to develop strategies for long-term sustainability of the Northwest Atlantic's ecological services, from the fisheries that feed human populations, to the reefs and barrier islands that absorb wave action and storm surges as sea level rises. The ultimate measure of its success is tangible effective marine conservation.

Northwest Atlantic Assessment Teams

The Northwest Atlantic Marine Assessment was led by a Core Team of Conservancy staff that included representatives from the three subregions in the study area. The Core Team conducted monthly meetings to direct the assessment process and other technical issues that arose. Separate teams were also developed to address the following issues:

- The Data Management Team identified existing data sources and produced maps and Geographic Information Systems that synthesize multiple data layers.
- The Communications Team coordinated public outreach and conducted a survey of stakeholders about their views of the region, and need for data and potential uses of the assessment.
- The Science Team established and organized eleven technical teams, composed of experts in the field, to review, compile and analyze data for each of the focal species and habitats. Each team had a TNC leader who was responsible for working external team members, and drafting and completing the chapters in this report.

The role of the technical teams was to provide guidance to the team leader on the selection of species and habitats, to review data products, provide critical review on the chapters, and ensure that the analyses used were appropriate to the data and species. Members of each technical science team are listed in each chapter.

The Conservancy is extremely grateful to the large number of scientific experts and representatives from government, industry and academia that provided assistance as technical team members or as participants in our peer review workshops.

This assessment is built on the foundation laid by many previous assessments of all or part of the region (see NRDC 2001; Department of Navy 2005; NCCOS 2006; CLF/WWF 2007; Cook and Auster 2007; NMFS 2009). As our understanding of marine systems grows, and as tools for analyzing dynamic spatial processes increase in sophistication, we expect more refined and comprehensive assessments to emerge. Just as this assessment utilized earlier ecoregional plans and data where it existed, the Conservancy anticipates that future assessments will build upon this baseline as scientific knowledge advances and methods are further refined.

The Study Area: The Northwest Atlantic

As defined in this assessment, the Northwest Atlantic region spans the area from Cape Hatteras in North Carolina to the northern limit of the Gulf of Maine in Canadian waters, and extends from the mean high tide mark seaward to the foot of the continental slope (depth of 2500 m). The study area includes the shorelines of 11 states and two Canadian provinces inhabited by more than 65 million people.

The Northwest Atlantic Marine Ecoregional Assessment focuses on two distinct and well-documented marine ecoregions – the Acadian (Gulf of Maine/Bay of Fundy) and the Virginian (Briggs 1974; Spalding et al. 2007). These two ecoregions nest together within the larger Cold Temperate Northwest Atlantic Province, and the similarly bounded Northeast Continental Shelf Large Marine Ecosystem (Spalding et al. 2007; Sherman et al. 1988).

The 140,745 square mile Northwest Atlantic study area is divided into three ecological sub-regions (Figure 1-1). These subregions were also based on biogeographic rather than political considerations to enable geographically appropriate analytical approaches to produce maps and tools to guide ecosystem based conservation. The three subregions described below have distinct and unique characteristics; stratifying our analyses by subregions enabled more meaningful and robust analysis of each subregion's characteristic habitats and species.

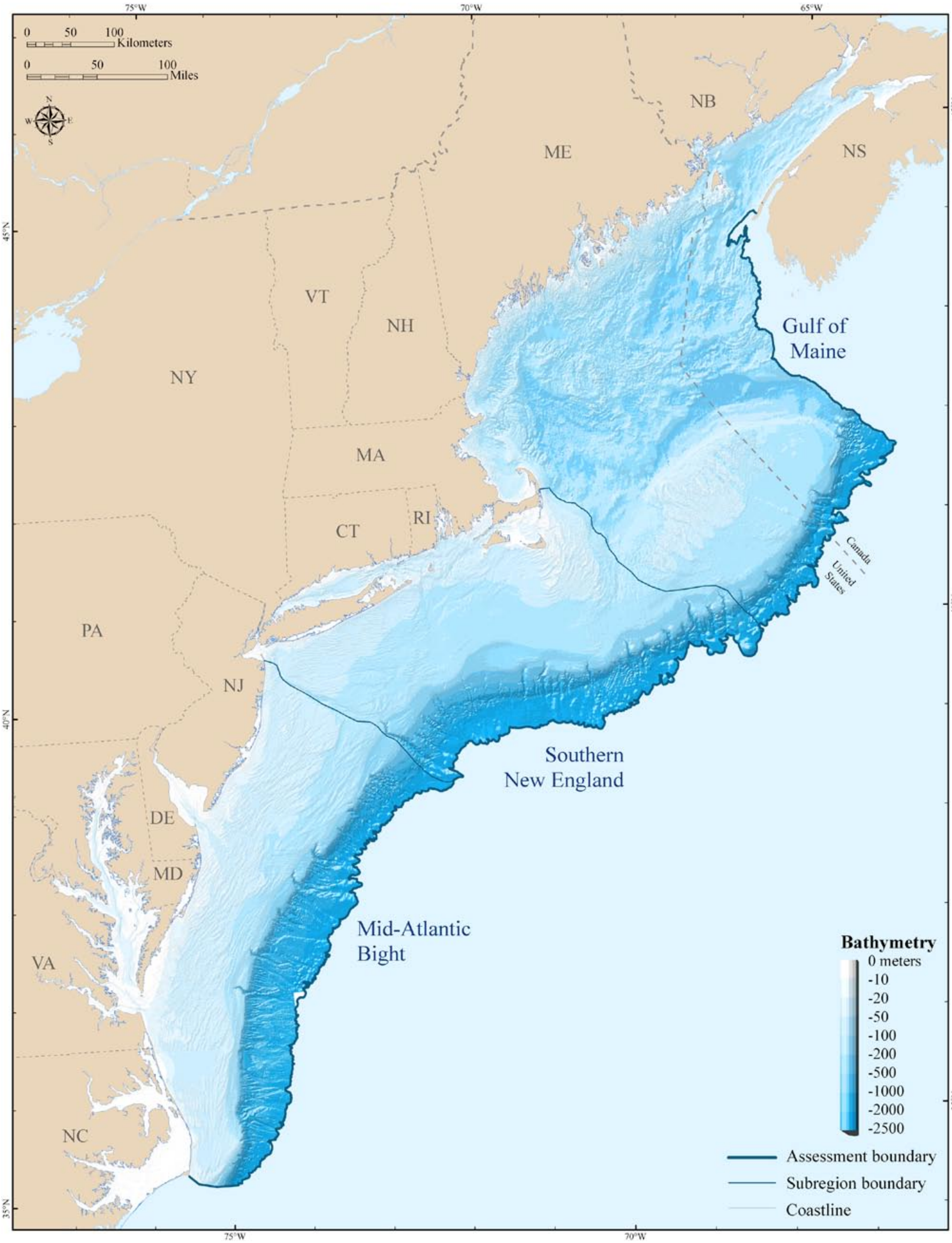

Figure 1-1. The Northwest Atlantic Marine Ecoregional Assessment study area.

1) Gulf of Maine, from Nova Scotia's Bay of Fundy to the tip of Cape Cod, including Georges Bank;
2) Southern New England, ranging from the base of Cape Cod to the southern coast of Long Island;
3) Mid-Atlantic Bight, from Sandy Hook, New Jersey south to Cape Hatteras, North Carolina.

Gulf of Maine Biogeography

The Gulf of Maine is a semi-enclosed sea located in the Gulf of Maine/Bay of Fundy ecoregion of the Cold Temperate Northwest Atlantic marine province (Spalding et al. 2007). The Gulf is bounded by Georges Bank and Browns Bank to the east and the coastlines and near-shore estuarine waters of Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia to the west and north. The Gulf spans over 90,000 square kilometers and has average depth of 150 meters.

The geology of the Gulf has been shaped by glaciation, volcanism, erosion, subsidence, and sea level rise and features prominent banks, basins and channels. The most notable seafloor features include: Georges Bank, Browns Bank, Georges Basin, and the Northeast Channel to the east; Stellwagen Bank, Jeffreys Ledge, Cashes Ledge, and Wilkinson Basin to the west; the Great South Channel to the south; and Jordan basin to the north. There are four hydrographically distinct sub-regions in the Gulf of Maine each having unique physical, hydrographic, and oceanographic conditions: estuarine areas, coastal regions, the central Gulf, and shallow offshore banks (NCCOS 2006).

The Gulf of Maine is one of the most productive marine systems on the planet. The Gulf's high productivity is heavily influenced by interactions between the Labrador Current from the north and the Gulf Stream from the south. When these currents meet, cold nutrient-rich water enters the Gulf through the Northeast Channel. These currents and tidal action in the Bay of Fundy create a counter-clockwise gyre that delivers nutrient-rich waters to the Gulf's banks and ledges, and along the coastal shelf. These nutrient-rich waters rise to the surface and enter the euphotic zone, creating optimal conditions for phytoplankton production, with primary productivity levels ranging from 270 gC m-2 yr-l in the offshore waters of the Gulf to over 400 gC m-2 yr-l on Georges Bank (Townsend et al. 2006). These high levels of primary productivity support a wide diversity of zooplankton species (predominantly copepods) and planktivorous fishes that form the base of the Gulf of Maine food web.

High rates of primary and secondary productivity in the Gulf of Maine support a wide diversity of marine life. Planktivorous fish including herring, mackerel, sand lance, and menhaden that thrive in the Gulf provide a critical forage base for a variety of species including demersal fishes, tunas, whales, marine mammals, and birds. The diversity of marine life in the Gulf if also characterized by a diversity of organisms including anemones, sea stars, sponges, kelp forests, and deep water corals.

Southern New England Biogeography

The Southern New England bays, beaches and rivers stretch from the mouth of the Hudson River to the tip of Cape Cod, and include four National Estuarine Reserves (Peconic Bay, Long Island Sound, Narragansett Bay, and Buzzard's Bay). The region shares a glacial moraine that creates the east-west archipelago of Long Island-Block Island-Martha's Vineyard (USFWS 1997). The subregion's rivers historically supported vast American shad runs, eel populations, and even Atlantic salmon, all of which have severely declined and are now highly managed. This subregion includes parts of what is often referred to as the American "megalopolis" from Boston to Washington that is home to one-in-five Americans although it only makes up 1.5% of the United States' landmass (Gottman 1961). Roughly 12.25 million people live in the subregion, with roughly 7.5 million on Long Island alone (US Census 2001).

This landscape encompasses several highly productive ecosystems situated in the most densely populated region of the Unites States. The coastal stretches of this region are comprised of beaches, bluffs, dunes, rocky shores, bays, estuaries, mud flats, tidal wetlands, and maritime forests. These coastal wetlands and beaches are home to a variety of shorebirds such as osprey, herons, egrets, oyster catchers, plovers, terns, sandpipers and gulls.

The shallow estuaries and embayments are home to a wide variety of migratory marine species that give this temperate region its unique character (Weiss 1995). Large mammals such as harbor seals and harbor porpoises have been frequently documented migrating close to shore. The region is also home to a variety of migratory fishes, many of which are commercially and recreationally important species including bluefish, bass, toadfish, flounder, shad, herring, menhaden and mackerel.

The subregion is well known for its productive estuaries that have historically supported thriving shellfish industries and a cultural history centering around the productive maritime industry. Subregional favorites include oysters, hard and soft shell clams, razor clams, bay scallops, and quahogs. Horseshoe crabs can be found on the shorelines throughout the landscape, as well as blue crabs, spider crabs, and fiddler crabs.

Mid-Atlantic Bight Biogeography

The Mid-Atlantic Bight extends from Cape Hatteras in North Carolina to Sandy Hook, New Jersey and is a transitional area between the rocky shores of New England and gently sloping, warmer South Atlantic. The Mid-Atlantic's oceanographic features, diversity and ecology are strongly influenced by two very large estuaries - Chesapeake Bay and Delaware Bay. Like the Gulf of Maine and Southern New England, the Mid-Atlantic is a highly productive region of one of the world's most productive large marine ecosystems.

The topography of the Mid-Atlantic is characterized as mostly flat, with low relief features such as sandy shoals and swales, sand wedges and waves, and relict coastal features with major submarine canyons at the shelf-slope break. The complex of shoals and swales are important structural features supporting biologically diverse and abundant benthic macrofauna, demersal fish, and foraging concentrations of sea birds, sea ducks and bottlenose dolphins. The shelf is typically covered by a sheet of medium-to-coarse grained sands with occasional pockets of sand-shell and sand-gravel sediments (Wigley and Theroux 1981). Natural hard bottom habitat is relatively scarce compared to the Southern New England and Gulf of Maine subregions. However, coldwater coral patch reef communities with associated structure oriented fish like black seabass and tautog are present, though poorly mapped at this time.

Warm core rings, filaments and mid-water intrusions peel off the meanders in the Gulf Stream, moving warmer, higher salinity pockets of waters from the slope westward across the shelf towards the coast. When these currents cross over topographic highs such as shoals or ridges - and notably canyon heads - they create significant cold-water upwellings and extremely productive biological events (Walsh et al. 1978). The freshwater outputs of the Chesapeake and Delaware bays function similarly to the Gulf Stream through their large plumes which collide with tidal forces to create highly productive nearshore upwelling events that support diverse marine life.

Due to its intermediate position between the cool New England and warm southeastern United States waters, the Mid-Atlantic subregion provides a critical migratory pathway with abundant forage resources for many migratory species from striped bass to right whales.

The Mid-Atlantic's chain of barrier islands includes roughly 30 inlets, formed by the interaction action of waves and currents with mainland drainages and underlying ancient river valleys. These inlets are important ecological systems in the Mid-Atlantic as well, functioning as corridors between the coastal lagoons and the shelf waters. The Mid-Atlantic's inlets and lagoons provide critical spawning areas for sciaenids such as drum, spot, croaker and sea trout, pupping grounds for coastal elasmobranches like sandbar shark, dusky sharks and sand tiger, foraging and nursery habitat for all life stages of the bottlenose dolphin, juvenile habitat for loggerhead turtles and low energy beaches for horseshoe crab spawning.

Species and Habitats Selection

A suite of habitats and species, characteristic and representative of the full diversity of the region were selected in consultation with external technical advisors. The Conservancy's standard conservation planning methods usually refers to the habitats and species one seeks to conserve as conservation targets. Although this methodology has been adopted or modified by many groups around the world, the terminology can be confusing. In this report, conservation targets are simply the habitats, species, and processes we focused on and not targets in the sense of numerical goals.

The concept of coarse and fine filters was used in selecting conservation targets in this assessment. The "coarse filter" approach is based on the efficiency of using large-scale habitat conservation strategies to benefit many species at once. Two habitat targets, coastal shorelines and benthic habitats, were indentified to serve as coarse filters to account for all the species and processes that they support. Both of these habitats were mapped comprehensively across the region, classified into many subtypes based on structure and composition, and characterized in detail. This analysis was designed to facilitate selection of a suite of priority conservation areas representing some of the best examples of each habitat type for the second phase of this assessment.

However, habitat conservation alone is not sufficient for conserving all species and so with guidance from each technical team, a "fine filter" approach was used to select a subset of the thousands of species found within the study area. Because it is not practical or feasible to produce a detailed and spatially explicit analysis for every species in the region, the teams identified focal species in consideration of representation, ecological guilds and processes, and rarity. For each species team, a set of 8 to 50 individual species were identified and a set of individual analyses were done for each species.

Phase Two of this assessment integrates the individual spatial data for all conservation targets to identify high priority conservation areas. In a few instances, such as seabirds, species concentration areas were identified as targets in their own right. All of the conservation targets are listed below and described in detail in the chapters of this report.

Coastal Ecosystems

The fringing ribbons of habitats that make up the land-sea interface help maintain marine diversity and play critical roles for both nearshore and offshore plants and animals. The Northwest Atlantic coastline is particularly well known for several large and hundreds of small productive estuaries that provide juvenile nursery and spawning grounds for fish, mollusks, seabirds, and crabs. Recognizing the heterogeneity and ever-changing nature of the coastline, this section of the assessment reviews the history of coastal systems in the region, provides an overview of coastal habitats such as salt marshes, seagrass beds, and oyster reefs, examines some of the threats and human interactions with these systems, provides an in-depth look at sea level rise and reviews potential strategies for enhancing resilience of coastal systems. This report focuses specifically on the contributions that coastal ecosystems make to marine diversity.

Benthic Habitats

In Northwest Atlantic region, benthic (or seafloor) habitats contain over 2000 species of invertebrates such as marine worms, sponges, shrimp, crab, clams, scallops, snails, sea stars, corals, anemone. , and. Because individual species are adapted to variations in the environment such as sediment grain size, topography and depth, a benthic habitat type is defined as a group of organisms repeatedly found together within a specific environmental setting. For example, silt flats in shallow water are characterized by specific amphipods, clams, whelks and snails. In this assessment, we identified and mapped over 90 of the most common habitats with characteristic benthic communities distributed throughout each subregion.

Diadromous Fish

Diadromous fish are species that utilize both freshwater and salt water habitats during their life cycle. These species have great cultural and ecological significance in the region, and they provide an important energy link among freshwater, estuarine, and marine food webs. The Northwest Atlantic populations of some of these species are particularly important because the global range of seven of the eleven target diadromous species (alewife, American eel, American shad, Atlantic salmon, Atlantic sturgeon, Atlantic tomcod, blueback herring, hickory shad rainbow smelt, sea-run brook trout, and shortnose sturgeon) is limited to the Atlantic coast of the United States and Canada. The species included as primary targets show evidence of significant decline or are already recognized as globally rare.

Demersal Fish

Demersal fish (or groundfish) are characterized by their close association with the seafloor for feeding, spawning, and juvenile nursery areas. This region is particularly productive for demersal fish with some such as cod, haddock, halibut, and hake believed to be largely responsible for initial waves of European settlement in North America. Six groups of demersal fish were analyzed in the report: 1) gadids (cod, haddock, pollock, cusk, white hake, red hake, and silver hake), 2) pleuronectids (American plaice, witch flounder, winter flounder, and yellowtail flounder), 3) elasmobranchs (clearnose skate, little skate, rosette skate, thorny skate, and spiny dogfish), 4) offshore wintering species (summer flounder, scup, black sea bass, and northern sea robin), 5) estuarine species (spot, croaker, weakfish, and tautog), and 6) other species of interest (halibut, wolffish, ocean pout, monkfish, tilefish, redfish, and longhorn sculpin). These species were chosen to represent a wide range of preferred habitats, life history patterns, food habits, population trends, and ecological roles.

Small Pelagic Fish

Small pelagic fish (such as herring and mackerel) are the dominant food source for top marine predators like marine mammals, sea birds, and larger fish. Because of their migration patterns and life histories, these species transfer energy and biomass seasonally from coastal embayments to offshore habitats, thereby providing a significant link between coastal and pelagic systems. The eight species (American sand lance, Atlantic herring, Atlantic mackerel, Atlantic menhaden, butterfish, longfin inshore squid, northern sand lance, and northern shortfin squid) studied represent the guilds of prey species most important to the food webs of the Northwest Atlantic region.

Large Pelagic Fish

Large pelagic fish are highly migratory fish species that are typically found well above the seafloor in the water column. Pelagic species play a key ecological role as predators that regulate their prey communities and structure marine food webs. Some inhabit the region only seasonally and many of the details of their life history are not known. The fourteen species selected as targets include five bony fishes and nine sharks (albacore tuna, Atlantic bluefin tuna, bigeye thresher, blue marlin, dusky shark, great hammerhead, porbeagle, sand tiger, sandbar shark, scalloped hammerhead, shortfin mako, swordfish, thresher shark, and white marlin). The wide ranging distribution of these species across diverse habitat types, their roles as apex predators, and their threatened population status make them prime candidates for inclusion in this assessment.

Cetaceans

Cetaceans (dolphins, porpoises, and whales) are large migratory species that use this region primarily in spring and summer when there is an abundance of food resources associated with cool nutrient-rich waters. As predators, cetaceans are major consumers at most trophic levels, specifically targeting organisms like zooplankton, invertebrates, and small pelagic fish such as sand lance or Atlantic herring. Due to their seasonal abundance and charismatic nature, marine mammals have a long-standing, complex relationship with humans in this region. Ten marine mammals (Atlantic white-sided dolphin, bottlenose dolphin, fin whale, harbor porpoise, humpback whale, minke whale, North Atlantic right whale, sei whale, sperm whale, striped dolphin) were chosen for this study based on their population status and distribution throughout the region.

Sea Turtles

Sea turtles are large, air-breathing reptiles that utilize both oceanic (inner shelf region and offshore) and terrestrial (beach) ecosystems. Their highly migratory and long-lived life history characteristics present unique challenges to their continued protection and recovery. Sea turtles may have once comprised an important component of the region's coastal food webs, consuming prey including fish, invertebrates, and sea grasses. Three species of sea turtle (green, leatherback and loggerhead) were selected based upon their status as endangered species and distribution within the region.

Coastal and Marine Birds

Birds are creatures of both land and sea. Seabirds spend the majority of their life at sea, but return to coastal areas to breed, while shorebirds spend their lives on the coastal land edge, but forage in marine environments. In some cases, these birds may connect geographically disparate marine environments, from southern South America to the Arctic. World-wide, a higher percentage of seabird species are at risk of extinction than any other bird group. Within this region, a number of coastal and marine bird species are listed as state and federally threatened or endangered and nine were chosen for this study (Arctic Tern, Audubon's Shearwater, Barrow's Goldeneye, Harlequin Duck, Least Tern, Piping Plover, Razorbill, Red Knot, and Roseate Tern).

Biodiversity Threats

Pollution and Nutrient Runoff

The Northwest Atlantic's major estuaries of Albemarle and Pamlico Sounds, Chesapeake Bay, Delaware Bay, Long Island Sound, Narragansett Bay, Massachusetts Bay, Penobscot Bay and the Bay of Fundy support enormous biodiversity, but also introduce runoff of nutrients (nitrogen and phosphorus) to the sea from land-based human activities such as agriculture and urban development.

In Chesapeake Bay, for example, nutrients from sewage treatment plant discharges and farming cause extensive blooms of algae. When the algae dies and decomposes, dissolved oxygen is removed from the water, creating a so-called dead zone of hypoxic, or oxygen-starved, water. In July 2003, the dead zone covered 40 percent of the Bay's main stem, the largest area in 20 years, causing stress and habitat loss for crabs, fish and oysters (Chesapeake Bay Foundation 2008).

Intensified occurrences of another phenomenon known as Sudden Wetland Dieback (SWD) have been reported to occur along the East Coast, including Delaware's inland bays, within the past decade. SWD is often characterized by rapid death, or failure to grow for a season or more, of the upper portion of marsh vegetation, primarily Saltmarsh cordgrass (*Spartina alterniflora*). Sometimes complete death occurs. The cause of marsh dieback is unknown, though the cumulative effect of multiple environmental factors are suspected (Bason et al. 2007).

Coastal Development and Population Trends

The Northeast region from Maine to Virginia is the most densely populated coastal region in the United States with 641 persons living per square mile in the coastal

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counties of those states in 2003. The population density of Northeast coastal counties increased from 543 per square mile in 1980 and is expected to increase to 661 in 2008 (Crosset et al. 2004). While these growth rates are similar to those for the country as a whole, the level of density on the finite land area of coastal regions has resulted in environmental stresses.

TNC's 2006 North Atlantic Coast Ecoregional Assessment (portions of which overlap the Northwest Atlantic study region), found that 40 percent of that ecoregion has been lost to conversion to development (3 percent is secured primarily for nature and 14 percent is secured from development while allowing multiple uses). An index of Housing Density Pressure based on census data trends from 1940 through 2050, indicate that 20 percent of the North Atlantic Coast area is predicted to have urban level housing densities by 2050.

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Sea Level Rise

The combined effect of rising sea level and stronger storms related to climate change is expected to accelerate shoreline retreat in certain areas of the ecoregion. The coastal plains from northern New Jersey to northeastern North Carolina, in particular, are expected to experience significant shoreline changes over the next century. Coastal wetlands and beaches that provide important feeding grounds for global bird migrations, as well as nursery grounds for fish and other aquatic species, are at risk from inundation due to sea level rise.

A committee of coastal scientists convened to discuss the potential effects of sea level rise on the mid-Atlantic coastal plain identified an increased likelihood for 1) erosion and shoreline retreat for spits, headlands, wave-dominated barriers and "mixed-energy" or tide-dominated barrier islands; 2) increased likelihood for erosion, overwash and inlet breaching for barrier islands, and 3) the possibility of segmentation or disintegration for some barrier island systems (Gutierrez et al. 2007). The committee also concluded that factors such as human engineering to protect property by building seawalls and jetties can interact with geologic and physical processes to alter sediment dynamics, making it difficult to predict the ultimate response of shorelines to sea level rise (Gutierrez et al. 2007).

Unsustainable Fisheries

The Northwest Atlantic includes Georges Bank, historically one of the richest fishing sites in the world. This plateau in relatively shallow ocean water is located on the eastern rim of the Gulf of Maine where the collision of the Labrador Current with the Gulf Stream creates a nutrient rich upwelling that nourishes plankton and fuels the marine food chain to support exceptionally high fish productivity. Overfishing in the Georges Bank, competed over by United States, Canadian and international fleets over the past century, has taken a toll on ground fish such as Atlantic cod, haddock and flounder, and portions are now closed to commercial fishing (Boreman et al.1997; Murawski et al. 2005).

Species and Resources at Risk

Numerous iconic species of the Northwest Atlantic region face challenges caused by loss or damage to habitat and other environmental stresses. For example:

- Habitat for lobster that support coastal fishing communities throughout New England, may be affected by increased ocean temperatures caused by global climate change, with populations potentially shifting from current locations

(NECIA 2007).

- Dams and other development create barriers to migration for anadromous species such as Atlantic salmon, which hatch in rivers and migrate to the sea for two years of extensive feeding before re turning two to three years later to spawn. Once native to nearly every river north of the Hudson, wild populations of Atlantic salmon are now known to persist on only eight rivers and certain population segments are federally listed as endangered species (NOAA 2008a).
- Juvenile loggerhead sea turtles forage for food from Cape Cod south along the continental shelf of the Eastern United States. A petition was filed in 2007 to change the status of the Western North Atlantic population from threatened to Endangered (NOAA 2008b).
- North Atlantic right whales, the rarest of all large whale species, arrive in the Bay of Fundy, Scotian shelf and waters off New England in the summer to feed. Numbering only about 400, the Western North Atlantic population of these baleen whales has been listed as federally endangered since 1973. Ship collisions followed by entanglement in fishing gear are the most common causes of injury and mortality (NOAA 2008c).

Conservation Action for the Northwest Atlantic

While the accumulated pressures of population growth and human use of the coasts and oceans has resulted in widespread degradation of marine and coastal resources. Nonetheless, significant resilience remains and it is not too late to take action to improve conservation of the Northwest Atlantic's biodiversity. This assessment highlights significant species, natural communities and ecological processes within the region, and specific areas that present compelling conservation opportunities for maintaining coastal and marine ecosystems that provide the goods and services that people want and need.

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